11th IEEE International Conference

www.aict.info/2017

AICT 2017

INTERNATIONAL CONFERENCE

APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES - AICT2017

20-22 September 2017, Moscow

CONFERENCE PROCEEDINGS

20-22 September 2017, Moscow, Russia

www.aict.info/2017

11th IEEE International Conference

www.aict.info/2017

AICT 2017 INTERNATIONAL CONFERENCE

APPLICATION OF INFORMATION AND COMMUNICATION TECHNOLOGIES - AICT2017

20-22 September 2017, Moscow

CONFERENCE PROCEEDINGS

2017 IEEE 11th International Conference on Application of Information and Communication Technologies (AICT)

IEEE Catalog Number: CFP1756H-PRT
ISBN: 978-1-5386-0500-4

Additional copies of this publication are available from
Curran Associates, Inc.
57 Morehouse Lane
Red Hook, NY 12571 USA
+1 845 758 0400
+1 845 758 2633 (FAX)
email: curran@proceedings.com

IEEE Catalog Number: CFP1756H-PRT
ISBN: 978-1-5386-0500-4

2017 IEEE 11th International Conference on Application of Information and Communication Technologies (AICT) is financially supported by the Russian Foundation for the Basic Research, proiect #17-08-20518.

RFBR

RUSSIAN
FOUNDATION
FOR BASIC
RESEARCH

The Stability Assessment Model of Financial and Economic Indicators

Alexander Mandel
M.V. Lomonosov State University,
Trapeznikov Institute of Control Sciences RAS
Moscow, Russia
almandel@yandex.ru

Natalia Sizykh
National Research University Higher School of Economics,
Trapeznikov Institute of Control Sciences RAS
Moscow, Russia
sizykh_n@mail.ru

Dmitry Sizykh
Trapeznikov Institute of Control Sciences RAS
Moscow, Russia
d.sizykh@gmail.com

Abstract: It is proposed the model for computation of the stability ratio of financial and economic indicators, which allows take into account the change depth of the analyzed indicator in time (periodicity, duration and magnitude) and interrelations of its values within the considered time period.

***Index Terms* — dynamic data series, financial indicators, economic indicators.**

I. Introduction

The effectiveness of financial and economic decisions is greatly influenced by consideration of various qualitative characteristics of the analyzed indicators and processes. For example, quality indicators are ever more needed when making decisions in management of companies, industries, investment processes, etc. When selecting companies for investment, investors use not only indicators of profitability and risk, but also different indicators of management quality, risk, stability of financial performance and so on. A large set of quality indicators are used by rating companies. Quality indicators can be either part of the main set of decision-making tools, or a supplementary measure. The majority of quality indicators have a fairly clear quantitative form.

Actuality and relevance of various quality indicators used promote continuous improvement of the methodology for evaluation and development of new indicators. In this paper the model is proposed for evaluation of the stability of variation of dynamic performance indicators (dynamic model of interrelated indicators), which takes into account all time variations of the analyzed indicators, their relationship and hierarchy in the considered time interval. Most financial and economic indicators can be considered as dynamic series. Therefore, the stability factor of changes in dynamic indicators (increase, decrease, stability in time, etc.) can be used in making financial and economic decisions.

II. Modern Methods for Evaluation and Analysis of Dynamic Data Series

Practical experience in managing financial and economic systems prompts that the most accurate results can be received using dynamic parameters, which characterize features and activities of the analyzed object, the effect of various causal relations, internal and external factors. In practice, a number of dynamic indicators are used to obtain different statistical estimates in terms of growth, variation, average indicators and so forth [1,5]. However, methods used for estimating these indicators do not account for consecutive interrelation of analyzed values in dynamics, the "history" of variation of the analyzed values. This paper proposes an additional qualitative indicator for estimating the dynamic variation of the analyzed indicators.

Nowadays there are various methods for analyzing data series, i.e. data sequences that include indicator values for the consecutive time periods [3,4]. It is established that as a measure of the volatility of the series of data, one can use the Hurst index [9]. The main direction for analysis of dynamic data sequences consists in the evaluation of the "stability" of numerical values of these data. There are two aspects of the stability concept: the variability and direction of variation in the data series (a trend). Variability is measured by standard deviation and variation. Variations in the data (time) series are estimated using absolute and relative values (absolute growth/fall, acceleration of absolute variation, growth rate). In addition, basis and chain values are calculated. One of the data series is taken as the base, with which other data series are compared. In chain values, each dynamic data series is being compared with the previous data series. It is indicated that both stability indicators are in direct correlation: the lower rate of variability is characterized by greater stability [4,5].

The above methods are static by nature. The method is proposed for evaluating the stability of data series variation, which combines evaluation of both, basic and chain, values and at the same time, characterizes the trend in terms of stability of variation of data series values. The purpose of the indicator is to evaluate the stability of variation of data series: growth, fall, sustention and growth, sustention and fall, or maintaining the data series values at a constant level. The proposed model is inherently based on comparison with the reference [7,13]. For more details, see the model in Section 3 of this paper. The received ratio reflects the qualitative evaluation of variations stability of the dynamic data series and it can be used in conjunction with known indicators.

Let us consider proposed model of evaluation the stability of dynamic indicators variation, applied at financial and economic decision-making on an example of analysis of one and several interrelated indicators. It necessary to note that all currently existing methods for analysis of share price movement take into account the share price change only in comparison with the previous value, but in this approach, is not taken into account the depth of share price increase or decrease within the observable period of time [1,2,5].

III. The Model for Evaluation of Variation Stability of Dynamic Single-Factor and Multifactor Indicators

Computation of the stability ratio of dynamic data series is based on matching with benchmark. Using the methodology of matching with benchmark, it is estimated, how much actual values of the observation period agree with the benchmark values. The benchmark indicator is calculated according to the research purpose. Stability ratio is calculated by the next formula:

The stability ratio, SVR*, %* = SVR^{actual} / SVR^{base} **100%,*

where SVR is stability ratio of the dynamic data series, in %;

SVR^{actual} is an indicator of actual variation of data series values (depending on the purpose of research) for the observed time period;

SVR^{base} is an indicator of the benchmark variation of data series values (depending on the purpose of research) for the observed time period.

If it is necessary to calculate the instability ratio, it can be calculated as the inverse indicator of the stability ratio:

Instability ratio, ISVR *% =100* – SVR*,%.*

Let us consider the model for analysis of single-factor indicators [13]. Let us set the objective of research as, for example, calculation of the growth stability or invariability of the values of the dynamic data series for the observed time period *n*. Thus, basic order of data series variation can be represented by the next set of inequalities:

$$y_0 \le y_1 \le y_2 \le y_3 \le \dots \le y_n ,$$

$$\begin{cases} y_1 \ge y_0, \\ y_2 \ge y_0, \\ y_2 \ge y_1, \\ \dots\dots\dots \\ y_n \ge y_0, \\ y_n \ge y_1, \\ \dots\dots\dots \\ y_n \ge y_{n-1}, \end{cases} \quad (1)$$

where, $y_1, y_2, y_3, \dots, y_n$ are values of data series for the period $t=1,2,3,\dots,n,$

y_0 is the value of data series for the period, preceeding the analyzed period.

This set of inequalities describes break-even variation of the data series values for the observed time period. The actual variation of data series values is described by constant fluctuation, both growth and fall. Frequency, duration and variation length of data series values (for one or more time periods) depend on various factors, which are practically impossible to consider or forecast. The indicator of the actual variation of data series values is calculated by a similar algorithm. Thus, both, the indicator of the benchmark variation and the indicator of actual variation, are calculated by the above set of inequalities.

For analysis and calculation of the ratio of stable growth one can use the lower triangular matrix. The lower triangular matrix for the period *n* has the following form:

$$A = \begin{pmatrix} a_{10} & 0 & \dots & 0 \\ a_{20} & a_{21} & \dots & 0 \\ \dots & \dots & \dots & \dots \\ a_{n0} & a_{n1} & \dots & a_{nn-1} \end{pmatrix}, \quad (2)$$

where the matrix elements a_{ij} are determined as:

$$a_{ij} = \begin{cases} 1 & \text{if } y_i \ge y_j, \\ 0 & \text{in all other cases,} \end{cases}$$

$i = 1,\dots,n$ and $j = i - 1$.

All elements of the matrix for calculation of the indicator for data series of the benchmark variation, are equal to 1, i.e. $a_{ij} = 1$ and for calculation of the indicator for data series of actual variation, are equal to actual values of data series.

Thus, in general, the indicator of stable growth for all analyzed periods, both for the benchmark and actual variants, is calculated as:

$$SVR = \sum_{i=1}^{n} \sum_{j=0}^{i-1} a_{ij} . \quad (3)$$

Thus the indicator of the benchmark variation of data series for the time period *n*, based on the benchmark norm of stable growth, is equal to:

$$\mathrm{SVR}^{base} = \frac{n*(n-1)}{2} . \quad (4)$$

The indicator of actual variation, SVR^{actual}, of data series values for the time period *n* is calculated using actual values of data series according to formula (3).

Hence, the stability indicator is calculated as the stability ratio:

$$SVR,\%=(\sum_{i=1}^{n}\sum_{j=0}^{i-1}a_{ij}\ /\frac{n*(n-1)}{2})*100=\frac{2*\sum_{i=1}^{n}\sum_{j=0}^{i-1}a_{ij}}{n*(n+1)}*100 \quad (5)$$

IV. Results of Practical Testing of the Stability Ratio Evaluation

The stability ratio of stock prices of companies. Within this research the authors made an estimate and have conducted the analysis of applications of the stability ratio of stock prices, as quoted on stock exchange, as one of the risk indicators of shares. Comparison is done of risk assessments by the proposed indicator, by VaR, by the standard deviation and by the share profitability indicator. Practical approbation is carried out by analyzing shares of automotive companies on the US and European stock exchanges for the period 2004-2014. There are analyzed quoted shares of 27 automobile companies on the stock exchanges NYSE (USA), Xetra (Germany), TSE (Japan), LSE (UK), OTC Markets (USA) [10,11,12]. The closing prices of shares of the selected companies by trading days are taken as initial data.

The simplest method for quantitative risk assessment of shares is the standard deviation [1,5,14]. Analysts note uselessness of the volatility for the main part of active traders, which work with underlying assets. However, in the research done the historical volatility, i.e. the volatility based on the sample of historical data has been calculated [1,8]. The assessment is done by calculation of the indicator σ, calculated by the standard deviation of returns r_i of the financial asset for N trading days [3,5]:

$$\sigma=\sqrt{\sum_i\frac{(r_i-\bar{r})^2}{N-1}} \quad \text{i.e.} \quad r_i=\ln\left(\frac{p_i}{p_{i-1}}\right),$$

where p_i is the price of share by closing of the *i-th* trading day.

The lower is this indicator, the lower is the risk of investing in shares. The standard deviation indicates the amount by which the yield of shares may differ from the average yield for the period under review, and it is a measure of volatility evaluation. The least risky shares are the shares with the lowest volatility. A significant disadvantage of this method is the assumption, that share prices are normally distributed, forming the bell-shaped curve. However, this is not always true, because there are collapses, which are not possible to predict with the help of the normal distribution.

Risk assessment based on the VaR approach is calculated using the Variance-Covariance method with the horizon of ten days, with the confidence level of 99%. The evaluation horizon is chosen ten days, since this is the maximum period for obtaining a qualitative result using this technique [2,6]. VaR is the value of losses, that with the probability, equal to the level of confidence (e.g., 99%), will not be exceeded. In 1% of outcomes, the loss will be greater than the VaR value. Method of estimation of the Variance-Covariance VaR is the most modified in terms of the adequate calculation of the risk of an asset. This method calculates the amount of the possible loss by multiplication of the volatility of the analyzed data series, the quantile value, the confidence level and the value of the asset.

VaR with the confidence level (probability of 99% and the horizon of 10 days) is calculated as follows:

VaR (abs.) = share price for the last day*volatility (daily)*quantile (with probability of 1% for the distribution with determined values of average and standard deviation)*square root of 10 (number of days).

VaR(%) = volatility (daily)*quantile (with probability of 1% for the distribution with given values of average and standard deviation)*square root of 10 (number of days).

As a convenient illustration of the results presented in this paper we offer an example of a common type of evaluation indicators of the risk and profitability of Volkswagen shares received for four quarters (Tab. 1). For comparison of risk indicators is applicated the instability ratio, inverse to the stability ratio.

TABLE 1. An example of risk-assessment indicators (%) and profitability indicators (%) for shares of the Volkswagen, quoted on different stock exchanges in 2011-2012

Indicator	Xetra (Germany)			
	3 quart. 2011	**4 quart. 2011**	**1 quart. 2012**	**2 quart. 2012**
Standard deviation	15,9	7,56	6,22	4,93
Instability ratio	78,9	41,1	30,1	58,1
VaR	24	20	12	18
Profitability	-27,1	23,0	10,8	-9,7
Stock Exchange LSE (England)				
	3 quart. 2011	**4 quart. 2011**	**1 quart. 2012**	**2 quart. 2012**
	10,2	6,9	5,5	5,08
	19,6	39,6	36,9	53,4
	22	30	13	21
	4,0	0,9	5,74	7,29
Stock Exchange OTC Markets				
	3 quart. 2011	**4 quart. 2011**	**1 quart. 2012**	**2 quart. 2012**
	4,84	2,36	1,83	1,7
	82,8	48,4	34,6	66,2
	28	25	14	17
	-27,7	14,2	8,1	-4,3

Analysis and comparison of the risk and return on equity indicators is done using the correlation coefficients. Let us estimate with the help of the correlation coefficients the interrelation of the risk and return on equity indicators (see. Tab. 2). Evaluation is carried out for the full data set for ten years. As an example, in table are given the correlation coefficients between risk and profitability indicators of the

Volkswagen shares, %. The data are based on the quarterly calculations of risk and return for the 10 year period.

TABLE 2. CORRELATION COEFFICIENTS FOR THE RISK AND PROFITABILITY OF THE VOLKSWAGEN SHARES, %

Indicators	Standard Deviation	VaR	Profitability
Standard deviation	10,44	27,80	-46,48
Instability ratio		39,53	-69,73
VaR			-46,71

It should be noted that there is almost the same inverse relationship between profitability indicator, standard deviation and risk assessment obtained by the VaR. Therefore, it is possible to eliminate one of these risk indicators, because they practically duplicate each other. In what follows only the VaR indicator will be used.

There is a fairly high negative correlation between the instability ratio and the profitability ratio of shares. This correlation coefficient has been the highest and negative in all calculations.

The relationship between the VaR risk indicator and instability ratio is insignificant or very low, and has a positive value. This indicates that these indicators are functionally different and may be used as a complement to each other.

The analysis has been done of interrelation of indicators of risk and shares profitability. The received data indicate that there is a high correlation between these indicators, and it was confirmed by the calculation of the correlation coefficients (Tab.3).

TABLE 3. CORRELATION COEFFICIENTS BETWEEN RISK AND PROFITABILITY FOR THE BMW AND FORD SHARES, %

Indicator	BMW (Xetra, Germany)		Ford (NYSE, USA)	
	VaR	Profitability	VaR	Profitability
Instability ratio	16,3	-89,4	8	-76,4
VaR		-31		9,5

The analysis of correlation coefficients showed that in 75% of the analyzed data, the relationship between measures of profitability and VaR, is negative and is quite low. But the relationship between profitability and instability ratio is high enough. The VaR indicator belongs to measures, which show the amount of potential financial losses by purchasing shares. With regard to this indicator one cannot say: "the higher is the risk, the higher is the profit". The findings are quite different and it is not possible to highlight some trends, which show relationship between VaR measure and the profitability measure. The instability ratio of share prices describes frequency and magnitude of decrease in share price over the period. This indicator shows a significant negative correlation with the profitability indicator of shares. In this case one can say "the higher is the risk, the higher is the profit".

Thus, our research established the following facts:

- at the values of the instability ratio less than 43% the profit is always positive;
- at the values of the instability ratio more than 53% the profit is always negative, i.e. there are losses;
- at the values of the instability ratio in the range from 43% to 53%, the profitability indicator can be both, negative or positive, it depends generally on the VaR risk indicator (research have confirmed the efficiency of this indicator in this case);
- using the ratio of instability of shares, it is possible to forecast their profitability. At the same time taking into account the value of the VaR, it is possible to estimate approximately the amount of profit/loss for different time periods.

By the analysis of the shares risk it is possible to use indicators of VaR and instability ratio as a complement to each other. For example, the instability ratio for BMW in 2004 and 2008 approximately amounts: 62.52% and 62.89%, which indicates losses in shares returns in those years. However, the VaR indicator in 2004 amounts 9.41% and losses amount 10.69%, in 2008 the VaR is significantly higher, 24.60% and losses are also higher, 48.97%.

Thus, it is possible to use risk indicators for choosing safe shares. Here are the guidelines to follow:

1. When choosing shares one should use the instability risk indicator;
2. It is recommended to consider jointly the instability ratio and VaR, inasmuch as, these indicators complement each other.

The ratio of stability of some indicators of financial performance. Let us consider the indicators of the net income, total assets, and the return on assets by the net profit of automotive companies for the 2005-2015. The analysis is carried out on the basis of growth ratio. The dynamic data series of growth rates is formed, and the following indicators are calculated: the average value of data series, standard deviation, the stability ratio and the instability ratio. Analysis of relationship between indicators is carried out on the basis of the correlation coefficients. In Table 4 an example is given of the analysis of dynamic data series of the growth rates of revenue.

TABLE 4. ANALYSIS OF REVENUE GROWTH RATES FOR THE AUTOMOTIVE COMPANIES, %

Comp.	Avrg,	Stand.dev.	Stab.ratio	Instab. ratio
BMW	107	8,3	92,7	7,3
FIAT (FCA)	111	26,5	82,2	17,8
Daimler	99,9	16,1	55,6	44,4
Avtovaz	107	29,3	85,7	14,3
Toyota	103	12,2	53,3	46,7
Ford	98,4	10,2	33,3	66,7
GM	102	17,6	90,5	9,5
Honda	103	13,8	53,3	46,7

The correlation coefficient between the standard deviation and the ratio of instability in terms of revenue indicators amounts to -44.2%, by the net profit margin amounts to -59.5%, by total assets amounts to 15.2%, by the assets profitability indicator (single-factor data series, consists of the ratios: net profit to total assets), amounts to -1.6%. These correlation coefficients have not confirmed the relationship between the standard deviation and the ratio of instability. Thus, the stability ratio differs from the stability indicator of the dynamic data series trend and it can be used independently as an additional qualitative indicator. For example, when forecasting the indicators, it would be useful to calculate the stability ratio. There is no doubt that the reliability of the forecasting indicators for the values with stability ratio of 90% will be significantly different from reliability of forecast with the stability ratio of 30%.

V. Conclusions

Results of the research described in this paper show that for the data series one can estimate the ratio of stability (instability) as an independent quality indicator. The paper presents the method for obtaining this indicator and investigate areas for its practical application. It is shown that the stability ratio differs from the indicator of dynamic data series trend stability and it can be used independently as an additional qualitative indicator. Application of the stability ratio improves the reliability of decision-making, for example, in selection of shares to purchase, in decision making at forecasting and so on.

The proposed ratio for evaluation of stability of share price can be used as the method for risk assessment of securities on stock exchange. Research results justify the possibility of application of the ratio for evaluation of share price instability risk, as an independent indicator of risk assessment and additional indicator for assessing the risk by the VaR method. The stability ratio of share price can be used for assessing the quality of shares, for formation of various share ratings and so on.

The proposed measure is a useful tool for investors, analysts, consultants, and other professionals for decision-making in economic systems.

References

[1] T. Andersen, T. Bollerslev, P. Christoffersen, F. Diebold. Volatility forecasting. Forthcoming in: Handbook of Economic Forecasting. Ed. by Graham E., Granger C., Timmerman A. Amsterdam: North Holland, 2005.

[2] A. Carol. Market Risk Analysis, Value at Risk Models. New Jersey: John Wiley & Sons, 2009, 492p.

[3] R. Hamming. Numerical methods for scientists and engineers. Courier Corporation, 2012.

[4] D. Hand. *Measurement theory and practice: The world through quantification*. London, UK: Arnold, 2004

[5] M. Hartfelder, E. Losovskaya, E. Hanush. Fundamental technical analysis of security market. Moscow: PAIMS, 2004.

[6] Glyn A. Holton. Value-at-Risk: Theory and Practice. 2nd ed. Available at: http://value-at-risk.net, 2012.

[7] A.S. Mandel. Method of Analogs in Prediction of Short Time Series: An Expert-statistical Approach. Automation and Remote Control, v. 65, No. 4, 2004.

[8] J. Mina, J. Xiao. Return to Risk Metrics: The evolution of a standard. New York: Risk Metrics Group, 2001.

[9] E. Peters, Fractal Market Analysis. Applying Chaos Theory to Investment & Economics. J. Wiley & Sons, New York, 1994.

[10] Site Frankfurt Stock Exchange. Available at: http://www.boerse-frankfurt.de.

[11] Site Google Finance. Available at: http://www.google.com/finance.

[12] Site New York Stock Exchange. Available at: http://www.nyse.com.

[13] D. Sizykh. Stable Growth Ratio of Share Prices: evaluation and use / Proceedings of the 14th FRAP Finance Accounting and Risk Perspectives Oxford UK. Oxford: Sept. 22-24, 2014.

[14] J. Stein, S. Usher, D. LaGatutta, J. Youngen. A comparables approach to measuring cashflow-at-risk for non-financial firms. Journal of Applied Corporate Finance, 2001, vol. 13, no. 4, pp. 100–109.

