Formation of the Investment Portfolio on the Basis of Adaptive-Discrete Model, Considering Globalization Effects

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Abstract*: The need to reflect the effects of globalization in portfolio investment models is currently beyond doubt. The problem is that these effects are of both continuous and discrete nature. To reflect their joint influence on the investment decision, it is proposed to use an adaptive regression modeling device. The versatility of the adaptive adjustment of the coefficients of econometric models provides the ability to reflect in the portfolio investment model discrete-continuous effects. Computational experiments with a model that implements the proposed approach to the formation of investment decisions in the context of globalization have shown a significant preference for the resulting portfolio solutions compared to the classical ones.

***Keywords* : securities portfolio, globalization, forecasting, adaptive modeling, discrete choice model, adaptive-discrete model.**

I. INTRODUCTION

Globalization determined new branch in development of stock markets. Now they regulate not only effective functioning of the real sector of economy, but also realize it's own self-sufficiency by creating new market instruments, increasing significantly of investment opportunities and hedging strategies, as well as growing variety of all kinds of risks. Appearance of new opportunities and unknown earlier risks makes new tasks for investors. The solution of this tasks is very important, since the stock market is still attracted by the fact that it provides a chance to increase their prosperity.

The globalization factor organizes mainly by western centers of the economy, and the effects of globalization manifest themselves in national markets. So, in this way, it is a reflection of the fact, that work of globalization effects if diversified across national markets. At the same time, the modern theory of portfolio investment in its models does not provide mechanisms that can fully reflect this heterogeneity adequately. First of all, this problem concerns the youngest Russian stock market. One of the ways to solve this problem is a development of the methodological tools for building of investment portfolio, taking into account the effects of globalization and which has adaptive property of predictor optimality.

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II. THE GRADE OF THE PROBLEM DEVELOPMENT

Since the middle of the last century, the problem of forming a securities portfolio has been permanently relevant. The foundations of portfolio investment laid by G. Markowitz (1952), W. Sharp (1963), J. Lintner (1965), J. Tobin (1965) and other famous scientists have been developed, in particular, thanks to the efforts of domestic researchers such as A.N. Burenin (2008), V.V. Davnis&M.A. Ziroyan & V.I. Tinyakova (2017), V.I. Shiryaev (2009), L.P. Yanovsky&S.N. Vladykin (2009) and others.

The possibilities and advantages of an econometric approach to the building of investments portfolio were convincingly demonstrated in the dissertation works of E.A. Akopyan (2008), S.V. Bakholdin (2012), E.R. Vartanova (2009), V.V. Korotkikh (2016), M.A. Martynova (2009), E.A. Ratushnaya (2010), O.V. Timchenko (2012), D.A. Khabibulin (2010). Besides that, the results obtained by this works indicated the necessity and prospects for the implementation of the idea of building of security portfolio on the basis of predictive estimates of their profitability.

The globalization of financial markets has also contributed to the emergence of new approaches to portfolio investment, in which it is proposed to take into account the effects of globalization formally. The results of development of such approaches are indicated in the works of V.V. Davnis &M.A. Ziroyan&M.V. Vladyka&E.N., Kamyshanchenko, V.I. Tinyakova (2015), T.V. Karyagina&M.V. Lebedeva&V.A. Fetisov (2015), V.I. Tinyakova&A.N. Maloletko &O.V. Kaurova&M.V. Vinogradova &A.A. Larionova (2017)/

Compliance of the adequacy requirements of the mathematical apparatus used for building of investments portfolio matching modern globalization environment makes actual the development problems. Within the framework of this problems it's possible to take into account not only the current, bit also the expected effects of globalization. One of such promising approaches can be considered adaptive modeling due to the well-known ability of adaptive models to reflect the dynamic

properties of predicted time series.

This research focused on the development of an adaptive-discrete model for predicting the effects of globalization and the building of a investments portfolio on this basis, which fundamentally distinguishes it from the work of other authors.

III. METHODOLOGY FOR CONSTRUCTING A PORTFOLIO INVESTMENT MODEL BASED ON AN ADAPTIVE-DISCRETE MODEL

The basic idea of building the proposed portfolio investment model is to use not single-index regression models in the well-known Sharp model, but regression models with an adaptive mechanism. In this case, the model becomes dynamic, because the usage of an adaptive mechanism, makes possible to show the expected changes in the patterns of the observed stock market processes, taking them into account when building a portfolio makes possible to endow it with the predictor's optimality property.

By predictor's optimality we intend the situation, where the portfolio does not have optimal properties at the current time, but it provides for these properties for the predicted future.

It is clear that the reliability of the optimal properties of the predictor portfolio is largely related to the reliability of those predictive models, on which basis was built this portfolio. That's why much attention is paid to the possibilities of an adaptive approach to forecasting when implementing ideas for building a predictor portfolio.

According to the plan, a portfolio with the predictor optimality property should bring higher returns than the traditional optimal portfolio in the future. However, there are questions that require further additional researches. First of all, it concerns calculations related to the value of risk. It is known that in the Sharp diagonal model, the risk is divided into two components, one of which shows the total risk of the assets included in the portfolio, and the second shows the market instability, weighted by the square of the portfolio beta/ An interesting question is about comparing of predictive portfolio with a traditional portfolio by the value of risks.

The portfolio's own risk is determined on the basis of the residuals obtained for the corresponding regression equations, which characterize the dependence of the asset's profitability on the average market profitability.

Normally, adaptive models has less value of the residuals than ordinary regression. That's why, we can assume that this component of risk in a portfolio with predictor optimality will always be lower on average than the optimal traditional portfolio has.

We cannot make such a conclusion about the second component of risk in the general case, but the logic used in its construction of the adaptation concept suggests that models, where the indication of recent trends are more preferred, will provide a more accurate identification of expected risks.

It should be noted that the primary importance in developing of an adaptive version of the investments portfolio (Bakholdin S., 2012). was transmitted to the issue of forecasting the index, which, in fact, was a factor in adaptive regression models of financial assets profitability.

That's why, in fact, in previous researches the index was also present in the approach, which we have developed, and it remains the main factor of reconfiguration of regression models to the expected patterns in the future. That means that the reconfigured coefficients of the models will have values that are relevant for the anticipating period, thereby ensuring the predictor optimality of the portfolio. That's why, the success of the implementation of the whole idea of building an adaptive portfolio with predictor optimality depends on the reliability of the forecast estimates of the index.

Building of an adaptive portfolio in context of globalization to a certain extent is intended to pursue the same goals as building an adaptive portfolio without considering the effects of globalization/ This building requires for its implementation a higher level of understanding of modern market processes, the usage of new models that indicate this understanding, as well as the involvement of a more complex modeling apparatus.

To show the synergistic effect of globalization it is proposed to use the main components (Davnis V.V.& Kasatkin S.E. &Ardakov A.A., 2012). Moreover, when building an adaptive model of portfolio investment, the main components must be used twice: in determining anticipatory calculated values of return on each financial asset included in the portfolio, and in estimating the expected value of the same return. A natural question arises about the difference between the calculated predictive value and the expected one, which, in fact, is also a predictive one.

In our opinion, the main difference is a basis of the approaches models used for calculation of this quantities. The case when these calculated values may coincide is not excluded. The necessity to use different conceptions in identifying future values is primarily due to the different nature of these quantities, which, according to the logic of modeling, should be indicated in the corresponding models.

In our research, the role of the adaptive mechanism, in a sense, has gained an explicit expansion of its usual purpose. As a rule, the newly received observation of the predicted indicator is used as a target value in the tasks of adaptive forecasting, but the character of the newly received observation in most cases is not taken into account in the model. Consequently, data of any character, including the expected values, can be used as a newly arrived observation, At the same time, no changes are made to the model or to the algorithm implementing the calculations for this model. At the same time any changes model or to the algorithm implementing the calculations for this model were made to the model or to the algorithm implementing the calculations for this model doesn't includes.

It was obtained that using the adaptive mechanism, the effect combines of the predicted and expected values occurs when the structure of the coefficients of the regression model changes. Thus, due to its universality, the adaptive mechanism, in our opinion, in an absolutely correct way provides the possibility of such combination.

Naturally, the question arises about the proportion where the model indicates the deterministic component of growth and the probability component of subjective expectations. There are special parameter in the adaptive model for solution of this problem,

which allows you to adjust the effect of the newly received observation on the model change. In a standard situation, this parameter is adjusted so that the prediction error would be minimal. The prediction error is estimated on data of a specially prescribed down-coming period.

For the considering case, the idea of a post anticipatory period is quite appropriate, but a question arises, the meaning of which is as follows. If to build a Sharpe model to use regression equations that predict well the artificially created future, will the portfolio built with such models ensure the highest possible profit. There is no clear answer about this. But the idea of using an artificially created future in the form of a post-anticipatory period to tune the optimality of an investment decision as a whole can be considered quite acceptable.

It is clear that the dependence of adaptive regression equations on a custom parameter is automatically transferred to the portfolio investment model. Therefore, we need a new criterion for optimal adjustment of the adaptation parameters. In our case, the natural criterion for the optimal setting of the parameter is the level of portfolio profitability, which is determined for the post-ahead period. This possibility is quite feasible, but in general the problem of optimization of the parameters of adaptation is multidimensional, with no analytical solution. Therefore, avoiding the direct enumeration of possible options, we will transform the task from multidimensional to one-dimensional, assuming that all models have the same adaptation parameter adjusted by the portfolio return level for the post-ahead period.

Clarifying the character of anticipatory values, first of all, we note that in our perspective the predictive estimate is the result of adaptive, but still deterministic modeling using weighted averaging of the sample, allowing to reproduce the pattern that flows into the future, in which the dynamics of the last historical period prevails. And the expected value is a value with probabilistic character of its own possible value, which is identified according to the conditional frequency of occurrence of these values.

Both in the first and in the second case, the obtained values refer to the future period and therefore can be obtained using special models only. To apply these special models, which provide both predictive and expected values, it is necessary to have a proactive value of the main components, which means that another model, the model predicting the values of the main components, is an important part in our calculations.

The development of such a model which would provide the possibility of obtaining predictive estimates of the main components, was carried out in the work (Tinyakova V.I. & Miroshnikov E.V., 2019). The peculiarity of the forecast calculations of the main components is that they provided for the implementation of a systemic balance of forecast estimates for each variable from the set for which the main components were built.

In case, when for building of models of portfolio investment we have to use the ideas that are embedded in the diagonal model of Sharpe, then we need to build primarily regression equations that indicates both components (predictive and expected), based on the values used for making ideas about the future.

Turning to the study of the properties of the portfolio investment model needed to obtain predictor optimal solutions, we first note that the single-component diagonal model of optimal portfolio investment has the same structure as the single-index diagonal Sharpe model and, therefore, can be written in the same way:

$$\boldsymbol{w}_{n+1}^{'}\boldsymbol{\Sigma}_{d}\boldsymbol{w}_{n+1} \quad (1)$$

$$\boldsymbol{w}_{n+1}^{'}\boldsymbol{\alpha}_{n+1} = \mu \quad (2)$$

$$\boldsymbol{w}^{'}\boldsymbol{i} = 1 \quad (3)$$

$$\boldsymbol{w}^{'}\boldsymbol{\beta} = w_{n+1}\,, \quad (4)$$

where $\boldsymbol{\Sigma}_{d}$– is a diagonal matrix with elements from the residual variances of one-component regression equations, except for the latter, which is equal to the variance of the main component;

$$\boldsymbol{w}_{n+1}^{'}\boldsymbol{\alpha}_{n+1} = \sum_{i=1}^{n} w_i\alpha_i + (\sum_{i=1}^{n} w_i\beta_i)\bar{r}_g = \sum_{i=1}^{n} w_i\alpha_i + w_{n+1}\alpha_{n+1} = \sum_{i=1}^{n+1} w_i\alpha_i$$

,

w_{n+1}– portfolio beta, defined as follows from the previous expression, in the form of a weighted amount of regression coefficients.

Model (1) - (4), in contrast to the diagonal model of Sharpe, allows building portfolios of securities, taking into account the effects of globalization. The adequacy of the reflection of the real market situation in investment decisions obtained using such a model is greatly enhanced. Obviously there is no alternative to this statement. Nevertheless, taking into account the effects of globalization can turn this model into a working tool for the formation of optimal investment decisions - this hope cannot be considered successful. First of all, this is due to the fact that it does not indicate the orientation of the pre-emptive period. It maintains its optimality till the trends of the past prevail in market processes. However, the high volatility of market processes normally makes such predominance short-term.

Any tries to find an answer to this remark in the recommendations providing for the use of forecast estimates in this case is useless. The problem is that during the building of diagonal model of portfolio investment, it's used not the data about the return of assets included in the portfolio, but the coefficients of the regression models describing the interaction of market processes.

If we omit the requirements for accuracy, the profitability of assets can be considered to the predicted value. That's why, if there was a question about obtaining forecast estimates of profitability, then the direction of searching for an answer to this question is quite obvious, but the Sharpe model does not use asset returns, but regression equation coefficients, which should be such as to ensure the predictive ability of the corresponding equations.

In fact, it is required the coefficients would be estimated with a focus on improving the accuracy of predicting the latest observations or the expected values of the return of assets in the stock market. This possibility appears only when using an adaptive

regression modeling apparatus.

Improving the accuracy of prediction of recent observations can be considered like a standard procedure for adaptive modeling. Its implementation is based on exponential smoothing, which ensures that old trends are forgotten.

In this case, we have the goal, which involves tuning the prediction accuracy of the expected value, which has not been determined yet. Obviously, the answer to this question can be obtained in the framework of the proposed integrated approach, which involves the construction of auxiliary models.

So, using these components, the values of 2 factors are formed, which on the other hand, are used like independent variables for constructing of two-factor logit models of the binary choice of each asset.

$$P_{it} = 1/(1+\exp(d_{0i} + d_{1i}\, r_{g_1 t} + d_{2i} r_{g_2 t})), \quad i = \overline{1,m}, \qquad (5)$$

Simultaneously used like independent variables of an adaptive linear prediction model of the same assets that are included in the portfolio

$$r_{it} = b_{0i}(t) + b_{1i}(t) r_{g_1 t} + b_{2i}(t) r_{g_2 t}, \qquad i = \overline{1,m} \qquad (6)$$

$$\boldsymbol{b}_i(t+1) = \boldsymbol{b}_i(t) + \frac{C_{it} r_{gt+1}}{r'_{gt+1} C_{it} r_{gt+1} + \alpha} (\check{r}_{it+1} - \hat{r}_{it+1}) \qquad (7)$$

$$\boldsymbol{C}_{it+1} = \frac{1}{\alpha}\left(\boldsymbol{C}_{it} - \frac{C_{it} r'_{gt+1} r_{gt+1} C_{it}}{r'_{gt+1} C_{it} r_{gt+1} + \alpha}\right). \qquad (8)$$

where r_{it} – the value of the return of *i*-th asset at time *t;*

P_{it} – the probability that the profitability of the *i*-th asset at time *t* is not negative;

d_{ki} –*k –th* coefficient of the binary choice model of the *i-th* asset;

$b_{ki}(t)$ – *k –th* coefficient of linear adaptive model of *i*-th asset at the moment of time *t*;

$\boldsymbol{b}_i(t)$ – the values of the coefficient vector of the adaptive model of the *i*-th asset at time *t*;

$\boldsymbol{C}_{it}$ –the matrix inverse to the matrix of the system of normal equations with the values obtained up to time point *t*, and used in the calculations of the current regression coefficients in the adaptive algorithm;

$\hat{r}_{it+1}$- forecast estimate obtained using an adaptive model, the coefficients of which are determined for time *t*;

$\check{r}_{it+1}$ – an estimate of the expected return, the value of the mathematical expectation, in the calculation, where the probabilities of a positive return of the *i*-th asset at a proactive moment of time were used;

The peculiarity of this adaptive model (5) - (8) is that it is focused on obtaining a solution that differs from the traditional one. This feature has been discussed above. Here we will make clarifications on the example of the written out model. Normally, an adaptive model provides the changes in the coefficients of the model in accordance with the changes occurring in the actual process. These changes are indicated by the difference between the newly observed value and the value calculated by the model reflecting past trends.

If the calculated values differ from those actually observed, the model is adjusted in proportion to the forecast error. In our model, the difference r˘_ (it + 1) -r^_ (it + 1) between the expected value and the predictive estimate is considered. The adjustment of the model is carried out precisely in proportion to this difference. We can make this adjustment due to the fact that the adaptive mechanism is universal and retains its ability to adjust the model regardless of the meaning of the deviation used. This possibility in mostly interested for us in developing approach.

The flexibility of the adaptive mechanism makes it possible to implement: not only the tracking process behind the dynamics of the simulated indicator, but also to combine various options for predicting the future. The necessity of combination is clearly exists in the process of building a securities portfolio with predictor optimality, formulated by us.

We propose to use an adaptive-discrete model for this purpose.

$$\check{r}_{it} = a_{0i} + a_{1i} r_{it-1} + \sigma_i [2P_{it} - 1], \quad i = \overline{1,m} \qquad (9)$$

where $\check{r}_{it}$ – the expected value of the return of the *i*– th asset at time *t;*

a_{0i} , a_{1i} – coefficients of the autoregressive model of the *i*-th asset;

σ_i – the root-mean-square value of the residues of the autoregressive model of the i–th asset;

P_{it} – the probability that at time *t* the return of the *i*¬th asset will be positive.

IV. THE RESULTS OF EMPIRICAL RESEARCHES

In accordance with the above mentioned methodology, there were conducted empirical researches. The empirical base of the research was data for the period from 01.07.2018 to 29.12.2018 about the stock prices of five Russian companies (Gazprom, Sberbank, SurgutNefteGaz, Lukoil and Rosneft) and stock index dynamics: US Dow Jones, French CAC-40, German DAX, English FTSE 100 and Russian RTS. It should be noted that this choice of companies in the oil and gas and financial sectors of the economy is explained by the fact that, for obvious reasons, their shares are rather closely related to foreign stock markets.

The results of the researches are indicated in the table.

Table 1: Results of the empirical researches

Lukoil	Gazprom	Rosneft	Severstal	Sberbank	Return	Return for 5 years	Risk	Risk per unit of return

PORTFOLIOS WITH THE LINEAR MODEL						PREDICTOR VALUES		
0.1533	0.3648	0.2312	0.2656	-0.0149	0.1	2.7577	2.2366	0.8110
0.2433	0.0882	0.0559	0.1240	0.4885	0.2	2.3450	1.8960	0.8085
0.3333	-0.1883	-0.1194	-0.017	0.9920	0.3	1.9323	1.5779	0.8166
PORTFOLIOS WITH AN ADAPTIVE MODEL						PREDICTOR VALUES		
0.1254	0.4758	-0.0418	0.5512	-0.1107	0.1	4.5504	3.6608	0.8045
0.0616	0.0728	0.0996	0.7415	0.0245	0.2	5.7803	4.6349	0.8018
-0.0020	-0.3303	0.2411	0.9318	0.1596	0.3	7.0101	5.6138	0.8008

Analysis of the results of the calculations shows that the adaptive approach allows you to create portfolio investment decisions in the context of globalization, which significantly exceeds the level of profitability non-adaptive portfolio solutions.

V. CONCLUSION

The article implements the idea of usage of universal properties of an adaptive regression modeling procedure in the processes of making investment solutions with predictor optimality. The necessity of using of universal properties is that the same value in the stock market can be predicted on the basis of inertial changes, and on the basis of discrete, discontinuous. The desire to turn these possible options into the only correct solution focuses on the result obtained as a combination of possible options. An effective tool for this, as shown in the article is an adaptive procedure for adjusting the coefficients of regression equations in case of changes in the operating conditions of the simulated process.

The obtained results of the calculative experiments has fully confirmed the validity of this point of view. It is possible that other options for using the universal properties of the adaptive approach will be useful while solving problems that require an integrated approach.

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