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THE FINANCIAL AND ECONOMIC ANALYSIS OF THE SITUATION OF BUSINESS ENTITIES USING QUANTITATIVE METHODS

Abstract:

Examination of economic reality requires a broad spectrum of methods for the analysis of economic operators situation. Economic entities operating in the financial sector such as other economic sectors have distinct individual - specialized methods of "market recognition". Striving for the globalization and internationalization trends requires from the enterprises to undertake continuous processes, analysis and situation control, which mostly affects the financial and innovative sphere. The steps taken in this direction by the management staff, must have a basis in real performance results, which is achieved through all kinds of analysis. Quantitative methods, regardless of business sector, relatively enable to determine precisely the company condition and estimate their expected outcome. Additionally the use of non-standard economic methods for financial data, allow you to look at the situation with new "fresh" angle. The author in the article presents some mixed methods under which the managers will be able to interpret financial data based on the use of mathematical and statistical methods.

Keywords:

analysis, finance, economics, quantitative methods

JEL Classification: C10, M21

Introduction

The study of the economic reality requires business entities to use a wide range of methods for the analysis of its situation. Entities operating in the financial sector like other separate economic sectors possess individual – specialized methods to recognize the market. (Wafi, Hassan, Mabrouk, 2015) Following the trends of globalization and internationalization requires enterprises to undertake continuous processes, analyses and control of the situation which most frequently concern the financial and innovative sphere (Berzon and Teplova, 2013). The steps in this area undertaken by the management staff must have the basis in the actual results which are achieved through all types of analyses. Quantitative methods, irrespective of the business sector, relatively precisely allow to determine the condition of the company and assess their expected result. Additionally, the use of non-standard economic methods for the financial data allows to look at its situation from a new ‘fresh’ perspective. In the paper, the authors present a few methods on the basis of which the management staff will be able to interpret the financial data based on the use of mathematical-statistical methods.

Efficient and effective management of the activity of the enterprise requires the involvement of numerous specialists from many different fields. In economic terms, companies are required to indicate the opportunity for development (Lesakova, 2016), therefore, generally – innovation. Very little emphasis, particularly with reference to the development of enterprises from the SME sector, is put on the performance of analyses which can reveal the mistakes made by the management staff. Medium and smaller entrepreneurs, in most cases, are oriented towards a single analysis which will allow to answer the question concerning how much they can earn due to specific activity/investment in the nearest future. Obviously, all large effectively managed businesses know that it takes time to see the effects of the investment and the costs, according to forecasts, will be reimbursed in a specific percentage (Skowron-Grabowska et al. 2015). The paper presents the examples of the application of significant, from the point of view of the authors, studies based on the data coming from the activity of two large banks in Poland in years 2005-2014.

Investment portfolio – setting the limits

To be competitive on the market the enterprise must have certain financial resources to engage in investment activities. The funds taking part in the activities of the enterprise may come from own sources or external ones. Each form of financing is dependent on the financial and legal situation of the company (Ślusarczyk, Kot, 2012) as well as on its policy of financial management. (Sukiennik, 2013)

One of the methods widely discussed in the literature in the field of financial mathematics is the investment portfolio (Sharpe, 1970). Its construction should include such securities which will maximally reduce the risk taken and will not reduce rates of return. (Reilly, Brown, 2011; Abramova, Radygina, Chernova, 2015). The relationship of rates of returns of some securities with others constitutes an important problem. The solution is the use of the correlation coefficient of rates of return, which is the measure of this relationship. (Nowak, 2001)

The rate of return is the amount of the investor's benefits to be achieved in a given period from the invested capital.

The correlation coefficient, based on the data of historical time series of rates of return, is determined by the formula:

$$r_{1,2} = \frac{\sum_{i=1}^{n}(Z_{1t} - Z_1) \cdot (Z_{2t} - Z_2)}{S_1 \cdot S_2} \qquad (1)$$

where:

$r_{1,2}$ – correlation coefficient of rates of return on shares

Z_1 – expected rate of return 1

Z_2 – expected rate of return 2

Z_{1t} – rate of return on shares 1 in period t

Z_{2t} – rate of return on shares 2 in period t

S_1 – standard deviation of rates of return on shares 1

S_2 – standard deviation of rates of return on shares 2

The calculation of the expected rate of return on shares 1 at a known distribution of rates of return on securities requires the application of the following formula:

$$Z_1 = \sum_{i=1}^{n} p_i \cdot Z_{1i} \qquad (2)$$

In turn, in order to calculate the expected rate of return on shares 1 without knowing the distribution of rates of return on securities in the future, the following formula must be used:

$$Z_1 = \frac{\sum_{t=1}^{n} Z_{1t}}{n} \qquad (3)$$

When calculating the correlation coefficient the following formulas determining the standard deviation of rates of return on shares must be applied:

$$S_1 = \sqrt{\sum_{t=1}^{n}(Z_{1t} - Z_1)^2} \qquad S_2 = \sqrt{\sum_{t=1}^{n}(Z_{2t} - Z_2)^2} \tag{4}$$

where:

Z_1 – expected rate of return 1

Z_2 – expected rate of return 2

Z_{1t} – rate of return on shares 1 in period t

Z_{2t} – rate of return on shares 2 in period t

The application of the correlation coefficient allows to determine both the direction and strength of the relationship of rates of return on shares. Its properties include: (Nowak, 2001)

1. standardized range [-1;1]
2. the obtained absolute value of the coefficient indicates the strength of the relationship of rates of return on shares. The higher the values the stronger the relationship. The maximum dependence is achieved for the values of the coefficient close to "-1" or "1" and the minimum values for the coefficient around the range of zero.
3. the sign of the coefficient allows to indicate the direction of the relationship of rates of return on shares: a positive coefficient (positive correlation) – an increase (decline) in the rate of return on a single share is accompanied by an increase (decline) in a rate of return on another one; a negative coefficient (negative correlation) – an increase (decline) in a rate of return of a single share is accompanied by a decline (increase) in a rate of return of another one.

In order to determine threshold of the investment portfolio, its rate of return (Z_p) and standard deviation (S_p) should be calculated using the following formulas:

$$Z_p = w_1 \cdot Z_1 + w_2 \cdot Z_2 \tag{5}$$

where:

Z_p – expected rate of return on the portfolio

$Z_{1,2}$ – expected rates of return on shares A and B

$w_{1,2}$ – weights (share) of shares A and B in the portfolio

$$S_p = \sqrt{{w_1}^2 \cdot {S_1}^2 + {w_2}^2 \cdot {S_2}^2 + 2 \cdot w_1 \cdot w_2 \cdot S_1 \cdot S_2 \cdot r_{1,2}} \tag{6}$$

$S_{1,2}$ – standard deviation of rates of return on shares A and B

$r_{1,2}$ – correlation coefficient of rates of return on shares

Portfolio risk estimated by portfolio variance is dependent on equity risk determining the size of the portfolio and the correlation coefficient of these shares (Fisher, Lorie, 1964). In turn, the expected rate of return on the entire portfolio can be achieved by the investor both at greater and smaller risk. In order to make full estimates of the investment portfolio its graphical form can be used. For this purpose there should be analyzed three cases for which portfolio risk (standard deviation) is less than weighted average of deviations of individual securities. (Nowak, 2001)

The case I – occurs when perfect positive correlation is dealt with. For calculations there should be applied the following formulas:

- correlation coefficient: r = 1
- expected rate of return: $Z_p = w_1 \cdot Z_1 + w_2 \cdot Z_2$ (7)
- standard deviation: $S_p = w_1 \cdot S_1 + w_2 \cdot S_2$ (8)

The case II – takes place with reference to the situation of perfect negative correlation for which there should be used the following formulas:

- correlation coefficient: r = -1
- expected rate of return: $Z_p = w_1 \cdot Z_1 + w_2 \cdot Z_2$ (9)
- standard deviation: $S_p = |w_1 \cdot S_1 - w_2 \cdot S_2|$ (10)

This case allows to consider the situation for which the risk can be eliminated (at least in theory). There should be made subsequent calculations using the following formulas:

- correlation coefficient: r = -1
- expected rate of return: $Z_p = w_1 \cdot Z_1 + w_2 \cdot Z_2$ (11)

for $w_1 = \frac{S_2}{S_1+S_2}$ $w_2 = \frac{S_1}{S_1+S_2}$ (12)

- standard deviation: $S_p = 0$

The case III – considers the situation where there is no relationship between rates of return, therefore, there is no correlation. The calculations must be made using the formulas:

- correlation coefficient: r = 0
- expected rate of return: $Z_p = w_1 \cdot Z_1 + w_2 \cdot Z_2$ (13)

- standard deviation: $S_p = \sqrt{{w_1}^2 \cdot {S_1}^2 + {w_2}^2 \cdot {S_2}^2}$ (14)

The case of the lack of relationship allows to find the values for which the portfolio achieves the minimum risk:

- correlation coefficient: r = 0
- expected rate of return: $Z_p = w_1 \cdot Z_1 + w_2 \cdot Z_2$ (15)

for $w_1 = \frac{{S_2}^2}{{S_1}^2 + {S_2}^2}$ $w_2 = \frac{{S_1}^2}{{S_1}^2 + {S_2}^2}$ (16)

- standard deviation: $S_p = \sqrt{{w_1}^2 \cdot {S_1}^2 + {w_2}^2 \cdot {S_2}^2}$ (17)

The practical dimension of the presented theory in the field of the investment portfolio shows the expected rates of return on two large banks operating in the area of Poland. The expected rates of return were calculated for the period of ten years using the archival data. In Table 1, there are presented only the expected rates of return for the last quarter of subsequent years to illustrate its variability.

Table 1: The expected rates of return for quarter IV in years 2005-2014

	2014	**2013**	**2012**	**2011**	**2010**	**2009**	**2008**	**2007**	**2006**	**2005**
Shares (A)	0,08	-0,04	0,02	-0,02	0,06	-0,06	0,23	0,17	-0,10	-0,14
Shares (B)	0,11	-0,05	-0,10	-0,01	-0,04	-0,07	0,26	0,28	-0,14	-0,23

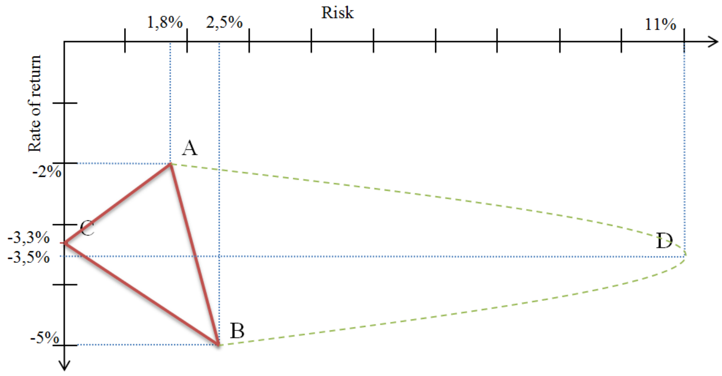
Source: Own study based on the stock-exchange listing available on the Internet

When assuming the share of the portfolio: shares A – 40% and B – 60%, there can be made the calculations due to which it is possible to estimate:

- expected rate of return on the portfolio: -3%
- standard deviation of rates of return on the portfolio: 13%

The analysis of the cases will allow to build the graphical form of the investment portfolio presented in Figure 1.

Figure 1: Double-dimension portfolio of securities



Source: Own study based on the calculations

The obtained portfolio of the shares of two large banks in Poland allows to specify the final results: (Nowak, 2001)

- x-axis, i.e. risk value (standard deviation)
- y-axis - value of expected rate of return.

In a given space, the investor may model the portfolio without limits obtaining various expected rates of return and portfolio risk:

- Points A and B illustrate single-dimension portfolios.
- Segment AB – an increase in the rate of return is accompanied by a proportional increase in risk
- Segment AC – a change in the portfolio results in an increase in the rate of return with simultaneous reduction in risk
- Point C – portfolio with zero risk
- Point D – portfolio with minimum risk.

Cointegration – the analysis of the relationship

The study of the relationship resulting from the calculation of the correlation should be considered in the short-term perspective in spite of the calculations based on historical data (Moosaa, Vaz, 2016). In long periods, the overwhelming number of macroeconomic phenomena is characterized by slow, continuous growth. In turn, short-term volatility frequently hinders this process. The components of the economic macroenvironment are very often created by the (long-term) trend, (short-term) fluctuations and random deviations. The elements of the environment tend to return to the state of long-run equilibrium every time after the occurrence of any changes which are associated with the functioning of external forces.

The state of long-run equilibrium (Sasaki, 2012) determines the situation which the system strives for after prior being thrown off equilibrium and which will be achieved after finite time under the circumstances in which it is not subjected to external forces. (Sałek, 2016)

Testing the relationships, first of all, consists in eliminating the occurrence of so called spurious regression. The validity of its verification is based on the assumption that nonstationary variables, which are not related to each other in the cause and effect context, on the basis of high value of the correlation coefficient, very often indicate statistical significance of their relationship. On that basis, there is built the model which in fact does not meet the assumed expectations. The causative agent of the occurrence of spurious regression is taking into account nonstationary variables in the model, which are not linked by cointegrating relationships. The foundation of the assumptions of the occurrence of the phenomenon of spurious regression is the existence of the relationship defined as “the rule of the thumb” (the calculated value of the correlation coefficient is higher than the calculated value of the empirical statistics applied for the study of the autocorrelation with the Durbin-Watson test). The data analysis allows to assess the regression function and to obtain information on their variability.

Another step is the verification of the hypothesis of non-stationarity of time series using the unit root test (the Dickey-Fuller test). This process (replacement of a non-stationary series with a stationary series) consists in differentiation of a series, which amounts to the calculation of increments of a time series $\{y_t\}$ d times, integrated of order d:$y_t \sim I(d)$. The chronology of the activities firstly consists in the calculation of increments of a non-stationary time series $\{y_t\}$. The result is a stationary series $\{\Delta y_t\}$, where $\Delta y_t = y_t - y_{t-1}$, which is a time series $\{y_t\}$ integrated of order 1 ($y_t \sim I(1)$). The process is repeated in the situation when a time series requires the calculation of increments e.g. twice $\Delta^2 y_t = \Delta\Delta y_t = \Delta(y_t - y_{t-1}) = (y_t - y_{t-1})(y_{t-1} - y_{t-2})$, then the output series is integrated of order 2 ($y_t \sim I(2)$). The activities are copied as many times until a stationary time series is obtained. In practice, however, the variables are tested maximum three times.

The previous research period allows to apply cointegration in order to verify the relationships with reference to the analyzed variables. The phenomenon of cointegration occurs when there are two (or more) non-stationary series assuming that their linear combination (random component) is stationary. This means that the variables y_t and x_t are cointegrated for $\{z_t\} \sim I(d)$ and $\{v_t\} \sim I(d)$ and the equation is regression or regression cointegrating with the parameter α_1 being the cointegrating parameter.

The definition of time series states that Y_t and X_t are cointegrated of order d, b, where d ≥ b > 0, which is written as Y_t, X_t ~ CI(d,b), when:

- both series are integrated of order d (Y_t, X_t ~ I(d))
- there is linear combination of the analyzed variables integrated of order d-b.

Additionally, there can be applied ECM (Error-Correction Model), which is the model for increments of variables, enriched with error-correction parameter. ECMs provide an opportunity to distinguish long-term and short-term relationships. As a result, it is possible to draw conclusions on the basis of the models characterized by spurious regression with reduced probability of their occurrence. (Strahl et al., 2004)

The theory in the field of cointegration was tested on the basis of the same data which were used to create the investment portfolio. The study of the relationships, based on the expected rate of return, allowed to determine regression, where the intercept α_0 amounted to 0.9% – therefore, such a mean value is taken by the endogenous variable of the expected rate of return on Shares of the bank (A), when the explanatory variable of the expected rate of return on Shares of the bank (B) assumes zero value. An increase in the value of the expected rate of return on Shares of the bank (B) by 1% will bring about an increase in the expected rate of return on Shares of the bank (A) by 54.1%. The significance of the structural parameters indicates the appropriate selection of the explanatory variable – the expected rate of return on Shares of the bank (B). The mean value of R^2 coefficient $R^2 = 0.536$ indicates the appropriate adjustment of the model to the empirical data. The calculated relationship $DW < R^2$ indicates the lack of existence of spurious relationship between the expected rate of return on Shares of the bank (A) and Shares of the bank (B).

The study of cointegration occurring between the expected value of rates of return on Shares of the bank (A) and Shares of the bank (B) taking into account their residuals, allowed to obtain the following orders of integration:

- Variable (A_t) representing the expected rate of return on Shares of the bank (A) is integrated of order zero $A_t \sim I(0)$
- Variable (B_t) representing the expected rate of return on Shares of the bank (B) is integrated of order zero $B_t \sim I(0)$
- Variable e_t (residuals) is stationary i.e. integrated of order zero $e_t \sim I(0)$

The obtained results allow for the conclusion that there is no long-term relationship between the expected rates of return, however, the exclusion of spurious regression and relatively significant correlation coefficient allows to imply that there is a short-term relationship between the expected rates of return on shares.

Conclusions

The conducted analyses for the expected rates of return in most cases are interpreted with reference to the level of investment risk. Additionally, the data used in the study come from the banks, which justifies the financial dimension of the analysis. The authors wish to draw attention to a different possibility of interpretation of the obtained information. The entities subjected to the studies, irrespective of the sector they operate in, can be treated as a manufacturing or service company whereas the expected rate of return, in spite of its 'stock' specificity, as a determinant of the condition of the entity. In such a situation, the analyzed data indicate the economically stable situation of the analyzed entities without a clear upward trend. The relationships between the entities are noticeable, however, it cannot be considered that e.g. an increased interest in products of one entity in the long term will translate into an increased interest in the other entity. Therefore, it can be concluded that the relationships between the discussed units result only from a similar nature of the conducted activity and they cannot be translated into the way of strategic management in the long term context. The advantages in favor of the necessity to conduct the analyses, even in small companies, include the fact that any information, even seemingly not bringing apparently positive/negative forecasts, is significant in the study of the economic reality. The research example discussed in the paper, using uncomplicated analyses, allowed for the formulation of a very important thesis – the observation of 'competitors' must be excluded in order to refer the conducted analysis as a signal for good or bad trends that may take place on the specific market.

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