Міжнародні економічні відносини

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Bondarchuk Liudmyla

PhD in Economics, Associate Professor,

Associate Professor of the Department of Management and Administration

Vinnytsia Institute of Trade and Economics of

State University of Trade and Economics

Бондарчук Людмила Володимирівна

кандидат економічних наук, доцент,

доцент кафедри менеджменту та адміністрування

Вінницький торговельно-економічний інститут ДТЕУ

ORCID: 0000-0001-9414-5515

Katerna Olga

PhD in Economics, Associate Professor,

Associate Professor of Air Transportation Management Department

National Aviation University

Катерна Ольга Костянтинівна

кандидат економічних наук, доцент,

доцент кафедри організації авіаційних перевезень

Національний авіаційний університет

ORCID: 0000-0002-6307-8767

Semenova Liudmyla

PhD in Economics, Associate Professor

University of Customs and Finance

Семенова Людмила Юріївна

кандидат економічних наук, доцент, доцент кафедри маркетингу

Університет митної справи та фінансів

ORCID: 0000-0001-5530-7497

Shevchenko Valentyna

Candidate of Science in Public Administration, Associate Professor,
Associate Professor of Department of International Marketing
Alfred Nobel University

Шевченко Валентина Миколаївна

кандидат наук з державного управління, доцент,
доцент кафедри міжнародного маркетингу
Університет імені Альфреда Нобеля
ORCID: 0000-0003-0614-0648

COMPARATIVE PROFITABILITY ANALYSIS ON THE GLOBAL INVESTMENT MARKETS
ПОРІВНЯЛЬНИЙ АНАЛІЗ ПРИБУТКОВОСТІ НА ГЛОБАЛЬНИХ ІНВЕСТИЦІЙНИХ РИНКАХ

Summary. *The article focuses on the comparative analysis of the dynamics of prices and profitability of the investment markets of precious metals (illustrated by the gold market), the Forex exchange market (the currency pair of EUR/USD), and the cryptocurrency Bitcoin. The purpose of the current study is making of the comparative analysis of the price dynamics and its profitability on the certain investment markets of the world, estimating the characteristics of the markets performance, developing of recommendations on the benefits of investing at different planning horizons, and building of the forecast of profitability, by usage of neural networks. It keeps the estimation of the statistical performance of the price dynamics of investment instruments, as well as the study of time series for presence of the deterministic chaos. As for the persistent time series, there was applied the method of sequential R/S analysis to determine the fuzzy memory depth. Taking into account that from the point of view of investment needs, not only the dynamics of the prices of the investment*

markets is quite significant for the analysis, but also its profitability, there were studied the time series of profitability. The above mentioned characteristics of the TS (statistical and fractal ones) can be used for comparison of the price dynamics both in the context of object-carriers (spacial comparison), and in the time section of comparing the changes in the nature of dynamics at different time intervals, in terms of determining the nature of the "response" to the impact of the environment (external and internal actions), etc. In terms of the stochastic nature of the profitability, it was proposed to study the family of time series of the "delayed" profitability. There was specified the time interval, required for the "delayed" profitability to receive the features of the time series of prices, as well as calculated the fuzzy memory depth. It became the basis for generation of the forecast model of the neural network in the software product Deductor.

Key words: *profitability, investment market, cryptocurrency, neural network, investment tools.*

Анотація. *Стаття зосереджена на порівняльному аналізі динаміки цін та прибутковості інвестиційних ринків дорогоцінних металів (проілюстровано ринком золота), ринку Forex Exchange (валютна пара EUR/USD) та біткойн криптовалюти. Метою цього дослідження є проведення порівняльного аналізу динаміки цін та її прибутковості на певних інвестиційних ринках світу, оцінюючи характеристики ефективності ринків, розробку рекомендацій щодо переваг інвестування в різних горизонтах планування та будівництво прогнозу прибутковості шляхом використання нейронних мереж. Здійснення оцінки статистичної ефективності динаміки цін інвестиційних інструментів, а також вивчення часових рядів для наявності детермінованого хаосу. Що стосується стійких часових рядів, то застосовувався метод послідовного аналізу R/S для визначення нечіткої глибини пам'яті. Враховуючи, що з точки зору інвестиційних потреб не тільки динаміка цін на інвестиційні*

ринки є досить важливою для аналізу, але і його прибутковості, вивчали часову низку прибутковості. Вищезазначені характеристики (статистичні та фрактальні) можуть бути використані для порівняння динаміки цін як в контексті об'єктних носіїв (просторове порівняння), так і в розділі часу порівняння змін у природі динаміки в різні інтервали часу, з точки зору визначення природи "відповіді" на вплив навколишнього середовища (зовнішні та внутрішні дії) тощо. З точки зору стохастичного характеру рентабельності, було запропоновано вивчити сімейство часових рядів "затримки" рентабельності. Було вказано часовий інтервал, необхідний для "затримки" рентабельності для отримання особливостей часових рядів цін, а також обчислила нечітка глибина пам'яті. Це стало основою для генерації моделі прогнозу нейронної мережі.

Ключові слова: *прибутковість, інвестиційний ринок, криптовалюта, нейронна мережа, інвестиційні інструменти.*

Problem setting. It is difficult to overestimate the significance of such activity for the economy as investing. Stable activity of the investment markets is the driving power and the basis for development of the economies of certain countries and the world at large. Therefore, understanding of the structure, dynamics, vectors of development and changes in progress already became the urgent need for researching of the economics.

The investment market is a set of various local markets, which are the meeting places for the interests of investors and investment objects, set of economic relations between sellers and buyers of investment goods and services, as well as investment objects in all its forms. The condition of the investment market is usually characterized by demand, supply, price and competition.

For making a research and comparative analysis of the processes developing on the global investment market, there were chosen three investment

objects related to the financial markets: the market of precious metals, the foreign exchange market (Forex), and the novel financial market of cryptocurrencies.

Undoubtedly, gold is the most excellent representative of the precious metals market. Gold has always attracted investors, and probably become one of the first investment tools. In addition, despite the fact that to date there are many alternative variants for investment, the gold market is still quite relevant and attractive.

The presence of a wide range of investment tools puts a question of the possibility of comparison, classification and understanding of each specific market. In order to make a correct and reasonable investment decision, it is required to clearly understand the market mechanism and its current dynamics that dominates for each investment tool.

Analysis of recent research and publications. To date, the leading experts in the sphere of economics and management specify the current conditions, which the business is actively developing, as "the period of turbulence" [1]. The reporting condition (which naturally affects the features of the economic time series) becomes a new standard, generates crises in the economy, as well as drives the need to develop and apply new tools for analysis, and forecasting of the economic dynamics.

There are various approaches for specification of the economic dynamics, which are usually formed by its nature, in other words, the nature of the considered dynamic series [2]. As it is commonly known, the time series can have the stochastic or deterministic nature, or even combine both features. In such case, the issue is about the deterministic chaos or fractal nature of the dynamic series. In each of the reporting cases, it is considered about the corresponding features of the dynamics.

In order to specify the fractal nature of the dynamics series, and determine its system characteristics, there was developed the fractal analysis, including [3].

The descriptive statistics includes the set of the basic statistical indicators of the empirical sampling of the quantitative attribute values [4]. The standard methods of their calculation were developed on the assumption that the distribution is rather normal.

Variety of tools are used for the reporting calculations, in particular, MS Excel, SP STATISTICA, etc.

Specifying of the center, width, symmetry, and dimension of the distribution are the main objectives of descriptive statistics.

The average value, median and mode characterize the center of statistical distribution [6]. The median is the value that divides the sample into two equal parts by volume. The mode is the value that has the highest frequency in the sample, which is the most commonly used in the distribution.

How do the indicators of the distribution width use variability indicators [7]. All variability indicators are divided into two groups: absolute and relative ones. The absolute values cover the range of variability, the mean linear deviation, the dispersion, and the mean square deviation.

The dispersion specifies the deviation ratio of elements of the assembly from the mean value scaled in the units of the corresponding characteristic [8]. The main benefit of the dispersion is that the dispersion of the sum of statistically independent samples is the sum of their dispersions regardless of the distribution laws of the component samples. In order to receive the sample standard deviation, there is required to make the square root of dispersion.
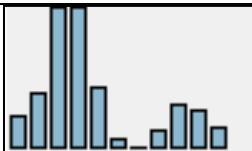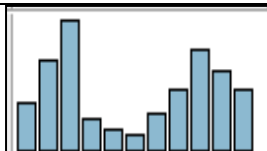
The formulation of the goals current study is making of the comparative analysis of the price dynamics and its profitability on the certain investment markets of the world, estimating the characteristics of the markets performance, developing of recommendations on the benefits of investing at different planning horizons, and building of the forecast of profitability, by usage of neural networks.

Presentation of the main research material. Bitcoin is one of the most famous cryptocurrencies. In rather short span of time, the price of bitcoin almost tripled. In different countries, the attitude to bitcoin significantly differs. In many countries, the status has not been determined yet, or it is currently on the turn. In some countries, the transactions with bitcoin are officially allowed. They are usually considered as the commodity or investment asset, and subject to the relevant legislation for tax purposes. The cryptocurrency market is one of the youngest investment markets. Its history goes back one decade only. Despite the reporting "youth", to date the market is extremely popular, and does not leave cold the investor, and incline him towards the more detailed studying and analysis of the financial tool. The Table 1 provides the results of calculations of comparison of the TS price dynamics of Z, V, B for the whole exploration period.

Table 1

Summary table of comparison of indicators of the TS price dynamics of Z, V, B for the whole exploration period

Indicators of the dynamics estimation	Z	V	B
I. Studying of the trends			
A) linear trend	$y = -0.2263x + 10834$ $R^2 = 0.538$	$y = -0.0001x + 7.0694$ $R^2 = 0.595$	$y = 0.8647x - 35732$ $R^2 = 0.43$
Growth / decline rates	-0.22	-0.0001	0.86
B) polynomial trend	$y = 0.0003x^2 - 25.5x + 542342$ $R^2 = 0.82$	$y = -3E\text{-}08x^2 + 0.0028x - 54{,}02$ $R^2 = 0.606$	$y = 0.001x^2 - 84.6x + 2E\text{+}06$ $R^2 = 0.596$
C) exponential trend	$y = 1E\text{+}06e^{-2E\text{-}04x}$ $R^2 = 0.528$	$y = 155{,}93e^{-1E\text{-}04x}$ $R^2 = 0{,}602$	$y = 2E\text{-}44e^{0{,}0025x}$ $R^2 = 0{,}74$
II. Statistical indicators			
1. Average	1337.1	1.217	558.843
2. Median	1277.5	1.23	360
3. Standard deviation	187.498	0.109	790.159
4. Range	742.35	0.354	4900.68
5. Variability coefficient	0.14	0.09	1.41
6. Oscillation coefficient	0.555	0.291	8.769
7. Distribution histogram			

8. Asymmetry	0.92	0.01	3.04
9. Excess	-0.35	-1.58	10.12
III. Fractal indicators			
1. The Hurst index (H)	0.961	0.952	0.95
2. Most significant ($\mu \geq 0.7$) memory depth, days	17, 12, 9, 13	19, 18, 20, 17	16, 17, 14

Source: author calculations

The maximum R-squared value of the linear trend in the TS V totals $R^2 = 0.595$. The minimum value is for the TS B ($R^2 = 0.43$), therefore less than half of the values of the bitcoin price can be described by the linear function.

Generally, the bitcoin time series differ from gold and currency with the greater volatility (the indicators of variability and oscillation are several times higher than the corresponding indicators of the TS Z and V), and the growth dynamics (the growth rate of price totals 0.865), therefore the series is best approximated by the exponential function ($R^2 = 0.74$).

As for the TS Z, the trend is quite downward, the decline rate of price totals 0.22, which is best approximated by the polynomial function ($R^2 = 0.82$).

As for the currency, the growth / decline rates of price are close to zero (-0.0001), and the TS V are almost equally poorly described by either linear, exponential or polynomial trend ($R^2 = 0.602$ and 0.595, respectively). The reporting series are characterized with the least volatility (the variability coefficient totals 0.09; and the oscillation coefficient – 0.3).

The histogram of the bitcoin distribution confirms that the dynamics do not match with the random distribution. Also, the large-scale value of the skewness and kurtosis coefficients (calculated values total 3 and 10, respectively, while in terms of normal distribution the skewness and kurtosis total 0), as well as the large difference between the average value and median

(average – 559, median – 360), are the major evidence of discrepancy of the TS B to the normal distribution.

The Figure 1 covers the graphical representation of the pseudo-phase space of the TS Z of gold prices, which indicates the existence of some dependence of the current value of the TS compared with the previous ones.
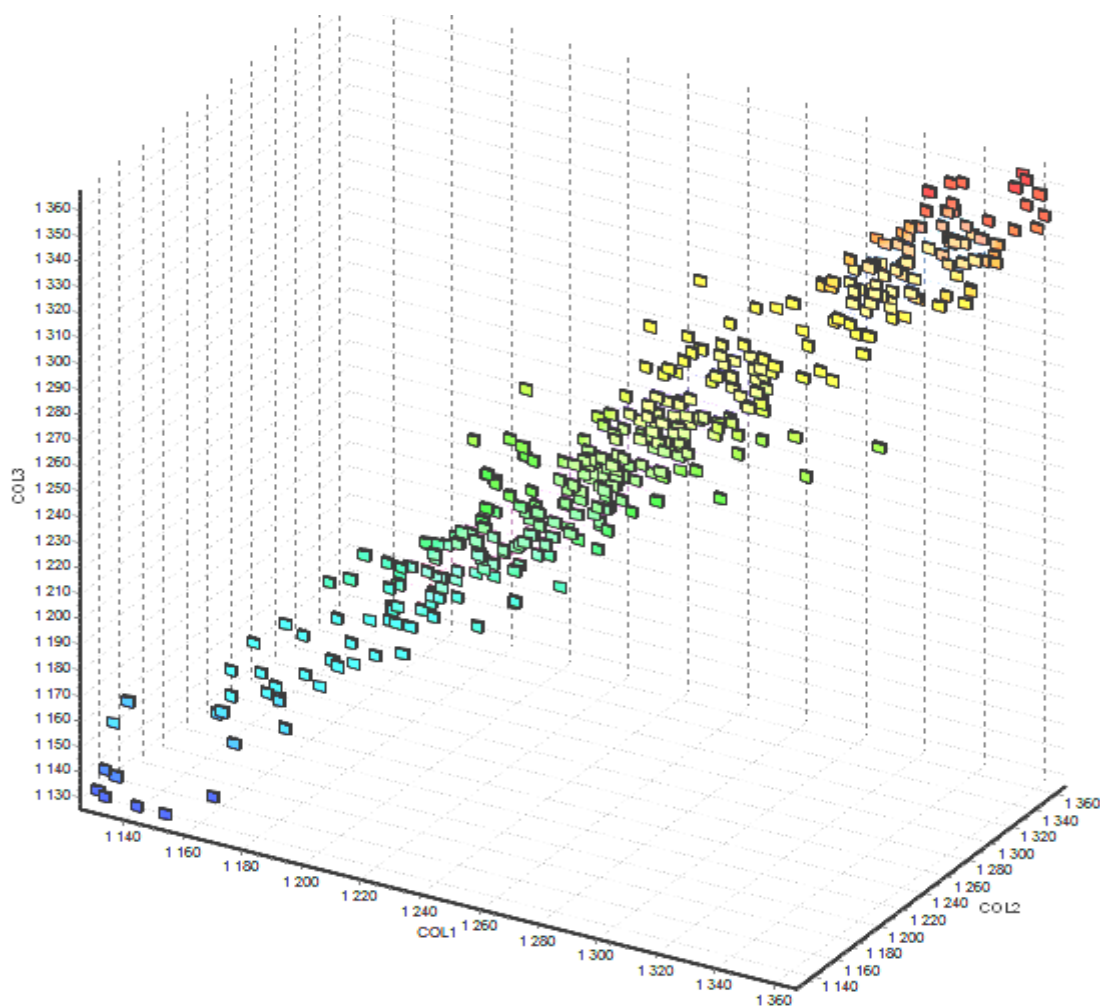

Fig. 1. Pseudo-phase space of the TS Z

Source: visualization of the software program Deductor Studio Academic, according to the author calculations

As for gold and currency, it is necessary to specify two periods for each type with different dynamics features. For the TS Z: before 15.04.2013 and after. For the TS V: before 2015 and after. The results of the analysis of the TS Z for the period from 15.04.2013 to 30.09.2017, and the TS V for the period

from 01.01.2015 to 30.09.2017, witness that the statistical indicators correspond to the characteristics of the normal distribution.

Hereinafter, let's consider the results of the fractal analysis. The results of fractal analysis indicate that during the whole period of the study from 2012 to 2017, the TS Z, V, B were persistent, in other words, they have the long-term memory. The values of the Hurst index for all time series vary within the range of H ϵ [0.950; 0.961]. For the moved values, the Hurst index vary within the range of H ϵ [0.501; 0.658].

Also, such diagnostic methods as construction of the pseudo-phase space of the dimension 3, making of the drift attractor test, and the Gilmore graphical test, indicate about the presence of nonlinear dynamic processes in the studied time series.

As a result, there was formed the fuzzy set of the memory depth of each studied TS, and revealed that most often for the TS Z the memory is stored for 17, 12, 9 and 13 days, for the TS V – for 19, 18, 20 and 17 days, and for the TS B – for 16, 17 and 14 days (the number of days is provided in order of increasing of the value of the membership function μ, $\mu \geq 0.7$).

According to the analysis of the TS Z, V and B, there can be made the following conclusions:

1. The TS Z and V have the characteristics of random distribution (absence of the well-defined trend, fluctuations within the average values, symmetry of distribution). At the same time, the TS V demonstrate the less volatility compared with the TS Z. The dynamics of the TS B are starkly different: there is a significant exponential trend, significant growth rates, asymmetry and high volatility. Therefore, the results of the statistical analysis indicate rather different nature of the dynamics of the considered time series.

2. The results of fractal analysis indicate that during the whole period of the study from 2012 to 2022, the TS Z, V, and B were persistent, in other words, they have the long-term memory. The reporting time series are characterized by

such properties of the fractal dynamics as dependence of the current value of the TS on the previous ones, dependence of the system parameters on the time factor, presence of the unstable pathes, as well as presence of the joker in the system.

In terms of application of the method of the sequential R/S analysis, there were formed the fuzzy sets of memory depth for each time series. Also, there was found that most often for the TS Z, the memory is stored for 17, 12, 9 and 13 days, for the TS V – for 19, 18, 20 and 17 days, and for the TS B – for 16, 17 and 14 days (the number of days is provided in order of increasing of the value of the membership function μ, $\mu \geq 0.7$).

3. Thus, the results of statistical analysis are completely different from indicators of the fractal analysis. According to the statistical indicators, the time series Z, V have random nature, in contrast to the TS B. The results of the fractal analysis indicate the similar persistent nature of all reporting three series.

The comprehensive analysis of price dynamics on the investment markets can assist in correct estimation and comparing of the condition, which the market is facing, the parameters of inertance, trend resistance or volatility. However, from the point of view of investment demand, it is important to analyze not only the price dynamics of the investment markets, but also the dynamics of its profitability. The profitability is the major indicator of investor activity and one of its main goals. Therefore, the profitability value can be used as indicator for the analysis and comparison of alternative investment markets.

On the basis of the analysis, there were established the time series of profitability for each studied market, which have the persistence, and which are qualified for forecasting. The memory depth was calculated for the reporting persistent series. It became the fundamental basis for creating of the forecast models based on application of neural networks in the software product Deductor.

Since there are considered three different markets, with different characteristics and features, so there were constructed three different neural network models. There were used the persistent profitability series with the lag of 21 days (Hurst index 0.82), with the lag of 10 days (H=0.83), and with the lag of 15 days (H=0.81), to train the neural networks.

Conclusions. In the current study, the statistical and fractal analysis methods were used to analyze and compare the dynamics of prices and profitability of three investment markets against each other, namely the precious metals market, for example the prices of gold, the Forex exchange market, with the example of the currency pair EUR/USD (V), and the cryptocurrency market, for example bitcoin.

The TS Z, V have the statistical characteristics of normal distribution, including the absence of the well-defined trend, fluctuations within the average values, symmetry of distribution. The TS V demonstrates the lowest volatility. The dynamics of the TS B are starkly different from the TS Z, V: there is a significant exponential trend, significant growth rates, asymmetry and high volatility.

Within frames of calculating of the Hurst index and making of the tests on the deterministic chaos (the drift attractor test, construction of the pseudo-phase space, the Gilmore test), it was found that the above-mentioned time series of prices have the strongly marked fractal dynamics, therefore there was used the method of the sequential R/S analysis to calculate the features of the memory depth for each studied ST.

The profitability of investment tool is the universal indicator, which is the determining one, in terms of comparing of the investment markets. In addition, specifying of the time interval, in which the profitability becomes persistent and displays the characteristics of the price, gives new opportunities for the analysis and choosing of the best investment tool, in terms of the reasonable forecast horizon. For example, it was found that the profitability of bitcoin gets the

persistence at the value of the lag of 10 days (the Hurst index totals H=0.829), which validates the application of the tool for the short-term investment purposes.

The definition of the TS of "delayed" profitability, which the TS get the persistence, and calculation of the fuzzy memory depth, became the basis for construction of the forecast model, based on the neural network in the software product Deductor for each studied investment tool.

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