APPLICATION OF ADAPTIVE MODELS WITH DISCRETE DEPENDENT VARIABLES IN THE SUBSTANTIATION OF INVESTMENT SOLUTIONS UNDER THE CONTEXT OF FRACTAL MARKET

Maria V. Dobrina, Voronezh State University
Ekaterina A. Kosareva, Voronezh State University
Yana A. Yurova, Voronezh State University

ABSTRACT

The aim of this work is to search for improved and completely new approaches to the formation of a portfolio of securities that brings maximum profitability. For this, calculations were performed to build the Markowitz investment portfolio, a portfolio based on a probabilistic binary choice model, and a portfolio using the adaptation mechanism under the conditions of the fractal market hypothesis, and a comparative analysis of the obtained calculations was performed. In this work, the authors were able to confirm that the fractal market hypothesis more accurately and correctly describes the processes occurring in financial markets than the effective market hypothesis. To obtain the most optimal and high-quality assessment of the results of the securities portfolio formation, control samples were used. Using the control sample makes it possible to evaluate the predictive properties of the constructed models, to analyze their suitability for applied work on the basis of the data taken, which are unknown at the time the model was formed. The results of a computational experiment demonstrate that the classic Markowitz portfolio in terms of total profitability is significantly inferior to the algorithm portfolio proposed by the authors. In addition, the results of the experiment in the control sample confirm the assumption expressed by the authors in the work that one asset in the financial market can be analyzed as a set of assets according to their investment horizons. The results of experimental calculations also confirmed that the results obtained are acceptable for shares of various issuers and organizations of various fields of activity.

Keywords: Markowitz Portfolio, Profitability, Effective Market Hypothesis, Probabilistic Binary Choice Model, Financial Market.

INTRODUCTION

The modern financial market can be used as a full-fledged indicator of the economy state. This is due to the fact that the financial market combines a fairly large group of indicators, such as the foreign exchange market, investment market, stock market, credit and insurance markets. The main task of the financial market can be called the task of redistributing funds between market participants, and in this case not only the fact of the specified redistribution, but also the direction that this redistribution has, will be of importance. Work on the market is performed by managing financial instruments. The most widespread are such financial instruments as bills, checks, stocks, bonds, insurance policies, etc. All of the above makes it clear that the market has a complex and very heterogeneous structure. In this regard, we can conclude that the financial market can be considered in the course of the study from several sides. First of all, this is a view of the market from the point of view of fundamental analysis. With this approach, the subject of research is the existing patterns, phenomena and influences that have been observed for a long time and are based on a whole group of macro- and microeconomic indicators. The second approach to the assessment and analysis of the financial market is a view from the point of view of technical analysis. In this case, the market is considered as if *"from within"*. The subject of research is internal movements, patterns of behavior and market structure.

LITERATURE REVIEW

The concept of *"fundamental analysis"* was given by Graham (2012) in 1943. Fundamental analysis was described as a universal way to predict future prices for financial instruments. Later, the concept of *"fundamental analysis"* was expanded. At the moment, fundamental analysis refers to the process of researching the state of the economy, an individual industry or an individual company in order to correctly determine the market value of a financial instrument. A fundamental analysis of financial markets assesses the economy state as a whole, studies the fluctuations in supply and demand, which in turn affect the price fluctuations of an individual financial instrument. Technical analysis allows you to analyze the value of financial instruments in the absence of access to data on financial statements. Such an approach assumes that all market information necessary for the analysis is contained in the general access, namely in the current and past value of a financial instrument, and this allows the investor to make the right decision (Elder, 2015). The basis of technical analysis is the study of repeating patterns and patterns of behavior identified on price charts. Based on the data obtained, we can make an assumption about the expected dynamics of the price movement of a financial instrument over the future period, since patterns and behavior patterns are prone to repetition. As mentioned earlier, technical analysis is directly based on data on transactions completed on the market, in other words, it illustrates the attitude of investors at a given moment in time to the company. All market participants are constantly working with charts and analytical tools in order to make assumptions about fluctuations in the demand for securities and their offers. This helps predict prices and shape trading strategies for all financial markets. However, the assessment and analysis of financial markets, being a fairly new and actively developing area of the economy, underwent sufficient changes in 1994, which made it possible to look at the market and its participants in a new way and receive a municipally different interpretation and assessment of processes that are locally on the market. The theory of fractals was adapted for economic processes by Peters (2000). It formed the basis of the fractal financial market hypothesis (FMN). Before the formation of this hypothesis, financial markets were considered only from the point of view of the effective market hypothesis (EMN). Prerequisites for the emergence of this hypothesis appeared in the XIX century. In particular, Gibson expressed one of the main postulates of this hypothesis: price is the best source of information about a stock (financial instrument) (Gibson, 2008). Afrina et al. (2020); Rahman et al. (2021); Shahriar et al. (2021); Vygodchikova et al. (2021); Zayed et al. (2020a & b); Zayed et al. (2021) etc. explained and analyzed financial performance and capital structure under the context of several financial markets during COVID-19 pandemic.

Hypothesis

Currently, the efficient market hypothesis is based on the following assumptions. Firstly, it is assumed that the price that has been established in the market at a given time is fair and brings the market into equilibrium. Secondly, all market participants uniformly interpret information and similarly adjust decisions when receiving new data. Thirdly, the goals of market participants are always uniform; their actions are of a *"collective rational"* nature (Peters, 2004). Despite the controversial nature of the postulates, the efficient market hypothesis was a major breakthrough in the study of markets and the construction of mathematical models to describe them. Subsequent study and analysis of the hypothesis, testing its ideas in practice showed that the hypothesis does not completely take into account the main feature of market participants, namely, that they all have heterogeneous expectations. In particular, substantiated criticism of the hypothesis is contained in the works of Abdullin & Farrachetdinova (2015); Lo et al. (2000); Williams (1999) etc. It has been proven that linear models are poorly adapted to explain real processes. This was the impetus for the creation of alternative approaches, which are based on non-linear methods of analysis of financial markets. These methods consider financial markets as non-linear dynamic systems, where all new emerging prices are in connection with their past values, and information entering the market is not always instantly reflected in market prices. The Fractal Market Hypothesis (FMN) that came to the place of the effective market hypothesis allows one to take into account the heterogeneity indicated above due to the assumptions underlying it. First, it is assumed that the market is stable, while investors who work on a large number of investment horizons are included in its structure. This principle is a necessary and sufficient condition for market liquidity. Secondly, the hypothesis states that the reaction to information among investors with different investment horizons is significantly different. As investment horizons increase, longer-term fundamental information dominates. Thirdly, it is believed that any event that casts doubt on the relevance of fundamental information leads to the fact that long-term investors either stop participating in the market or start trading based on a short-term information set.

METHODOLOGY

Frankly speaking, the FMN hypothesis is also criticized, but, according to the authors, it more correctly and accurately describes the processes that occur in the financial markets, and much more realistically reflects the mood and behavior of market participants. Also, the fractal market hypothesis allows you to correctly combine the ideas of technical and fundamental analysis, use the ideas of fundamental analysis (for example, an investment portfolio) in the plane of technical analysis. This can be achieved by dividing investors by investment horizons within the framework of one financial instrument. Since the fractal market hypothesis implies the existence of investors with different investment horizons, it follows that they will interpret the incoming information in different ways, carry different risks and receive different returns. Therefore, we can hypothesize that the same financial instrument A can be considered as a set of instruments $\{A_1, A_2, \dots A_n\}$, where A_i is the value of a financial instrument on the i-th investment horizon. It should be noted that such an assumption can be formulated only if the nature of the time series, in each horizon, of behavior does not depend on the time series of other investment horizons. In order to show that the nature of the time series corresponds to that described earlier, we analyze the stocks traded on the Moscow Exchange MICEX-RTS in the first and second tier. In addition to choosing stocks of companies of different echelons, companies were selected that belong to different industries and business lines: ordinary shares of PJSC Gazprom, ordinary shares of PJSC LUKOIL Oil Company, ordinary shares of OJSC Novolipetsk Metallurgical Plantand ordinary shares of Magnit JSC. The values of the correlation coefficient for four periods are shown in Table 1.

Table 1
THE VALUE OF THE CORRELATION COEFFICIENT BETWEEN THE TIME SERIES OF FINANCIAL INSTRUMENTS

Indicator	Value
PJSC Gazprom	
$r_{1\ мин,10\ мин}$ 1 min, 10 min	0.583575
$r_{1\ мин,30\ мин}$ 1 min, 30 min	0.39636
$r_{10\ мин,30\ мин}$ 10 min, 30 min	0.444521
PJSC LUKOIL	
$r_{1\ мин,10\ мин}$ 1 min, 10 min	0.59866
$r_{1\ мин,30\ мин}$ 1 min, 30 min	0.448951
$r_{10\ мин,30\ мин}$ 10 min, 30 min	0.48288
Magnit JSC	
$r_{1\ мин,10\ мин}$ 1 min, 10 min	0.253565
$r_{1\ мин,30\ мин}$ 1 min, 30 min	0.19899
$r_{10\ мин,30\ мин}$ 10 min, 30 min	0.286524
OJSC Novolipetsk Metallurgical Plant (NLMP)	
$r_{1\ мин,10\ мин}$ 1 min, 10 min	0,68268
$r_{1\ мин,30\ мин}$ 1 min, 30 min	0.567071
$r_{10\ мин,30\ мин}$ 10 min, 30 min	0.491556

Source: Estimated.

The calculated values of the correlation coefficient allow us to make an unambiguous conclusion that there is no close correlation dependence between the considered series, and, therefore, they can be considered as independent assets that can become part of the investment portfolio. I would like to further emphasize the fact that one asset can be considered as a combination of assets in terms of investment horizons of the fractal hypothesis. To do this, we evaluate the correlation between individual asset pairs and compare the obtained values with the calculation results for the investment horizons of the fractal market. The results of calculating the correlation coefficient for assets are shown in Table 2.

Table 2
CALCULATION OF THE CORRELATION COEFFICIENT FOR ASSET PAIRS

Asset pair	Correlation coefficient value
$r_{Газпром,Лукойл}$ Gazprom, Lukoil	0.559721
$r_{Газпром,НЛМК}$ Gazprom, NLMP	0.298197
$r_{Газпром,Магнит}$ Gazprom, Magnit	0.725476
$r_{Лукойл,Магнит}$ Lukoil, Magnit	0.614794
$r_{Лукойл,НЛМК}$ Lukoil, NLMK	0.614794
$r_{НЛМК,Магнит}$ NLMK, Magnit	0.484095

Source: Estimated.

The obtained values for the correlation coefficient show that the correlation between the quotes of one stock, considered at different investment horizons, is comparable with the correlation of two independent financial assets, and therefore each set of quotation values can be considered as an independent financial instrument.

Theory & Model

The proposed approach is used in the formation and subsequent analysis of the Markowitz's and Sharp's investment portfolios (Kosareva, 2017 & 2019). Based on the constructed portfolios, one can come to the following conclusion: using the fractal hypothesis when analyzing financial markets gives investment portfolios with higher profitability and significantly lower risks, in comparison with profitability when investing in one asset. The issue of obtaining the optimal investment portfolio does not lose its relevance today. Moreover, now in the theory of portfolio analysis there is a fairly large volume of models. Despite this, the problem of finding an effective applied tool, like the Black-Scholes formula, has not been solved, and therefore continues to be investigated. Although, of course, it should be noted the existence of various approaches to building an investment portfolio. In this paper, we will concentrate on the algorithmic approach to building an investment portfolio containing elements of novelty. Consider the process of modeling the probable cases of a pair combination of assets in the investment portfolio. We propose the following hypothesis: the profitability of each i-th financial asset will be fairly accurately described below by the presented econometric model:

$$r_{it} = \overline{r_i} + d_i x_{it} + \varepsilon_{it}, \quad (1)$$

Where

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

$\overline{r_i}$ – average profitability of the i-th asset;

d_i – the absolute value of the average deviation of the observed values of the the i-th asset profitability from its average value;

x_{it} – discrete random variable equal to +1 if the current value of profitability is above average and equal to -1 if less than average;

ε_{it} – an unobservable random variable with a mathematical expectation equal to zero.

In general, any financial asset at any time can be characterized as follows: there is an increase in its value or a decrease in its value. Thus, two scenarios are possible, which makes it possible to use the binary selection model:

$$\mathrm{P}(x_{it} = 1 / r_{It}) = \frac{1}{1 + e^{b_{0i} + b_{1i} r_{It}}}. \quad (2)$$

The coefficients of this model are calculated using the maximum likelihood method. For the practical implementation of the maximum likelihood method, specialized packages for statistical data processing are used (Verbik & Marno, 2016). As a result, the potential the i-th asset profitability will be determined as the mathematical expectation of the model using the obtained coefficients $\hat{b}_0$, $\hat{b}_1$ (1):

$$\hat{r}_{it} = \mathrm{E}(r_{it}) = \overline{r_i} + d_i[2P - 1] = \overline{r_i} + d_i[\frac{2}{1 + e^{\hat{b}_{0i} + \hat{b}_{1i} r_{It}}} - 1]. \quad (3)$$

The considered model contains a non-trivial approach to risk assessment. In the described situation, risk is the deviation of the asset's profitability from its average level:

$$rs_i = d_i[2P_i - 1], \quad (5)$$

Such a deviation can be either positive or negative depending on the probability P_i.
In this case, profitability, based on probable risks, is determined as follows:

$$r_{pt} = w_1\overline{r}_i + w_2\overline{r}_k + w_1 d_i(2\text{P}_{it} - 1) + w_2 d_k(2\text{P}_{kt} - 1) + w_i w_k \text{IA}_{ik}. \quad (4)$$

In formula (4), the interaction IA_{ik} is not calculated. The process of determining this interaction was considered in sufficient detail in an article devoted to the algorithmic approach to the formation of an investment portfolio (Davnis & Dobrina, 2017). Thus, formula (4) can serve as a specific criterion for constructing an optimal portfolio of securities (Davnis, 2015). We apply this formula when the investment portfolio includes two assets. Imagine the final expression in the expanded matrix form:

$$r_p = (w_1, w_2)\begin{pmatrix} \overline{r}_i \\ \overline{r}_k \end{pmatrix} + (w_1, w_2)\begin{pmatrix} d_i(2P_i - 1) \\ d_k(2P_k - 1) \end{pmatrix} + (w_1, w_2)\begin{pmatrix} 0 & \frac{1}{2}\text{IA}_{ik} \\ \frac{1}{2}\text{IA}_{ik} & 0 \end{pmatrix}\begin{pmatrix} w_1 \\ w_2 \end{pmatrix}. \quad (5)$$

In formula (5), the first term shows how the average profitability on assets affects the profitability on the entire portfolio of securities. The second term is responsible for the risk of assets, which can lead to an increase or decrease in the level of profitability of a portfolio of securities under various time conditions and at different market conditions (Kazakov, 2006). At the same time, the third term represents the result of a market interaction of assets, which can both positively and negatively affect the profitability of the investment portfolio. In this case, the final structure of the securities portfolio based on this model and the mandatory requirement of triviality of settlements will look as follows:

$$w^* = \begin{pmatrix} 0{,}5 \\ 0{,}5 \end{pmatrix} + \tau \begin{pmatrix} \frac{r_i + \hat{d}_i - r_k - \hat{d}_k}{IA_{ik}} \\ \frac{r_k + \hat{d}_k - r_i - \hat{d}_i}{IA_{ik}} \end{pmatrix}. \quad (6)$$

Where

$\hat{d}_i = d_i(2P_i - 1)$ for any i-th asset.

The proposed formula allows us to conclude that it is necessary to modify the optimal investment portfolio so that the share of assets with higher expected profitability increases and the share of assets with lower expected profitability decreases. Economic processes can often be characterized by a high level of uncertainty and a complex dynamic nature, which leads to the emergence of specific conditions necessary for the correct construction of forecast models. This specificity is considered the basis for the correct selection of algorithms and models for forecasting. The use of adaptation mechanisms in describing the specifics of economic processes and systems is associated with changing real conditions that accompany the process of making investment decisions. In this case, adaptation is a tool for adapting and matching the system to new changing conditions. This implies the direct need to use this mechanism, as well as the inclusion of the principles of a discrete adaptation procedure. The binary selection model, which was proposed by the authors for a detailed description of the algorithmic portfolio, could equally well and effectively be used in conjunction with the discrete adaptation procedure mechanisms. The initial n observations will be used to construct the joint probability distribution function in the form of a binary choice model (3) with initial values of the coefficients b_{00}, b_{10}. In the next step, earlier data will be discarded due to the loss of its relevance, in parallel duplicating the current values for the last period and evaluating the changed values of the coefficients b_{00}, b_{10}. This has a direct effect on the binary choice model, which contributes to a more accurate reproduction of the probabilistic distribution of alternative events of the last period, showing the desired adaptive property, which is then allocated to all regression models using exponential smoothing {6}. The total length of the array of discarded and added data matches each other. The operation of the mechanism is constantly adjusted and adjusted by replacing the duplicated data with newly received values that reflect the actual situation. So, the adaptive approach continues its functioning, constantly recounting the values of the parameters, if necessary, displaying some patterns of the appearance of alternative events of recent observations. Using this, it is possible to more accurately build the probability distribution of alternative events for each subsequent period. The process of repeatability of the latest observations will continue until the full application of all existing observations. This approach can exist and function effectively an infinite number of cycles, if necessary.

RESULTS & DISCUSSION

Table 3
COMPUTING EXPERIMENT RESULTS

Control sample composition	Markowitz portfolio profitability	Algorithmic portfolio profitability	Algorithmic portfolio profitability with adaptation
Asset 1: PAO "*Lukoil*", t=1 min., Asset 2: PAO "*Lukoil*", t=30 min.	0.04492	0.065464	0.074654
Asset 1: PAO "*Lukoil*", t=1 min., Asset 2: PAO "*Lukoil*", t=10 min.	0.04256	0.079856	0.086465
Asset 1: PAO "*Lukoil*", t=10 min., Asset 2: PAO "*Lukoil*", t=30 min.	0.036544	0.0653456	0.0695454
Asset 1: PAO Gazprom, t=1 min., Asset 2: PAO Gazprom, t=30 min.	0.034925	0.045464	0.054654
Asset 1: Gazprom PAO, t=1 min., Asset 2: Gazprom PAO, t=10 min.	0.03256	0.049856	0.050465
Asset 1: PAO Gazprom, t=10 min., Asset 2: PAO Gazprom, t=30 min.	0.03014	0.042554	0.04995
Asset 1: AO Magnit, t=1 min., Asset 2: AO Magnit, t=30 min.	0.03302	0.035424	0.05054
Asset 1: AO Magnit, t=1 min., Asset 2: AO Magnit, t=10 min.	0.02925	0.039856	0.04245
Asset 1: AO Magnit, t=10 min., Asset 2: AO Magnit, t=30 min.	0.02018	0.04864	0.04995
Asset 1: OJSC «NLMK», t=1 min., Asset 2:: OJSC «NLMK», t=30 min	0.02522	0.049552	0.05012
Asset 1:: NLMK OJSC, t=1 min., Asset 2:: NLMK OJSC, t=10 min.	0.02925	0.04156	0.04941
Asset 1:: OJSC «NLMK», t=10 min., Asset 2:: OJSC «NLMK», t=30 min.	0.02011	0.04854	0.05285

Source: Estimated

We present the calculations for the construction of the Markowitz investment portfolio (Markowitz, 1952), a portfolio based on a probabilistic binary choice model, and a portfolio using the adaptation mechanism under the conditions of the fractal market hypothesis. In order to most optimally and qualitatively evaluate the results of building an investment portfolio, we will use control samples - data on the value of financial instruments that were not used to build the model. The use of the control sample allows us to evaluate the predictive properties of the obtained models, to assess their suitability for working on data that are unknown at the time of model building.

The results of a computational experiment as in Table 3 show that the authors proposed approach to assessing and analyzing financial markets from the point of view of the fractal hypothesis allows us to build a Markowitz portfolio that shows some profitability. Also, the results of the experiment in the control sample confirm the arguments made earlier that one asset in the financial market can be considered as a combination of assets according to their investment horizons. These assumptions are valid for shares of various echelons and companies whose activities relate to various fields. The results of a computational experiment clearly show that the classic Markowitz portfolio loses significantly in terms of total profitability on the algorithmic portfolio proposed by the authors. Algorithmic construction of the investment portfolio in the control sample allows us to see that the profitability shown in the control sample is on average 30% higher than the profitability obtained with the classical approach. Also, the algorithmic construction of the investment portfolio is applicable to the approach proposed by the authors to consider an asset as a group of assets under the conditions of a fractal hypothesis and does not depend on the choice of a financial instrument.

CONCLUSION & POLICY RECOMMENDATIONS

Unlike all previous methods, adaptation mechanisms allow to take into account new data coming from the control sample, which makes the forecast result in the control sample more accurate. Profitability is the largest of all obtained for all simulated portfolios. Thus, it was shown that the fractal market hypothesis more accurately and correctly describes the processes taking place in financial markets, in contrast to the efficient market hypothesis. Considering the market from the point of view of the fractal market hypothesis allows you to divide the market into investment horizons and thereby combine the ideas of technical and fundamental analysis. The binary choice model can be used to build an investment portfolio. In this case, the model is based on a probabilistic approach: it considers the probability that the profitability on the asset will be higher than the profitability on the market. Algorithmic portfolio building allows you to build an interaction matrix. Unlike the correlation matrix, the interaction matrix allows you to consider all cases of mutual movement of assets. Adaptation mechanisms allow the model to change depending on market fluctuations. The principles proposed by the authors for the construction of an investment portfolio are applicable for stocks of companies of different levels and business profiles.

REFERENCES

Abdullin, A.R.M & Farrachetdinova, A.R. (2015). The hypothesis of market efficiency in the light of the theory of finance. *Management of Economic Systems: An Electronic Scientific Journal*, 1-23.

Afrina, T., Beg, T.H., Zayed, N.M., Hossain, M.S. & Shahi, S.K. (2020). An Analysis of the Effects of Corona Virus (COVID-19) on International Financial Derivatives Market, 2020. *Indian Journal of Finance & Banking*, *4*(2), 93-98.

Davnis, V.V. (2015). Predictive justification of investment decisions in financial markets. RUSAINS, 220.

Davnis, V.V., & Dobrina, M.V. (2017). Econometric approach to the algorithmic formation of a portfolio of securities. *Modern Economics: Problems and Solutions*, *12*(96), 48-58.

Elder, A. (2015). *Trading with Dr. Elder. Encyclopedia of the exchange game*. Alpina Publisher, Moscow, 496.

Gibson, R. (2008). *Investment Portfolio Formation: Financial Risk Management*. Alpina Business Books, 276.
Graham, B. (2012). Securities Analysis. Williams, Moscow, 880.
Kazakov, V.A. (2006). Models of forming a portfolio of shares in the modern theory of investment. *Finance and Credit, 5*(209), 17-20.
Kosareva, E.A. (2017). The insufficiency of the G. Markovits model in the conditions of short-term investment. *Modern Economics: Problems and Solutions, 93*(9), 8-13.
Kosareva, E.A. (2019). Sharpe's portfolio building for a pair of assets under the conditions of the fractal market hypothesis. *Modern Economics: Problems and Solutions, 6*(114), 44-54.
Lo, A.W., Mamaysky, H., & Wang, J. (2000). Computational Algorithms, Statistical Inference, and Empirical Implementation. *Journal of Finance, 55*(4), 1705-1765
Markowitz, H.M. (1952). Portfolio Selection. *Journal of Finance*, 7(1), 77-91.
Peters, E. (2000). Chaos and order in capital markets. *Mir*, 333.
Peters, E. (2004). Fractal analysis of financial markets. Application of chaos theory in investment and economics. *Internet trading*, 304.
Rahman, A.A.A., Meero, A., Zayed, N.M., Islam, K.M.A, Rabbani, M.R., & Bunagan, V.D.R. (2021). Impact of Leverage Ratios on Indicators of Financial Performance: Evidence from Bahrain. *Academy of Strategic Management Journal*, 20(S3), 1-12.
Shahriar, M.S., Hasan, K.B.M.R., Hossain, T., Beg, T.H., Islam, K.M.A., & Zayed, N.M. (2021). Financial decision making and forecasting techniques on project evaluation: A planning, development and entrepreneurial perspective. *Academy of Entrepreneurship Journal, 27*(4), 1-7.
Verbik, & Marno. (2016). Guide to Modern Econometrics. *Scientific Book*, 616.
Vygodchikova, I.Y., Gorskiy, M.A., Khalikov, M.A., & Zayed, N.M. (2021). Assessment Of Phosagro's Capital Structure Based at two Hierarchical Methods of Integral Ranking of Important Financial and Economic Activity Indicators. *Academy of Strategic Management Journal, 20*(S1), 1-5.
Williams, L. (1999). *Long-Term Secrets to Short-Term Trading*. Wiley, 272
Zayed, N.M., Islam, K.M.A., Shahi, S.K., Rahman, M.S., & Raisa, T.S. (2021). An Analysis on the Effects of Coronavirus (Covid-19) on the Financial Management of Multinational Corporations. *Australian Finance & Banking Review, 5*(1), 43-53.
Zayed, N.M., Shahi, S.K., Neloy, A.H., & Haque, T. (2020a). Effects of Coronavirus (COVID-19) on International Capital Market: A Conceptual Analysis. *European Journal of Accounting, Finance and Investment, 6*(4), 13-20.
Zayed, N.M., Shahi, S.K., Neloy, A.H., Afrin, M., & Haque, T. (2020b). Effects of Coronavirus (COVID-19) on International Financial Market: A Conceptual Analysis. *Journal of Accounting Research, Business and Finance Management, 1*(1), 13-19.