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Modeling Share Prices Based on Investors' Irrational Behavior

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ABSTRACT

The subject of the research is the economic and socio-psychological aspects of investment behavior in the stock market, which is the most volatile segment of the stock market.
The purpose of the study is to develop a methodology for assessing deviations in stock market prices from their rational (fundamental) values. **Objectives:** to reveal the essence of the market value of shares and its irrational component, which is a set of heuristic estimates of the future benefits of the share owner; to describe the stages of development of behavioral economics considering irrationality in consumer choice models; to analyze research in the field of irrational stock pricing and propose an algorithm for solving the problem. **Relevance:** Irrational valuation of financial assets can become a catalyst for economic crises. This is why distortions in consumer behavior require government supervision and regulation. **Methodology:** The authors employed Discounted Cash Flow Model, Logit model, the Least Squares Method, and Lasso Regularization. **Research result:** The author's approach to assessing financial heuristics, including a set of indicators that reflect distortions in consumer behavior in the stock market. Based on the results of the study, we **concluded** that the market value can deviate significantly from rational expectations. We proved that there is a relationship between cognitive distortions and quotation dynamics. However, we found that the methods we considered do not allow us to determine the duration of irrational assessments. **Scientific novelty:** A new approach to modeling the irrational valuation of stocks has been developed based on the relationship between the deviation of stock prices from their fair values and indicators can be used to make heuristic estimates of future benefits from owning a particular stock. **The practical significance:** The use of the developed methodology can be beneficial for investors to accurately assess the fair value of their portfolios. Businesses can use it to create models of consumer behavior when developing of financial products. Mega-regulators can use it to analyze investment behavior factors and respond to market distortions in a timely manner.
Keywords: action; behavioral finance; irrational valuation; financial heuristics; cognitive distortion

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INTRODUCTION

The issues of valuation of investment assets have been studied by scientists and market analysts for a long time in different countries. Since the 1960s, economic theory has been dominated by the concept of rational expectations, which states that economic agents use all available information about the market to make rational investment decisions. However, with the increasing number of non-professional investors in some markets and in the context of deglobalization and related political and economic crises, the valuation of financial assets can differ significantly from rational calculations. This is because the behavioral aspects of pricing need to be carefully researched in order to be taken into account when developing investment strategies and government programs to regulate the economy.

The study of investment behavior from an economic and socio-psychological perspective is particularly relevant for the stock market, which is the most volatile segment of the financial market.

From a macroeconomic perspective, the relevance of this issue lies in the potential for irrational valuation of financial assets to become a catalyst for economic crises. This can lead to significant distortions in consumer behavior, requiring government supervision and, in some cases, regulation.

The scientific significance of this study is in the possibility of improving the predictive power of DCF models by taking into account heuristic errors.

The aim of the research is to explore approaches to irrational stock valuation as an object of behavioral economic research, identifying their advantages and limitations in order to develop a comprehensive methodology for such assessments.

To accomplish this goal, the following objectives are being pursued:

1. To reveal the economic essence of the market value of shares and its irrational component, which is a set of heuristic estimates of the future benefits for the owner of the share.

2. To characterize the key stages in the development of behavioral economics and its relevance to accounting for irrationality in consumer choice models, including investment decision-making models.

3. To analyze research on irrational stock pricing and the applicability of author's approaches for predicting market value deviations from fundamental estimates, and to propose an algorithm for addressing this problem.

The novelty of this work lies in the development of an author's approach to modeling the irrational valuation of stocks. This approach is based on the relationship between stock price deviations from fair values and indicators that lead to heuristic estimates of future stock benefits.

The results of the research contribute to the theory and practice of financial science. The practical significance of the article is that it provides a developed methodology that can be used by:

- Investors to assess the fair value of their investment portfolios and individual investments.
- Financial businesses (brokerage companies and commercial banks) to understand consumer behavior and create financial products that meet market demand.
- A mega-regulator to analyze factors and trends in investment behavior to respond quickly to market imbalances by taking restrictive measures against unqualified investors and providing information about the risks associated with financial products.

DEFINITIONS OF IRRATIONAL STOCK VALUATION

Behavioral finance issues are becoming quite popular in modern research on the investment behavior of retail investors. The authors believe that in addition to profitability and risk, behavioral factors influence investment decision-making, which

are based on motives of thrift and caution combined with fear of missed opportunities and other phenomena of behavioral finance theory [1]. Scientific papers note that different attitudes due to differences in upbringing and education have a significant impact on consumer behavior [2, 3]. Research shows that consumer behavior is often irrational, which requires in-depth research in the context of their investment decisions.

The study of irrational valuation of stocks from the perspective of behavioral finance requires disclosure of the following concepts: stocks, the market value of stocks and its constituent components: rational and irrational valuations of stocks. It is also necessary to formulate a definition of financial heuristics, which is one of the factors responsible for the irrational valuation.

Shares are equity securities that assert the rights of their owners to receive a portion of the issuer's (joint–stock company's) profits in the form of dividends, to participate in its management, and also to a portion of the property remaining as a result of the company's liquidation. A complete description of the essence of stocks as an economic and legal phenomenon allows for an analysis of their classifications and properties.

The most common classification of shares is based on the priority right to receive dividends: it is customary to distinguish between ordinary (voting) and preferred (shares with a fixed amount of dividends with restrictions on management rights). Preferred shares, in turn, are divided by convertibility, as well as by the possibility of prolongation of the company's obligations in case of refusal to pay dividends in the current period. In the course of the study, ordinary shares were considered.

The main properties of shares include: title of ownership; perpetuity; limited liability of the shareholder of the shares; lack of liability of shareholders to the obligations of the issuer; indivisibility of the rights assigned to the owners of shares.

Thus, from a financial point of view, the stock can be represented as an indefinite unstable (including negative) cash flow, the value of which is influenced by many internal and external factors. Therefore, the sum of current estimates of expected cash flows is equal to the current share price [4].

The market value of a stock is the price at which purchase and sale transactions are concluded on the secondary market. From an economic point of view, market value is not the same as fair value. Otherwise, prices on the secondary market would be constant, and the number of transactions would be minimal. This discrepancy is due to a number of factors: the limitation of arbitration, the investment policy of institutional investors, as well as the limitation of predictive capabilities regarding future cash flows, the profitability of alternative investments, and the likelihood of systemic risks. Thus, the market valuation of shares can be decomposed into two components: rational and irrational [5].

A rational estimate is an estimate based on accurately predicted values of future cash flows and alternative returns. The concept of rational valuation is identical to the concept of fair value, provided that the forecast is correctly constructed. In financial market practice, it is difficult to determine a rational valuation due to computational errors, methodological limitations, and cognitive biases (based on intuitive bias and heuristics), which leads to an irrational component in stock valuation.

An irrational valuation of stocks is an opinion about future earnings from their purchase based on errors in thinking and market constraints. It can be expressed in terms of the market value of a stock on the secondary market, which significantly deviates from a rational estimate. The study of cognitive causes of irrational valuation of stocks is included in the list of issues of behavioral economics [6, 7]. According to the provisions of this school of economics, as

Table 1

Comparative Analysis of Definitions and Classifications of Heuristic Approaches among Representatives of Different Scientific Fields

Author	D. Kahneman [7]	V.E. Erovenko [8]	S.Y. Bogatyrev [10]	A.V. Khutorsky [12]
Definition Unique aspects	Mental habits that provide quick responses to common tasks, but can lead to errors when applied to unfamiliar situations	A technique that uses previously known or received data to simplify the solution of a problem	Shortcuts to programmed actions of a financial decision-maker	A science that studies the patterns and methodologies of the processes involved in searching for and finding solutions, with the goal of limiting the number of possible solutions to a problem
Classification	– Recognition heuristics; – evaluation heuristics	– Accessibility heuristics; – Heuristics of representativeness; – Anchor heuristics	– Accessibility heuristics; – Overreaction heuristics; – Anchor heuristics; – Self-confidence heuristic	– Accessibility heuristics; – Heuristics of representativeness; – Anchor heuristics
Unique aspects	Heuristics are considered as an associative-evaluative mechanism for subconscious problem solving	Heuristics are considered as a way to solve mathematical problems	Heuristics are considered as a model of human financial behavior	Heuristics is considered as a method of scientific knowledge

Source: Compiled by the authors.

a result of evolutionary processes, humans have developed the ability to heuristic thinking, allowing them to make decisions based on similarity, risk avoidance, prejudice, in conditions of limited access to information and time for decision-making [6].

It should be emphasized that heuristic thinking is a multidimensional phenomenon, the study of which is reflected in the scientific works of researchers in the field of mathematical sciences [8], psychology [6, 9], economics and finance [10, 11], as well as pedagogy [12]. A comparative analysis of these approaches is presented in *Table 1*.

In this study, the authors explore heuristic thinking within the context of behavioral economics. Based on the findings of the comparative analysis, a definition has been formulated.

Financial heuristics refer to algorithms for making financial decisions that are based on the principles of similarity and/or subjective perception of probabilities of outcomes and expected results. Behavioral economics studies heuristic thinking as it relates to economic decision-making, and some aspects of this are relevant to the scope of this study.

A HISTORICAL TOUR OF DEVELOPMENT BEHAVIORAL FINANCE

Behavioral economics is a branch of economics that studies how cognitive biases affect economic decision-making in situations with limited resources and uncertainty.

The focus of behavioral economics is on heuristic thinking, which is a way of thinking that uses mental shortcuts to make decisions.

Table 2

Analysis of Methodological Approaches to Modeling Irrational Valuation of Stocks

Author	Applicable metrics	Research subject	Hypothesis testing methods
M. Huang [28]	Google trends Search Query Index	Sentiment analysis of stock returns	Granger test, Ridge regression. Modeling the impact of sentiment on S&P500 returns
Al-Nasseri A. [27]	Divergence of opinions on the StockTwits platform	Sentiment analysis of stock returns	Linear multivariate regression analysis
Teplova T.V., et al. [29]	Author's HYPE metric	Sentiment analysis of stock returns	Machine learning methods, regression analysis
Boswijk, H. Peter and Hommes, Cars H. and Manzan [40]	Fortune polls, survey data	The effect of the predisposition effect on risk sensitivity	Calculation of required profitability for companies with a high and low popularity index
Loctionova E.A. [5]	Fibonacci levels, forecast of the ABA, consistency of analytics	The influence of the psychophysical factor on stock valuation	Calculation of the irrational behavior coefficient (the ratio of the Fibonacci forecast to the forecast average)
Bogatyrev S.Yu. [41, 42]	Behavioral Beta Coefficient, Emotional News Rank	The influence of sentiment on risk sensitivity	Statistical assessment of the influence of the news background on the discrepancy between the price and behavioral Beta coefficients

Source: Compiled by the authors.

Behavioral economists study how this type of thinking influences economic decisions. Common research methods used by behavioral economists include thought experiments and surveys [11].

The main stages of the formation of the doctrine of irrationality in consumer choice models are related to the development of economics in a broad sense. The first provisions on irrational behavior were formulated in the works of representatives of the classical and neoclassical schools of economics. In general, researchers at this stage adhere to the hypothesis of a rational individual. Discrepancies are observed in the causes of irrationality. In particular, A. Smith in his work "The Theory of Moral Feelings" pointed out the importance of emotions and sympathies in making economic decisions, which contradicts the model of a fully rational agent [13]. G. Becker also tried to formalize "irrational" forms of behavior (habits, altruism, discrimination), including them in the framework of rational choice [14].

Neoclassicists believed that the reason for irrationality lies in the limited information and computing capabilities of the individual. This approach is reflected in the works of G. Simon [15] and J. Stigler [16], who believed that an agent would search for and process information until the costs of searching and processing exceeded the expected benefit.

The second stage of the research was conducted by A. Tversky and D. Kahneman in the field of cognitive psychology. They discovered the effect of irrational paternalism, which is manifested as the result of the development of heuristic thinking in economic agents. The levels of thinking were identified, and a fundamental classification of heuristic errors was developed: recognition heuristics (when a person tends to make typical decisions in typical situations) and evaluation heuristics (when a person misinterprets the probability and cost of an outcome) [17, 18].

At the next stage, behavioral economics and behavioral finance are separated according to the results of the works of R. Thaler [19, 20], K. Camerer and J. Levenstein [21]. The main position of this theory is a critique of the homo-economicus hypothesis, which assumes that a person makes a decision based on the principle of maximizing utility, choosing the most optimal of a variety of solutions.

At the present stage, behavioral decision-making models (including investment ones) are being created. For example, researchers study the effect of psychological factors on risk appetite [22, 23], the influence of news publications on financial instrument quotes [24], behavioral portfolio theories [25, 26], sentiment analysis of financial asset returns [27–29], and the integration of behavioral models into the strategies of institutional financial market participants [30–34], macroeconomics and monetary policy [35–39].

The most interesting issue in this study is the study of irrational valuation of stocks. An analysis of modern publications has shown that the approach based on sentiment analysis (analysis of the influence of the information background on the actual and required profitability of stocks) has become the most widespread in assessing the irrationality factor. A summary of existing approaches to stock valuation modeling is presented in *Table 2*.

It should be noted that the methodologies discussed in this paper do not solve the problem of estimating the probability and magnitude of market value deviations from fair values. Meanwhile, E.L. Loktionova's approach, which is a system of analytical adjustments to stock prices, is not supported by historical data. Therefore, the authors have developed an econometric approach to solve this problem.

THE AUTHOR'S APPROACH TOWARDS MODELING IRRATIONAL STOCK VALUATIONS

The author's approach is based on modeling the probability and relative magnitude of the discrepancy between the market value and the DCF confidence interval of the 90% model under the influence of the most popular heuristic errors (*Fig. 1*).

Indirect indicators are used as metrics of irrationality, indicating an increase in the probability of making decisions based on these heuristics (*Table 3*).

To assess the statistical relationship, several types of models are formed: to assess the probability of deviations, logistic regression is used; to assess the relative magnitude of deviations, multifactorial regression using the MNC method, multifactorial Ridge regression, and structural vector autoregression (VAR).

Applying the widely used DCF model, we obtained 3-year forward looking estimates of the company's value with a 3-year lag. For this purpose, the actual financial reporting data for the forecast period, formula (1) was used.

$$PV_t = \sum_{i=1}^{3} \frac{FCF_{t+i}}{\left(1+WACC_{t+i}\right)^i} + \\ + \frac{\widehat{EV}}{EBITDA} \times \frac{EBITDA_{t+3}}{\left(1+WACC_{t+3}\right)^3}, \qquad (1)$$

where PV_t — the present value of the company, including debt, FCF_{t+i} — free cash flow $t + i$, $\frac{\widehat{EV}}{EBITDA}$ — the average value of the multiplier EV/EBITDA for the forecast period, $WACC_{t+i}$ — weighted cost of capital during the period $t + i$.

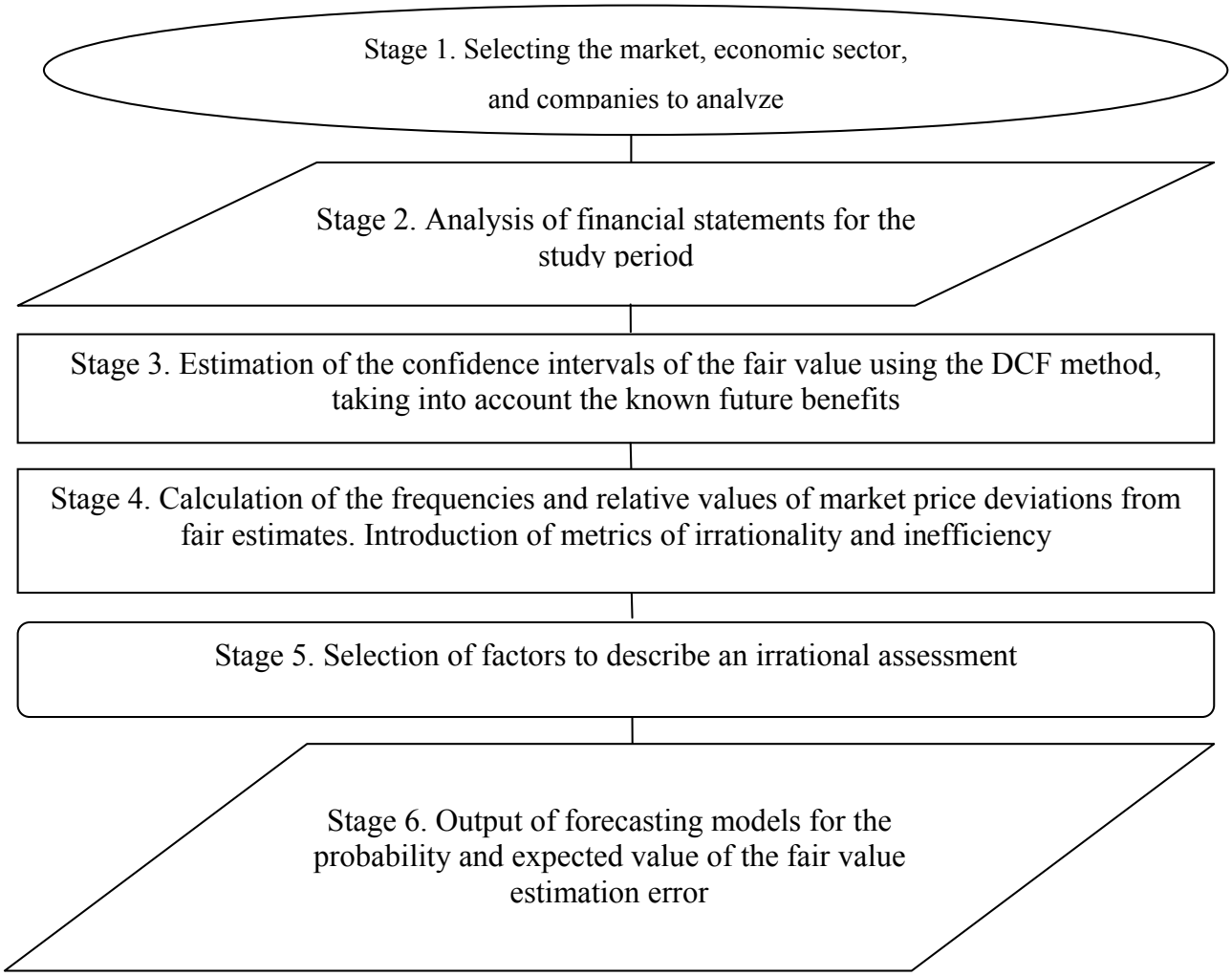

Fig. **Author's Methodology for Modeling Irrational Stock Valuation**

Source: Compiled by the authors.

Table 3

The Relationship between Heuristics and Observed Factors

Name of the heuristic	Meaning	Observed factors
Accessibility heuristics	Recent events are assessed as more likely	Total return on the stock over the past year, the short-term trend in the prices of the company's products and exchange rates
The heuristic of representativeness	Making a judgment based on the similarity of a sample element to an element of the general population	Technical analysis patterns and short-term changes in the direction of the stock price trend
Anchoring heuristics	Making a judgment about the future value of a random variable with reference to the initial value	Growth rates of operating indicators and free cash flow and cost multipliers
Predisposition heuristics	Popular solutions seem to be the most effective	Google trends Search Query Popularity Index

Source: Compiled by the authors.

Table 4

A Model for Predicting the Likelihood of a Price Exiting an Upward Range

Factor	Parameter estimation
Observations	3326
Average approximation error	14.7%
The constant	–10.90
Brent Crude Oil (MA10/MA125)	6.24
EV/NPE	5.98
Price/historical maximum	5.60

Source: Compiled by the authors according to IFRS and investing.com.

Table 5

A Model of the Probability of the Price Falling Outside the Range

Factor	Parameter estimation
Observations	3326
Average approximation error	9.1%
The constant	5.03
VIR	–31.27
EV/NOPLAT	–10.88

Source: Compiled by the authors according to IFRS and investing.com.

Table 6

A Model of the Probability of a Price Falling Within the Range

Factor	Parameter estimation
Observations	3326
Average approximation error	26.6%
The constant	2.47
Price/historical maximum	–10.28
Total return for t – 1 year	9.03
MICEX (MA10/MA125)	4.79
Oil(MA10/MA125)	–2.78

Source: Compiled by the authors.

The confidence interval for this estimate was obtained using the historical volatility of the EV/EBITDA multiplier. We assume that market participants use a similar model and their expectations of future financial performance to form an idea of the fair value of the company. Thus, if the market predicts future cash flows, multiplier and discount rates well, the market price should be within this range, and deviations of market prices from the calculated ones are largely due to irrational factors.

The shares of PJSC Rosneft were selected as the object of observation as the most frequently exceeding the confidence interval of the DCF model for the period 2007–2019. In 1331 of 3505 trading sessions, the closing price was outside the confidence interval.

Tables 4–6 present the logistic regression parameters estimating the probabilities of finding the market value of Rosneft shares relative to the DCF confidence interval of the model. The models are based on normalized data.

The growth of oil prices, the ratio of market value to profits earned from equity financing, and the ratio of the current price to the historical high have a direct impact on the likelihood of a company's revaluation.

The author's interpretation of the investment cost multiplier (VIR) is calculated as the ratio of P/E to the payback period estimated using the CAPM model. Low multiplier values indicate the effect of avoiding losses (anchoring heuristic), thereby increasing the likelihood of underestimating the company.

The ratio of the price to the historical maximum and the direction of the trend in oil quotes reduce the effectiveness of the DCF estimate, while the total return on the positive dynamics of the benchmark increases the probability of finding the price within the range of the DCF model.

The relative deviations are modeled by the OLS estimation and Lasso regression method.

Table 7

A Model for Estimating the Upward Deviation of the Price from the DCF Model Range

Model	OLS estimation	Lasso estimation
R-square	0.49	0.44
Observations	830	830
The constant	–1.24	–0.58
Stock MA10/MA125	1.97	1.60
MICEX MA10/MA125	–0.65	–0.59
Price/historical maximum	0.31	0.38
EPS Growth rate	4.97	0.00
EV/NOPLAT	–0.29	–0.07
PEGY	1.26	0.46
VIR	–0.98	–0.50

Source: Compiled by the authors according to IFRS and investing.com

Table 8

A Model for Estimating the Normalized Price Deviation below the DCF Model Range

Model	OLS estimation	Lasso estimation
R-square	0.68	0.57
Observations	531.00	531.00
The constant	–0.15	0.15
Total return for t – 1 year	13.34	0.00
Oil MA10/MA125	1.41	1.18
USD/RUB MA10/ MA125	0.96	0.35
Stock MA10/MA125	–1.58	–1.79
MICEX MA10/MA125	2.40	1.54
Price/history maximum	–9.15	–0.89
PEGY	8.96	1.34
VIR	–5.82	0.19
Google trends	0.80	0.58

Source: Compiled by the authors according to IFRS and investing.com.

Table 9

Descriptive Statistics for Model Calculations

Indicator	Maximum	Minimum	Average
Upward deviation from c.i.	0.49	0.00	0.13
Downward deviation from c.i.(modulo)	0.27	0.00	0.13
Total return for t – 1 year	1.62	–0.59	0.35
Oil MA10/MA125	1.37	0.47	1.01
MICEX MA10/MA125	1.42	0.42	1.02
Stock MA10/MA125	1.43	0.45	1.01
USD/RUB MA10/MA125	1.43	0.85	1.02
Price/ history maximum	1.06	0.29	0.81
EV/NOPLAT	18.77	–2.37	3.52
EPS Growth rate	8.29	0.14	1.17
PEGY	1.74	0.14	0.51
VIR	5.84	0.60	2.04
Google trends	100.00	0.00	25.83

Source: Compiled by the authors according to IFRS and investing.com.

For upward deviations, the accuracy of the OLS estimates is 49%, Lasso 44% (*Table 7*).

The most significant factors are the growth rate of earnings per share, the trend direction of stock prices, and PEGY (the P/E multiplier adjusted for average annual EPS growth and current dividend yield). For downward deviations, the accuracy of the MNC estimate is 68%, Lasso — 57% (*Table 8*).

The most significant factors are: total return for the previous year, PEGY, price / historical maximum.

The statistical data necessary for reproducing the calculations are presented in *Table 9*.

The obtained models were used to estimate the probability and magnitude of the deviation of the market price from the boundaries of the confidence interval of the discounted cash flow (DCF) model with perfect foresight. On May 13, 2024, the estimated probability of a revaluation of Rosneft shares was 40%, and the estimated price within the confidence interval was 71%. The market price was either near or exceeded the upper limit of the confidence interval by up to 31%, according to the data as of January 16, 2026. Based on the data, we estimate that the probability of finding the price within the 90% confidence interval of the DCF model is 77% and the probability of an upward deviation is 9%.

Thus, an irrational valuation can take a significant share in the market value of a stock. The models obtained describe the irrational component of the market value of Rosneft shares in conditions of uncertainty about the company's future cash flows, and the proposed approach is applicable to any public company with a long history of trading on the stock market.

CONCLUSIONS

Based on the studied works, we can conclude that in the modern economy, irrational factors have a more significant influence on investment decision-making than a rational approach. This is because a significant part of people are influenced by external factors, mass sentiment, and lack the necessary level of education and expertise in investment.

A comparison of existing research on irrational stock valuation has shown that no method can accurately predict how long irrational valuations will persist in a specific security or how far the price will deviate from rational values. Therefore, further research should focus on developing metrics to measure irrational valuation in individual securities and the market as a whole.

A list of problems currently facing researchers in the field of irrational assessment has also been formulated. The ability to practically test hypotheses about the impact of certain patterns of heuristic thinking is limited by the lack of statistical data describing them. All quantitative indicators used in the models come from heuristic sources and are not always influenced by cognitive distortions. Including each individual indicator in a model requires clear logical and/or empirical justification.

An algorithm for modeling the irrational component of share prices through a set of parameters capturing the manifestation of errors in heuristic thinking has been proposed. This algorithm was tested using the example of Rosneft shares.

This work contributes to the further improvement of classical cost models by taking into account the irrational component in order to help investors and market participants solve practical tasks:

- Evaluate the effectiveness of a particular methodology for a company.
- Calculate fair value boundaries without predicting future cash flows, which is important in conditions of uncertainty and limited information.
- Test portfolio strategies based on minimizing irrational overestimation.

The results of the study can be applied in the context of state regulation of investment activities and the promotion of financial

literacy related to investments and the stock market. The theoretical significance of this work lies in its potential to improve the methodology of behavioral finance by adopting an integrated approach that identifies the degree of irrationality in consumer behavior.

In this regard, the authors address the scientific challenge of equity securities valuation through the proposal of an original approach based on developing the concept of examining the frequency and extent of market value fluctuations from the confidence interval of a fair valuation

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