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ROBUSTNESS MEASURE FOR PORTFOLIO MANAGEMENT STRATEGY

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A practical approach to estimating of the investment strategy robustness is presented. As a quantitative measure of robustness, the objective function smoothness degree is proposed for utilization. After the optimization has been conducted, it is essential to utilize an additional criterion for the selection of strategies that possess better robustness property. The utilization of the quantitative estimate of the strategy robustness enables a better strategy to be chosen in the efficiency analysis of investment systems. This strategy is more stable and provides higher return in various stock market conditions, including the sideways trend and downtrend.
Keywords: portfolio management, investment strategy, robustness, strategy optimization.

Introduction

The efficiency of portfolio management of most asset management companies varies significantly from year to year. Portfolio management results of most mutual funds and asset management companies during the latest financial crisis demonstrated a failure of achieving a positive investment return in downtrend market conditions. For instance, the drop in Russian stock indices RTS and MICEX in 2008 affected the assets value of management companies' portfolios. As a result, the return of investment management was negative and reduced the size of the invested assets. Most asset management companies use only positive return investment periods in their ads. As an illustration of this approach, the following marketing technique is often employed. The asset management company provides its prospective investors with the portfolio management efficiency data over a rather long time period without mentioning the prior recession year. Hence, the average return of the mentioned investment period seems to be positive or higher than the average return in consideration of the recession year.

Conventional portfolio management strategies prove to be efficient in the uptrend market conditions. In order to make a positive return during downtrend and the lack of the price directional movement, it is essential to review the portfolio management concepts. On the basis of the efficiency increase analysis of the portfolio management in downtrend and sideways trend, the problem of portfolio management methods optimization becomes topical. During high volatility periods, the solution lays in active portfolio management in terms of the investment problem. The appropriate tools are to be developed for valid choice of strategies and asset management principles of portfolio management strategy development.

Consider the active portfolio management in the context of utilization of trading concepts. During unfavorable price movement at the stock market the portfolio manager has an opportunity to temporarily put assets over in cash or bonds. This might be considered equivalent to opening and closing of a long position in conventional trading, applied to much longer timeframes. To compensate for downtrend or sideways trend, a trading strategy as part of active portfolio management can be used.

The solution of collective investment problems might lie in utilization of trading strategies in portfolio investment management for achieving positive return in mid-term periods during global downtrend or the lack of directional price movement. As analysis of asset management shows, it is not enough to conduct the portfolio diversification for positive return and decrease of risks of capital drawdown Many prefer invest in mutual funds in the hope of return over time, due to expectations of the portfolio asset value increase with time. Classical portfolio management mostly assumes buying stocks and the utilization of "buy-and-hold" strategy. However, nowadays one can conclude that in the mid-term investment period, the operational portfolio assets might be revised and redistributed with the utilization of technical analysis principles, realized in conventional trading strategy algorithm.

The active portfolio management requires the valid selection of the investment strategy and asset management principles. Moreover, one of the major efficiency indicators is stability and positive investment result. This requirement refers to investment results of asset management companies and involves the robustness analysis of utilized investment strategy. In this paper, the problem of the quantitative estimation of the investment strategy robustness is considered as an active portfolio management tool. It is essential to determine which estimates of the robustness can be applied to investment strategies as distinct from the known approaches in the modern control theory and statistics.

There are a number of technological and mathematical tools for the investment strategy development. However, despite the variety of developed systems, many of them do not consistently demonstrate high efficiency over the investment period. The main problem of the investment system design based on technical analysis principles is how to determine the best parameters for the system set of rules [1]. Mostly, efficiency indicators are economic statistics presented as net profit, maximal drawdown, average profit per trade and etc. In most cases, values that demonstrate the higher return on account or other objective are utilized to determine the best conditions of entry/exit position and selected as strategy rules. Constantly, the search of optimal strategy parameters results in the overfitting of the objective function. Especially, that might be if considered system has a lot of rules and parameters of strategy indicators [2].The parameters that were identified as the most optimal in one range of the financial instrument historical data might be not necessarily optimal in another range or other financial instrument. This approach results in unstable performance of the strategy algorithm with identified parameters values in another analyzed set of data or stocks.

Known approaches of the portfolio optimization require additional analysis of the optimization results stability for different time series. Moreover, there is a problem of optimal parameters values alternative and additional criteria for the appropriate estimation of investment strategy testing results. Today there is no valuation technique of the investment result in the context of the analysis of the optimal parameters stability. In such a way, the estimation of the investment strategy should be conducted with the application of the additional criterion of the algorithm efficiency.

The efficiency of the active portfolio management in various conditions of the stock market appears an actual problem. From our prospective, it is essential to develop the method of the investment strategy "stability" analysis for the selection of asset management companyand the investment strategy. The main difficulty of the portfolio management is the stable deposit growth. The criterion of the investment strategy stability is increasingly mentioned among professional traders. One of the major problems of the investment strategy design is the estimation of the investment system robustness. Though there is no specific methodology to identify the robustness of the investment strategy. Today, under the robustness requirement is regarded that the system demonstrates stable performance of the investment strategy algorithm.

Theoretical methods of the automatic objects stability study are widely used in solving various practical problems. The research of the system stability (robustness) is associated with the uncertainty of the object performance and with a variety of unaccounted environment factors. The term robustness is borrowed from the field of the control theory and statistics. It is not clear enough how to apply this criterion for the investment strategy design. In such a way, it is essential first to determine what the robustness means in various fields of social and economic systems.

1. Robustness concepts overview

As analysis of world citation databases shows, starting from the 1990s onwards the exponential growth of publications is observed, concerning robustness issues. In the social and economic domain, there is still no agreed upon definition of robustness and methods of its quantitative determination. According to the dynamics of publications on research of the robustness concept, it is possible to say that currently the research results are presented mostly at the theoretical level. Moreover, the number of articles concerning robustness in social and economic systems is much less than that in engineering sciences. It can be concluded that the robustness research is less mature in the social and economics domain and further development might be expected towards its practical implementation in the next 15 years.

In the papers mentioned in the reference list, the term "robustness" is mostly related to solving optimization problems and decision making, including portfolio management. The concept of "robust optimization" appeared as an attempt of the reduction of parametric and stochastic uncertainties in decision making problems. Decision maker faces the necessity of the specification of the solution, characterized by robust properties. Moreover, it could guarantee some specified value of the objective function or feasible system parameters variability in some range. The main idea of the robust optimal solution search consists in analysis of the most unfavorable alternative whereby the search of the solution is carried out under worst uncertainty parameters level of the system operation [3].

The application of robust optimization provides for the solution which will lie in the admissible range of uncertain parameters in any system model realizations, with the account of uncertain coefficients. In such a way, the search for the objective function optimal solution under given parameters uncertainty enables the system performance to be retained within tolerable limits. The determination of the optimal solution from all obtained values in the optimization problem under specified set of uncertainties enables a valid choice in the decision making process [4].

In [5], the problem of the logistic systems decision-making is considered on the basis of the sensitivity analysis and robust measures. The robustness analysis is the tool for increasing efficiency in the cost estimation of the transport projects. Various approaches to sensitivity and robustness estimation could be employed in decision making support. The robustness estimation is proposed to be performed at the final stage of decision making.

In [6], a logical-and-probabilistic method is discussed for solving problems in social and economic systems. For the purpose of credit risks analysis, the investment and management terms are used, such as "accuracy", "transparency" and "robustness". Stability/robustness is the essential characteristic which expresses the instability of the results obtained with various analysis techniques. The robustness is proposed to be measured as the stability parameters ratio, evaluated during the optimization process, in particular, in credit risk analysis. The author concludes that the proposed logical-and-probabilistic method possesses greater robustness than the known approaches.

2. Optimal strategy: solution surface analysis

The general idea of the robustness properties estimation is based on the requirement of low sensitivity to the uncertainty of various system parameters or environment conditions. In the context of investment strategies, the term robustness means stability of the system expressed in the steady positive deposit dynamics. One of the basic methods of the investment strategy estimation is its backtesting with the determination of all potential deals on the basis of the strategy algorithm and the calculation of major efficiency indicators. The investment strategy robustness assumes that the system applied to various markets, financial instruments and time periods, has a capacity of maintaining efficiency indicators values in some average range.

The robust investment strategy should be that demonstrating low variance of efficiency indicators, instead of achieving higher indicators values. This means that the system maintains stable output under varied parameters values. For instance, Fig. 1 presents the objective functions values of the "moving average cross-over the price" strategy and obtained trading signals depending on the crossing type. For plotting the objective function, daily prices of "Gazprom" financial instrument in 2007–2013 were used. Fig. 2 demonstrates all deals according to this investment strategy with the 30 day simple moving average. Fig. 3 indicates the diagram of the deposit dynamics.

The analysis of the objective function diagram allows to conclude that the investment strategy has chaotic return in various investment periods. This indicates the strategy sensitivity to the financial instrument price dynamics. Consequently, this system lacks the robustness degree.

The major purpose of the investment strategy development is the selection of optimal values. It is possible to construct an objective function for one or several varied parameters of the investment strategy algorithm during the analysis of the investment strategy properties. For the investment strategy optimization problem, the analysis of the objective function properties has to be conducted. It is additionally proposed to introduce constraints on the character of the objective function. These constraints are assumed as quantitative estimates of the smoothness of the solution surface. The robustness estimation of the investment strategy enables to evaluate the sensitivity of the obtained values to the object uncertainty. The intended robustness property consists to a greater extent of the objective function smoothness. The algorithm of the investment system might be tested on several financial instruments, time series samples and ranges of varied system parameters.

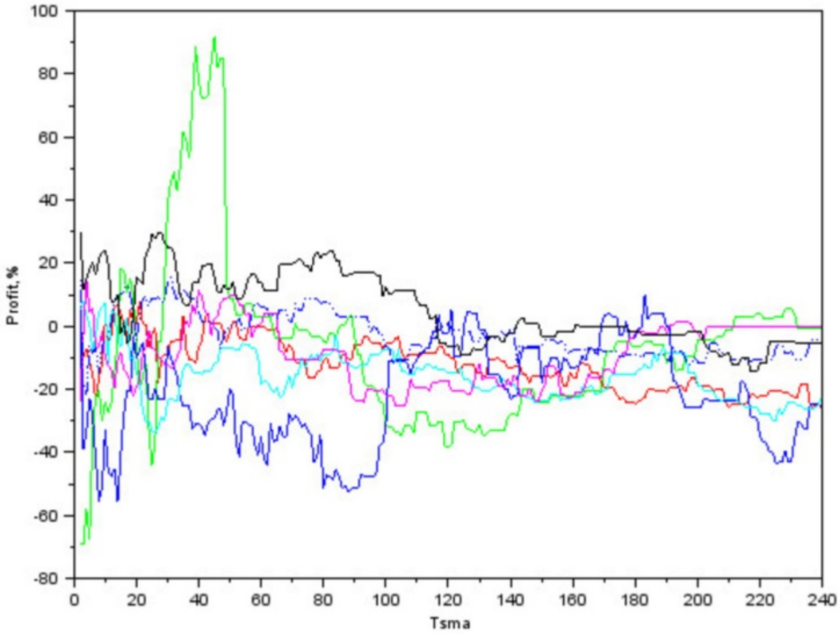


Fig.1. Objective function (annual return) in 2007–2013
Note: each line presents investment results over one calendar year, depending on the smoothing period of moving average Tsma

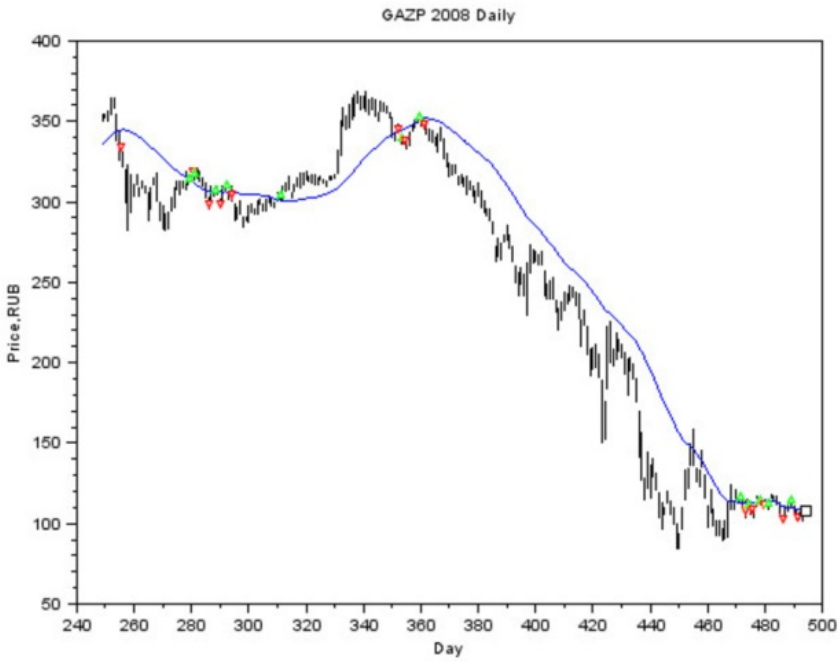


Fig. 2. Investment system realization

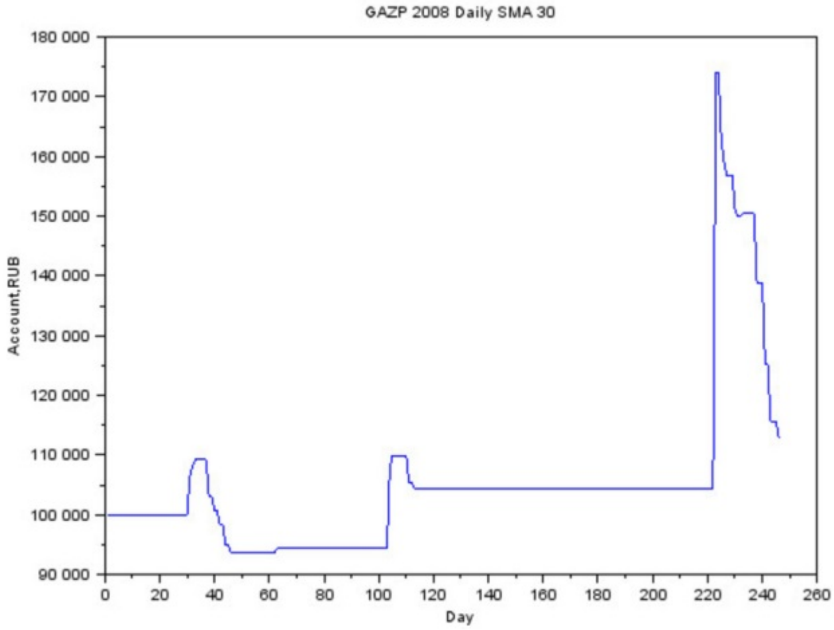
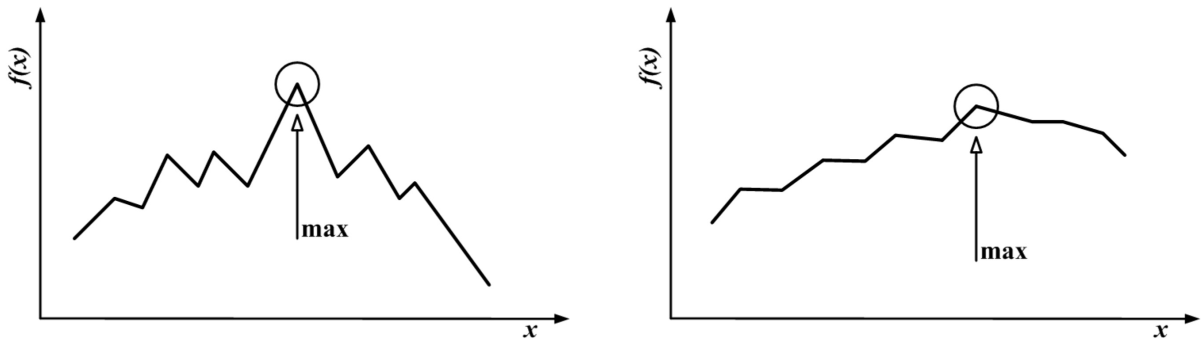


Fig. 3. Deposit change

The surface area can possess various smoothness degrees (Fig. 4). In [7], it is supposed that if the objective function is characterized by larger smoothness (b), then it is usually more stable (robust). This approach to solving the optimization problem of the investment strategy assumes the desired robustness property. However, this requirement is stated in the verbal form. For the correct investment strategy efficiency analysis, it is essential to develop quantitative estimates of this robustness property expressed in terms of the objective function form.



a) Ridge-like objective function

b) Smooth objective function

Fig. 4. The objective function form

In this paper, the research of optimization results is conducted using the analysis of the objective function surface. The objective function surface characterizes the investment strategy performance in several historical data samples with different sets of parameters values. For the comparison of the various investment strategies, the annual return is utilized as the main efficiency criterion.

The optimal solution of the investment strategy parameters cannot guarantee the same deposit dynamics in real investment conditions, as compared to the previous investment period. Therefore, one of the most essential stages of the optimization process is the validation of the obtained optimal parameters values using another sample. According to the analysis of the validation set testing results, it is possible to say that obtained parameters are useful and efficient in various market conditions. In this paper, the major idea of validation set testing is the determination of the objective function surface characteristic.

For the property investigation of the objective function, it is necessary to conduct the analysis of the return diagrams. The visual analysis on quantitative level gives only a general concept of the objective function form because of the following. First, investment strategy efficiency indicators are evaluated for a discrete set of parameters values. The second reason is the high complexity of the investment strategy testing process with different parameters values combinations, particularly in case of the necessity of manual run of the system rules sets with specified parameters. For this problem, the expression for the objective function in analytical form is a challenging task.

In such a way, the utilization of investment strategies as the active portfolio management tool assumes periodical review of strategies and the determination of optimal parameters in the return maximization or the deposit drawdown minimization problem. Also, the search for the optimal investment strategy with various parameters combination is a time consuming process. Consequently, for the optimization of the ill-formalized investment strategy algorithm, it is necessary to select carefully varied parameters, in order to decrease the complexity down to an acceptable level.

3. Robustness measure development

In the paper, two investment strategies based on technical analysis are considered as the tool for active portfolio management, namely visual-graphical analysis (VGA) and moving averages crossover strategy (MAC).

VGA is a trend-following investment strategy based on breakout and bounce of the price. The main concept lies in drawing the price trajectory for the instrument, drawing of trend/channel lines and support/resistance levels, followed by the identification of the most optimal moments of buying/selling securities (Fig. 5).

The parameters affecting the price trajectory of financial instrument are the following:

– the number of candlesticks, M;

– the price range at each side of local extremum, N, %.

The parameters for the identification of the most optimal investment moments:

– the width of the support/resistance level zone L, % ($L/2$ % at each side of the price local minimum);

– the price filter P, %.

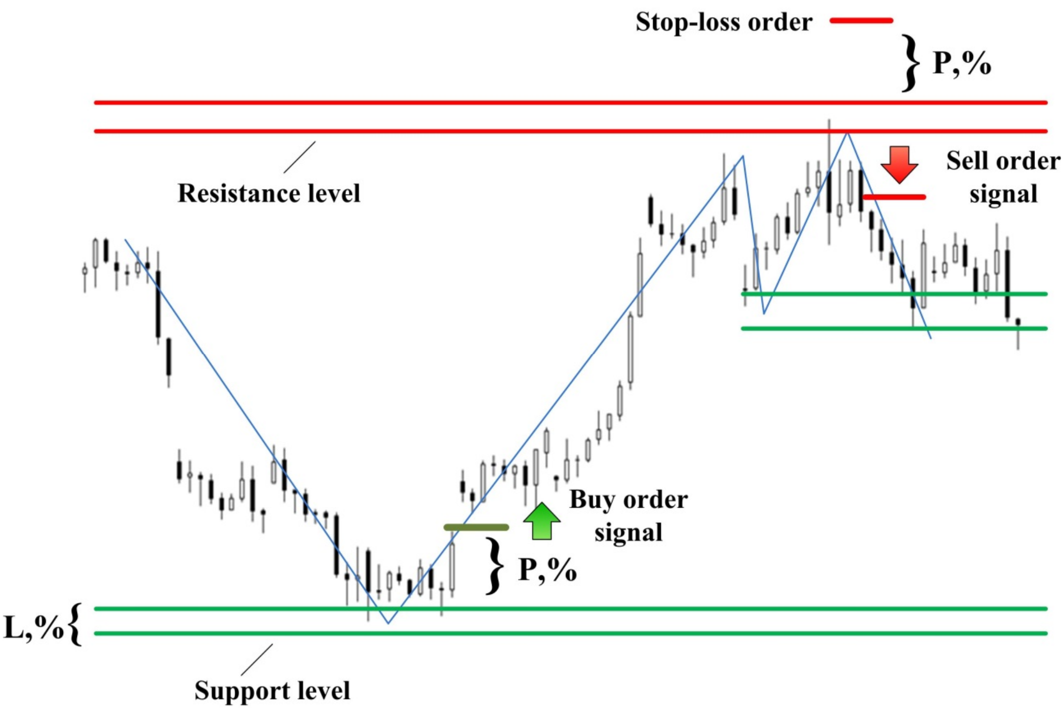


Fig. 5. Investment strategy based on visual-graphical analysis

The analysis of the optimization results is the essential part of the investment strategy development in the context of the robustness estimation. The main difficulty of the strategy parameters optimization is the representation of investment strategy rules as the formalized algorithm for its implementation in strategy testing and optimization software. For instance, the VGA investment strategy is conducted using computer-aided procedures as distinct from fully automatic systems (trading robots), based on the application of technical indicators values. In this case, the testing and optimization process for the computer-aided investment strategy requires a large amount of manual operations for each run (iteration). Consequently, it is important to select most significant parameters for strategy optimization.

The selection of investment strategy parameters is based on the major strategy rules producing trading signals. The VGA strategy parameters to be optimized are as follows: $\{x_1 = M,\ x_2 = N,\ x_3 = L,\ x_4 = P\}$. The most significant parameter of the VGA strategy is the price filter P, utilized in the determination of the order price a position and, consequently, this parameter affects the profit. Also, the price filter is applied for the closing position and influences the capital drawdown in the protective stop utilization. The size of the support/resistance level L is utilized in the determination of the order price and the price filter plotting from the support/resistance level boundary.

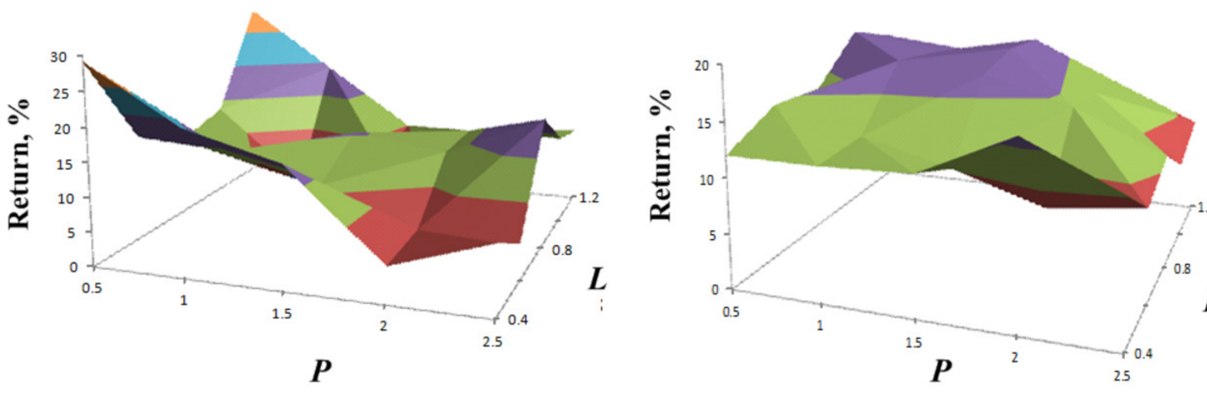
The considered moving average crossover strategy uses the exponential moving average of the stock closing price. Varied parameters of this investment strategy are the smoothing periods of the fast (*Tf*) and slow (*Ts*) moving averages. For the order price, the investment signals are affected by the smoothing period value. In such a way, these signals impact both the expected profit and the deposit drawdown.

The shape of the solution surface (objective function) characterizes the investment system performance with different set of parameters values in several historical data samples, see Fig. 6, 7. For the comparison of the investment strategies efficiency, the annual return was used. The value of the objective function reaches its extremum under given constraints in the investment strategy parameters testing.

Consider the quantitative estimation of the objective function smoothness degree. In exhibits 6–7, the objective function diagrams (annual return) present results of the optimization of VGA and MAC strategies with two varied parameters in 01.02.2012–30.04.2012 (sample I) and 01.09.2012–30.11.2012 (sample II).

Qualitative characteristics of the algorithm robustness (the objective function smoothness) might be examined visually by diagrams. For the quantitative validation of one or another investment strategy, it is essential to estimate the investment strategy testing results in various time ranges over normalized values.

The quantitative estimation of the investment strategy robustness is based on the smoothness degree of the objective function, which can be considered as the finite-difference measure of the function derivative.



Sample I Sample II

Fig. 6. Objective function of VGA strategy in samples I– II

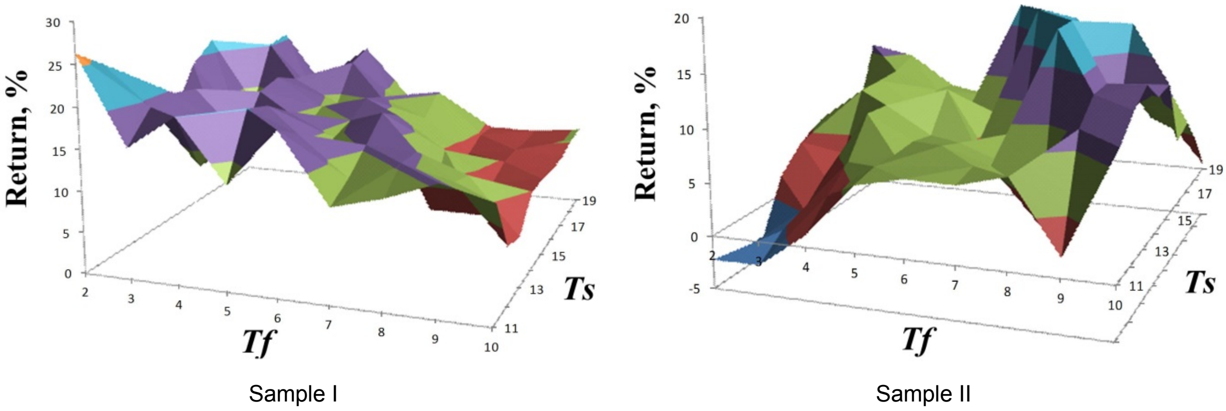


Fig. 7. Objective function of MAC strategy in samples I– II

The smoothness degree evaluation of the objective function is characterized by the following estimate:

$$I_{sm} = \overline{\left\{ \sqrt{\left(\frac{\Delta S x_1}{\Delta x_1}\right)^2 + \left(\frac{\Delta S x_2}{\Delta x_2}\right)^2} \right\}},$$

where I_{sm} is mean gradient modulus (finite-difference equation), Δx_1 and Δx_2 are the increments of arguments, and $\Delta S x_i$ is the increment of the function.

After the smoothness degree indicator has been evaluated with normalized values of strategy parameters in each sample, the objective function smoothness estimates in samples I and II are calculated. On the basis of the objective function smoothness estimate of the considered VGA and MAC investment systems, the following values of I_{sm} are obtained (Table 1).

Table 1

Results of objective function smoothness degree estimation of VGA and MAC

	VGA	MAC
Sample I	155,4	711,24
Sample II	46,55	704,95

The results of the objective function smoothness calculation indicate that VGA strategy is characterized by higher robustness than MAC strategy. Larger values of the smoothness degree of MAC strategy in comparison to VGA demonstrate that the inclination of the objective function is greater, consequently, the objective function surface is less gently sloping than the VGA surface. This conclusion is supported by visual analysis of the objective function diagrams in both samples of considered investment systems (Fig. 6, 7).

4. Investment strategy efficiency validation

For the robustness analysis of the investment strategy optimization results, simulation software tools were utilized such as Metastock and Matlab. Source data are daily market prices of “Gazprom” financial instrument in 2011–2013. Assume that in mutual funds management, short sell orders are not allowed. Only long positions deals were considered for the simulation of the investment strategy performance. For the estimation of the efficiency of the investment strategy and the robust estimate utilization, the algorithm of VGA strategy is analyzed with the optimal parameters values. Fig. 8 demonstrates all deals during the investment period along with some basic statistics in 2013 (Table 2).

Table 2

Modeling results of visual graphic analysis investment strategy in 2013

№	Date	Deal type	Price, rub.	Quantity	Investment result, RUR 000's
1	24.04.2013	open “long”	121,0185	41316	
2	13.05.2013	close “long”	129,0941		333,65
3	25.06.2013	open “long”	108,1381	49322	
4	19.07.2013	close “long”	129,0941		1033,6
5	05.09.2013	open “long”	136,3044	46713	
6	13.09.2013	close “long”	143,0417		314,72
Total					6681,983
Annual return, %					33,64

Data source: MOEX quotations.

Profitable portfolio management during sideways and downtrend conditions requires additional tools for the determination of short-term moments of stock price increase during the global trend. For instance, year 2013 is characterized generally by the sideways trend. However, there was a mid-term uptrend during July through October. The active portfolio management in this case would include periodic revision of the portfolio every six months. As a result, the proposed investment strategy demonstrated the stable deposit growth, as compared to the “buy-and-hold” one.

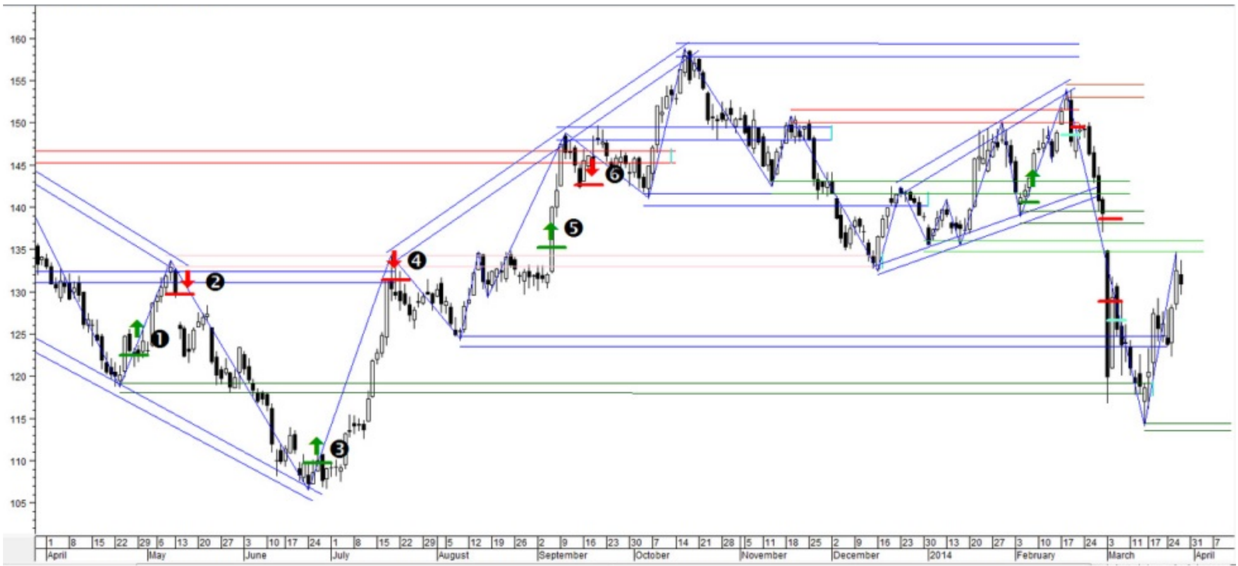


Fig. 8. VGA investment strategy deals (2013)

Table 3 presents the investment results of VGA strategy and the annual return as the major efficiency indicator.

Table 3

VGA strategy investment results (2011–2013)

Year	Annual return (AR), %	Number of trades	Trend direction
2011	86,67	10	downtrend
2012	34,74	6	downtrend
2013	33,64	6	sideways trend

The analysis of the simulation results leads to the conclusion that the investment system possesses robustness, which resulted in the positive deposit dynamics. The annual returns in 2011, 2012 and 2013 investment periods differ due to the trend direction. In the conventional portfolio management, this would result in investors’ losses.

Conclusion

The problem of active portfolio management has been considered, with the emphasis the robustness property of the objective function (annual return). Concerning mutual and pension funds, only long deals are taken into account, performed on the basis of mid-term portfolio revision. The desired robustness property is proposed to be characterized with the solution surface smoothness. MOEX-based examples demonstrated positive return, even during the sideways and downtrend periods, as opposed to the conventional buy-and-hold strategy. This makes the emerging markets, such as BRICS, more attractive investment tools, when combined with active robust portfolio management. One should also take to account the volumes of shares circulating at the exchange, in order to avoid market manipulation situations.

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МЕРА РОБАСТНОСТИ СТРАТЕГИИ УПРАВЛЕНИЯ ПОРТФЕЛЕМ

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Представлен практический подход к оценке робастности инвестиционной стратегии. В качестве количественной меры робастности предлагается использование степени гладкости целевой функции. После проведения оптимизации стратегии необходимо учитывать дополнительный критерий при выборе стратегий, обладающих лучшими показателями робастности. Применение количественной оценки позволит выбрать лучшую стратегию по результатам анализа эффективности инвестиционных стратегий. Данная стратегия более устойчива и обеспечивает более высокую доходность в различных условиях фондового рынка, включая падающий и боковой тренды.

Ключевые слова: управление портфелем, инвестиционная стратегия, робастность, оптимизация стратегии.

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