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CRYPTOCURRENCY MARKET TRENDS AND FUNDAMENTAL ECONOMIC INDICATORS: CORRELATION AND REGRESSION ANALYSIS

Abstract. The first cryptocurrency was born in 2008. Already today, virtual financial assets and tokens are a significant part of trading in global financial markets. The cryptocurrency market capitalization currently exceeds 600 billion U.S. dollars. However, there is a lot of discussion about cryptocurrency functions and the correlation between Bitcoin prices and the basic economic indices.

Therefore, the purpose of the paper is to define the statistical substantiation of the influence of fundamental economic indicators on the market of virtual financial assets and the possibility of using cryptocurrency as the investment assets.

This article is based on the theoretical principles and methods of econometric analysis; the system approach methods to define the main vehicles and trends of the international financial market. The study presents correlation analysis, regression models with paired and multiple variables. For these models, R-Studio instruments are the main tools of quality estimation and results interpretation.

The article shows the results of the correlation analysis of Bitcoin's U.S. dollar price dynamics and changes in the main stock, monetary market indicators, cryptocurrencies market tendency, levels of the United States fundamental economic indicators for the period from 2014 to 2021. Traditional multifactorial regression models are used to determine the level and the impact of individual indicators of the world stock market at the U.S. dollar price of Bitcoin. A comparison of the level of volatility of key investment financial assets in the market of cryptocurrencies and stock markets is carried out.

The authors determine the level of correlation dependence and make a regression model of the impact of fundamental economic indicators and stock market trends on the dynamics of U.S. dollar prices for key cryptocurrencies. The article presents conclusions on trends and problems of using cryptocurrencies as an investment asset, considering volatility and profitability.

Implementation of the results allows to clarify the economic essence of cryptocurrencies as a specific financial vehicle, as well as improving the existing models of investment management, considering the statistical characteristics of the virtual financial assets.

The main direction of further research is to build models of medium-term prediction of prices for the main cryptocurrencies as an investment asset in conditions of changes in global financial markets, which must consider the fundamental economic indicators of the world economy and trends on key stock and commodity markets.

***Keywords*:** virtual financial asset, cryptocurrency, bitcoin, econometric model, financial market, economic indicator, investment asset.

JEL Classification D53, E44, G15, C58

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ТЕНДЕНЦІЇ РОЗВИТКУ РИНКУ КРИПТОВАЛЮТ І ФУНДАМЕНТАЛЬНІ ЕКОНОМІЧНІ ІНДИКАТОРИ: АНАЛІЗ КОРРЕЛЯЦІЇ ТА РЕГРЕСІЇ

Анотація. Перша криптовалюта народилася 2008 року. Уже сьогодні віртуальні фінансові активи та токени є значною частиною торгівлі на світових фінансових ринках. Ринкова капіталізація криптовалют у даний час становить більш ніж 600 мільярдів доларів США. Однак існує багато обговорень щодо функцій криптовалюти і співвідношення між цінами біткоїна і основними економічними показниками.

Тому метою роботи є статистичне обґрунтування впливу фундаментальних економічних показників на ринок віртуальних фінансових активів та можливості використання криптовалюти як інвестиційного активу.

Ця стаття базується на теоретичних засадах і методах економетричного аналізу; системного підходу для визначення основних інструментів і тенденцій розвитку світового фінансового ринку. Представлено кореляційні оцінки, регресійні моделі з парними та множинними змінними. Інструменти R-Studio є основними для оцінки якості та інтерпретації результатів для цих моделей.

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Наведено результати кореляційного аналізу динаміки цін біткоїна в доларах США і змін у фондових показниках, індикаторах грошового ринку, тенденцій на ринку криптовалют, рівня фундаментальних економічних індикаторів розвитку США за період з 2014 до 2021 рр. Традиційні багатофакторні регресійні моделі використовуються для визначення рівня і значущості впливу окремих показників світового фондового ринку на ціну біткоїна в доларах США. Проведено порівняння рівня волатильності ключових інвестиційних фінансових активів на ринку криптовалют і фондових ринках.

Визначено рівень кореляційної залежності та складено регресійну модель впливу фундаментальних економічних показників і трендів фондового ринку на динаміку цін на ключові криптовалюти. Наведено висновки щодо тенденцій і проблем використання криптовалюти як інвестиційного активу з урахуванням рівня волатильності та прибутковості.

Реалізація отриманих результатів дозволяє уточнити економічну сутність криптовалюти як специфічного фінансового інструменту, а також вдосконалити наявні моделі інвестиційного менеджменту з урахуванням статистичних властивостей віртуальних фінансових активів.

Основним напрямом дальших досліджень є побудова моделей середньострокового прогнозування цін на ключові криптовалюти як інвестиційні активи в умовах змін світових фінансових ринків, що повинні враховувати фундаментальні економічні індикатори розвитку економіки світу, тренди на ключових фондових і товарних ринках.

***Ключові слова*:** віртуальний фінансовий актив, криптовалюта, біткоїн, економетрична модель, фінансовий ринок, економічний індикатор, інвестиційний актив.

Формул: 3; рис.: 3; табл.: 3; бібл.: 31.

Introduction. After 2008—2009 the World financial system has been significantly changed. Cryptocurrencies offer a contemporary investment vehicle that is based on decentralization system blockchain technology. The price of Bitcoin has risen since 2014 from 465 U.S. dollars to 60,000 U.S. dollars [6]. Therefore, many investors and other financial professionals are interested in cryptocurrencies as a high profitability asset. This dramatic price change and related volatility level had generated significant changes in traditional investment theory. On the one hand, there is a high risk of a financial bubble. On the other hand, cryptocurrency assets acquire their value and price outside of financial speculation. Financial professionals and researchers disagree on the nature and meaning of Bitcoin and other virtual financial assets. Government regulators impose restrictions on the use of cryptocurrencies as means of payment. Therefore, there is significant interest in virtual financial assets from investors, as well as theoretical substantiation of the influence of fundamental economic indicators on prices and volatility of the cryptocurrency market. Thus, the problem of evaluating the ability to use the virtual financial vehicle as an investment asset is urgent for individual and institution investors.

Literature review and the problem statement. There are a lot of studies that concentrate attention on different problems of fundamental macroeconomic indicators trends, exchange rates forecasting, real cryptocurrency prices defining, and other econometric problems. Firstly, Fantaccini D., da Silva A. C., Maganini N. D., Almeida E. F., Garcia D., Tessone C. J., Kristoufek L., Hunter G. W., Li J., Tasca P. etc. [1; 2; 7; 11; 13; 15; 16; 18; 26] show blockchain technology specifics as a base of the Bitcoin price level. The study identifies the following price drivers of the virtual financial asset exchange rates, bitcoin circulation speed, network complexity, number of coins in circulation. In addition, the studies define a method of financial bubblies forecasting. Secondly, there is a lot of research in the field of determining the macroeconomic basis for the formation of prices and volatility of financial assets [4; 12; 14; 19; 20; 24; 27; 28]. Choudhry T., Hryhoruk P., Kandilov I. T., May J. B., Morina F., Serenis D. and Symitsi E. define fundamental economic indicators as the basis for the formation of long-term prices for investment financial assets, such as GDP, levels of imports and exports, consumer price index, level of government expenders. As a result, the authors show the investment potential level (profitability

and risk estimations) of the contemporary financial vehicles. Thirdly, Stock market trends and exchange rate dynamics have been an object of different studies [3; 3; 2120]. Aghion P., Baranovskyi O. I. and Omane-Adjepong M. identify and statistically prove the presence of trends in the related markets because of the impact of fundamental economic factors. For example, economic growth indicators have a high correlation with stock market indexes. Therefore, a comparison of trends in financial markets and cryptocurrency markets deserves the special interest of researchers.

Financial mathematics and regression methods are widely used to confirm links between financial market indicators, macroeconomic trends, and prediction of the results of using contemporary investment vehicles. Baranovskyi O. I., Derbentseva V., Dirk G., Hryhoruk P., Perchuk O. V., Yuzvovich L. I. and etc. [3; 8; 9; 12; 22; 31] show regression, correlation, and time-series models for analysis and predict basic and contemporary financial markets instruments and currency rate dynamics. But these models require practical adaptation to determine the correlation of cryptocurrency assets and predict prices.

The purpose of the paper is to define the statistical substantiation of the influence of fundamental economic indicators on the market of virtual financial assets and the possibility of using cryptocurrency as investment assets.

There are key research hypotheses.

H1: The dynamics of the Bitcoin prices correlate with fundamental indicators of the global stock market trend.

H2: Cryptocurrency cannot be an investment asset due to its high volatility.

H3: Fundamental economic indicators (e.g., U.S. economy) have a high correlation with the cryptocurrency's asset price.

Research methods. The investigation is based on classical methods of correlation analysis, multiple regression modeling and machine learning methods, and R-programming instruments (caret and Performance Analytics libraries). The function model includes evaluating the elasticity parameters as follows [3; 4; 12; 17; 25]:

$$y = \beta_0 \prod_{i=1}^{n} \left(x_i^{\beta_i} \right) \cdot \varepsilon, \tag{1}$$

for regression evaluation is [3; 4; 12; 17; 25]:

$$\ln (y) = \ln (\beta_0) + \sum_{i=1}^{n} (\beta_i \cdot \ln (x_i)) + \ln (\varepsilon), \tag{2}$$

where y — dependent variable (BTC price in USD or other economic indicators);

β_0 — intercept coefficient (unregistered factors influence);

β_i — factor's elasticity coefficients ($i = \overline{1 \ldots n}$);

ε — level of normal error evaluation.

For further research, the Person's correlation coefficients and classical multiple regression methods will be used. They are based on relationships between the U.S. Dollar price of Bitcoin and fundamental economic indicators, stock market indices, and altcoin cryptocurrencies price dynamics. Coefficient performances of the proposed models are presented and estimated by the Akaike information criterion (AIC), adjusted multiple R-squared, F-statistic, the variance inflation factor (VIF), p-value for studentized Breusch-Pagan test, and so on [8; 3; 17; 23; 29].

Further research is based on the same assumptions and includes the following variables for cryptocurrency market trends estimations and fundamental economic indicators analysis.

Dependent variables (CoinMarketCap data, currency in U.S. dollar*):*

BTC.USD — Bitcoin price, daily close values (a quarterly average of daily close values for use to the USA economy fundament indices correlation estimation).

Global financial market indicators (period from 09-2014 to 03-2021):

X.DJI — Dow Jones Industrial Average (^DJI). DJI Real Time Price;

X.RUT — Russell 2000 (^RUT). Chicago Options Delayed Price;

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X.IXIC — NASDAQ Composite (^IXIC). Nasdaq GIDS Real Time Price;

AAPL — Apple Inc. share price (AAPL). NasdaqGS Real Time Price data. Currency in U.S. dollar;

MSFT — Microsoft Corporation share price (MSFT). NasdaqGS Real Time Price data. Currency in U.S. dollar;

GC.F — Gold Futures, Jun 21 (GC=F). COMEX Delayed Price data. Currency in U.S. dollar.

CL.F — Crude Oil Futures, Jun 21 (CL=F). NY Mercantile Delayed Price data. Currency in U.S. dollar

ZC.F — Corn Futures, Jul-2021 (ZC=F). CBOT Delayed Price data. Currency in U.S. dollar.

ZR.F — Corn Futures, Jul-2021 (ZC=F). CBOT Delayed Price data. Currency in U.S. dollar.

EURUSD — EURO currency price. CCY Delayed Price data. Currency in U.S. dollar.

Cryptocurrencies market indicators (CoinMarketCap data for the period from 07-2017 to 03-2021. Daily close values. Currency in U.S. dollar):

ETH.USD — Ethereum cryptocurrency daily price in U.S. dollar;

BNB.USD — BinanceCoin cryptocurrency daily price in U.S. dollar;

XRP.USD — Ripple cryptocurrency daily price in U.S. dollar;

USDT.USD — Tether/USDT cryptocurrency daily price in U.S. dollar;

DOGE.USD — Dogecoin cryptocurrency daily price in U.S. dollar;

BCH.USD — Bitcoin cash cryptocurrency daily price in U.S. dollar;

LTC.USD — Litecoin cryptocurrency daily price in U.S. dollar.

Fundamental economic indices from U.S. Federal Reserve Bank economic research data (FRED quarterly data for the period from Q1 2018 to Q4 2020):

GDP — U.S. Gross Domestic Product, Billions of Dollars;

GDPC1 — U.S. Real Gross Domestic Product, Billions of Chained 2012 Dollars;

CPI — Consumer Price Index: All Items for the United States, Index 2015=100;

TW — Trade Weighted U.S. Dollar Index: Broad, Goods and Services (Index Jan 2006=100, Daily);

DXY — US Dollar/USDX – Index — Cash (DX-Y.NYB), NYBOT Real Time Price. Currency in USD.

The variables have been selected considering the result of research [4; 12; 14; 19; 20; 24; 288], as well as a result of processing the data, which are represented by the US Federal Reserve System, Yandex Finance, etc. [6; 10; 30].

Research results.

The impact of stock market trends on Bitcoin U.S. dollar price. For the past 12 years, after Bitcoin has arisen, the digital economy has shown dramatic change.

In 2014 lots of alternative virtual financial assets were bubbling growth or showing effective growth strategy (*Fig. 1*).

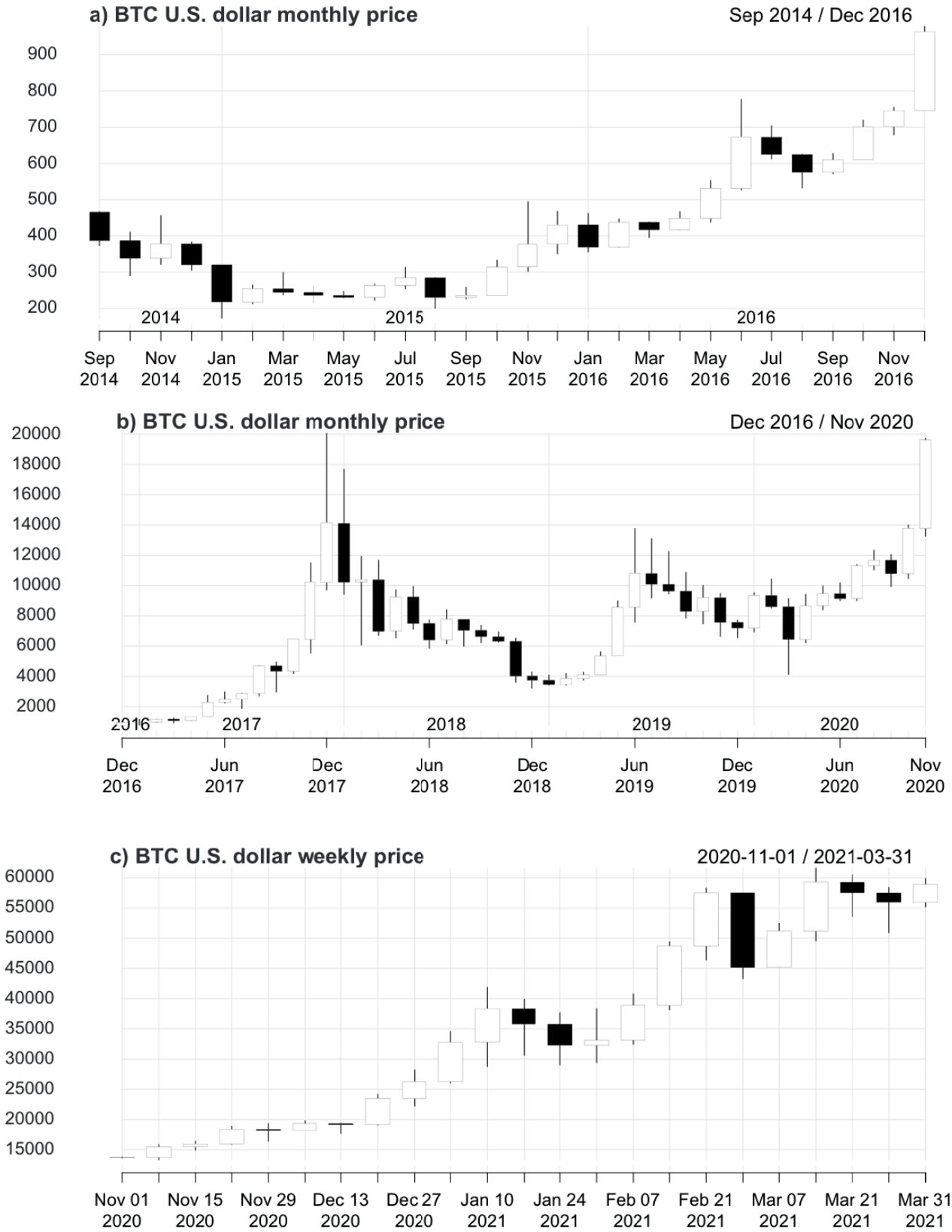

Fig. 1. **Dynamics of the Bitcoins price by 3 bubbling periods (years 2014—2021),** the U.S. dollar price

As it is shown in *Fig 1*, the dynamic of Bitcoin price changing can be split into the following subperiods. First, from 2008 to 2014, the period of blockchain technology extensive progress and low fluctuating in Bitcoin price. The Bitcoin price has become a part of the

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international financial market only in the middle of 2014. Second, from the middle of 2014 to 2016, the time of the first cryptocurrency market bubbling (*Fig. 1a*). A lot of alternative virtual financial assets and tokens have arise at a time. For example, the Etherium was born in 2015, the DASH first block was generated in 2014. Altcoins had begun to represent more innovation, profitability, and risk. Cryptocurrency market platforms and related mining technologies has gained popularity and generated high demand. Third, the period from Dec 2016 to Nov 2020 is the time, when the cryptocurrency market has got some stabilization trends (*Fig. 1b*). The average Bitcoin price was 9000 U.S. dollars and cryptocurrency assets had become widely used as investment vehicles. Forth, the last period, which began in November 2020 and continues now (*Fig. 1c*). There is a second bubbling period. *Fig. 1* shows that the volatility of the bitcoin market within the considered periods is not high. However, from Sep 2014 to Feb 2021 the Bitcoin U.S. dollar price has risen more than 150 times.

Now, investors use virtual financial assets as a highly risky financial vehicle, but which is carried out enormous profitability potential. There is correlation estimation (*Table 1*) for the goal of further research and verifying of hypothesis H1.

Table 1

Pearson's correlation coefficient for Bitcoin U.S. price and the main stock market indices

Variables	Pearson's coefficient (linear)	p-value	Pearson's coefficient (*ln* transformation)	p-value
BTC.USD	1.00	*<<0,001*	1.00	*<<0,001*
X.DJI	**0.75**	*<<0,001*	**0.96**	*<<0,001*
X.RUT	**0.83**	*<<0,001*	*0.86*	*<<0,001*
X.IXIC	**0.83**	*<<0,001*	**0.92**	*<<0,001*
AAPL	**0.79**	*<<0,001*	0.86	*<<0,001*
MSFT	**0.76**	*<<0,001*	**0.92**	*<<0,001*
GC.F	0.65	*<<0,001*	*0.72*	*<<0,001*
CL.F	0.12	*<<0,001*	0.12	*<<0,001*
ZC.F	**0.72**	*<<0,001*	0.28	*<<0,001*
ZR.F	0.39	*<<0,001*	0.48	*<<0,001*
EURUSD	0.38	*<<0,001*	0.36	*<<0,001*

Table 1 shows Pearson Correlation Coefficients of the general financial market indices and Bitcoin price in USD. They have been calculated on datasets for the period from Sep 2014 to Mar 2021. There is a high linear correlation (coefficient greater than 0.7) between Bitcoin U.S. dollar price and Dow Jones Industrial Average index, Russell 2000, NASDAQ Composite, Apple Inc., and Microsoft Corporation share price, and even Corn Futures price (*ZC.F*). The highest logographic impact (coefficient greater than 0.9) on Bitcoin U.S. dollar price shows Dow Jones Industrial Average and NASDAQ Composite index, Microsoft Corporation share price, and Gold Futures. In addition, the EURO price in U.S. dollars is practically independent of fluctuations in the cryptocurrency market (coefficient less than 0.4).

Regarding the results (see *Table 1*), hypothesis H1 cannot be rejected. There is a correlation between the dynamics of the Bitcoin prices and key stock market indexes, share prices, and product futures.

Considering the correlation analysis result, power regression model (Model 1) of the stock market vehicles impact on Bitcoin prices can be estimated. The following variables were excluded from further analysis due to their high multicollinearity: *X.IXIC, AAPL, MSFT, X.DJI*. The method of the least squares is used, which is known as a standard approach to regression analysis and R-Studio tools to approximate the key factors influence.

Model 1. Multivariate regression Bitcoin U.S. price with Russell 2000 index and Gold Futures.

Residuals:
```
   Min     1Q  Median     3Q    Max
-2.3671 -1.2078  0.2273  1.1461  2.3880

Coefficients:
     Estimate Std. Error t value Pr(>|t|)
X.RUT   2.7100     0.2256  12.015  < 2e-16 ***
GC.F   -1.6426     0.2270  -7.236 7.17e-13 ***

Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ‘ 1

Residual standard error: 1.387 on 1588 degrees of freedom
Multiple R-squared:  0.9696,     Adjusted R-squared:  0.9695
F-statistic: 2.529e+04 on 2 and 1588 DF,  p-value: < 2.2e-16
```

The Model 1 estimation result shows a high level of the model and coefficients' performances. Intercept of Model 1 is not statistically significant and excluded.

The mathematical form of Model 1 is as follows:

$$BTC.USD = X.RUT^{2.71} GC.F^{-1.64}. \quad (3)$$

Therefore, it is a direct influence of the Russell 2000 Index dynamics on Bitcoin prices and an inverse relationship with the prices of Gol Futures. The corresponding elasticity coefficients show that a 1% increase in the Russell 2000 index is associated with a 2.71% increase in the Bitcoin U.S. dollar price. On the other hand, a 1% increase in Gold Futures price occurs with a simultaneous decrease in the Bitcoin U.S. dollar price by 1.64%. This is very impotent to prove hypothesis H1 and it can be used to optimize an investment portfolio.

Correlation between top cryptocurrencies. Many cryptocurrencies have been issued since 2014, during the first bubbling period. Some cryptocurrency projects have gone bankrupt, but many altcoins have entered the open markets and have added value of innovative technology. For further analysis we have selected 8 top virtual financial assets, chosen by capitalization level [6]. The correlation for the following investment vehicles shows in *Table 2*.

Table 2

Pearson's linear correlation matrix between the basic cryptocurrencies

Variables	*BTC. USD*	*ETH. USD*	*BNB. USD*	*XRP. USD*	*USDT. USD*	*DOGE. USD*	*BCH.USD*	*LTC.USD*	*EURUSD*
BTC.USD		0,87	0,88	0,13	-0,06	**0,88**	0,10	0,56	0,37
ETH.USD	**0,87**		0,71	0,46	-0,06	**0,82**	0,45	**0,78**	0,65
BNB.USD	**0,88**	**0,71**		0,04	-0,06	**0,89**	-0,04	0,41	0,17
XRP.USD	0,13	0,46	0,04		0,00	0,17	**0,78**	**0,70**	0,47
USDT.USD	-0,06	-0,06	-0,06	0,00		-0,05	0,05	0,06	-0,06
DOGE.USD	**0,88**	**0,82**	**0,89**	0,17	-0,05		0,10	0,50	0,30
BCH.USD	0,10	0,45	-0,04	**0,78**	0,05	0,10		**0,77**	0,50
LTC.USD	0,56	**0,78**	0,41	**0,70**	0,06	0,50	**0,77**		0,57
EURUSD	0,37	0,65	0,17	0,47	-0,06	0,30	0,50	0,57	

As it is shown in *Table 2*, the top 3 cryptocurrencies are highly correlated. Linear impact of Bitcoin price in U.S. dollar has more than 0.8 Pearson's linear correlation coefficient with Etherium and BinanceCoin price in U.S. dollar. A direct relationship is observed between all the top 8 cryptocurrencies, except for Tether/USDT. Tether Coin (USDT) is a stable token project to replace

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the fiat dollar based on blockchain technology. The main function of USDT is to be a means of payment and settlement, not to maximize investment returns. Thus, the correlation of major cryptocurrencies makes them homogeneous in terms of the level of covariance within the investment portfolio. However, like any investment asset, Bitcoin has a specific rate of return dynamics (*Fig. 2*).

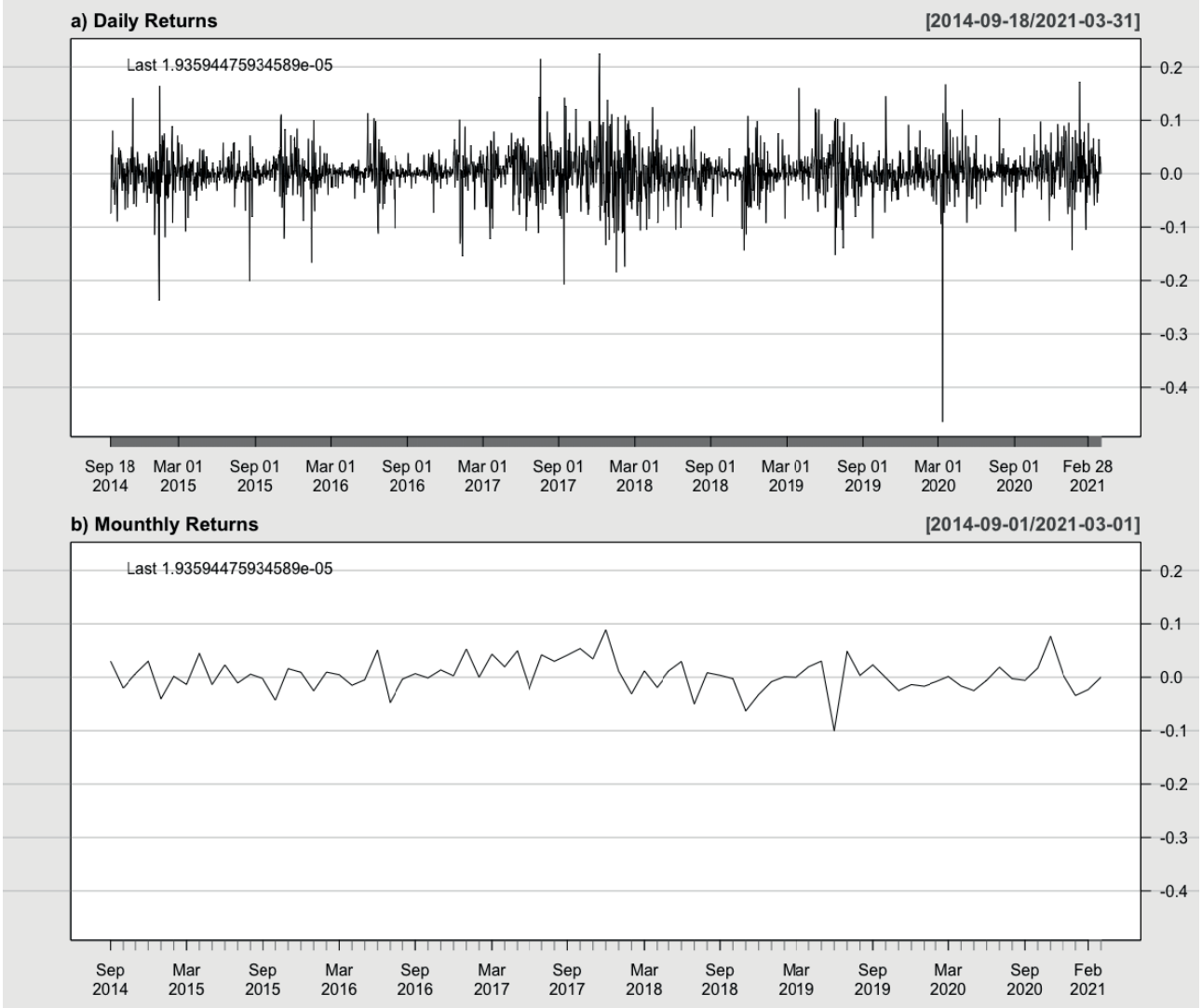

Fig. 2. **Dynamics of the Bitcoin log-returns rate (years 2014—2021)**

Fig. 2 shows the high volatility of the Bitcoin returns rate for the daily period (*Fig. 2a*), but not grater than 0,2 standard deviation. For the average monthly return, these fluctuations do not exceed 0.1 standard deviations.

Therefore, Bitcoin daily profitability indicators do not allow accepting the hypothesis H2 about using cryptocurrencies as an investment asset due to high volatility.

A graphical analysis of the indicators of the returns rate (see *Fig. 2*) proves the opposite. Bitcoin can be a risky investment asset.

An additional argument for rejecting hypothesis H2 is provided by an analysis of the mean, standard deviation, and coefficient of variation for the price level and rate of return of other financial market indicators (*Table 3*). The analysis of volatility indicators of stock market and cryptocurrency market vehicles confirms the possibility of their using as investment assets.

Table 3

Volatility analysis for price and rate of return of the basic financial market investment vehicles

Variables	Price			Rate of return		
	Mean	Standard deviation	Variation coefficient	Mean	Standard deviation	Variation coefficient
Period from 2017-07 to 2021-03						
BTC.USD	10998,16	10332,21	0,94	0,0033	0,0506	15,1290
ETH.USD	416,03	380,87	0,92	0,0024	0,0630	26,4403
BNB.USD	24,93	45,08	1,81	0,0085	0,0955	11,2245
XRP.USD	0,40	0,32	0,80	0,0013	0,0764	61,0224
USDT.USD	1,00	0,01	0,01	0,0000	0,0061	26273,6785
DOGE.USD	0,01	0,01	1,98	0,0036	0,0913	25,0224
BCH.USD	523,80	492,87	0,94	0,0003	0,0844	273,2020
LTC.USD	85,74	55,92	0,65	0,0016	0,0675	40,9190
Period from 2014-09 to 2021-03						
BTC.USD	6390,87	9349,04	1,46	0,0031	0,0470	15,3871
X.DJI	22596,37	4396,25	0,19	0,0004	0,0121	29,5343
X.RUT	1424,57	253,14	0,18	0,0004	0,0148	35,9676
X.IXIC	7060,10	2312,55	0,33	0,0007	0,0132	19,7567
AAPL	48,51	29,65	0,61	0,0011	0,0188	17,9182
MSFT	98,03	58,50	0,60	0,0011	0,0174	15,8222
GC.F	1357,95	228,49	0,17	0,0002	0,0094	45,7446
CL.F	52,04	12,21	0,23	0,0001	0,0319	232,5607
ZC.F	374,24	42,15	0,11	0,0003	0,0151	47,8661
ZR.F	1157,77	150,73	0,13	0,0000	0,0175	533,2269
EURUSD	1,14	0,05	0,04	-0,0001	0,0053	-84,7657

For example, the coefficient of variation (risk level) of Bitcoin U.S. dollar price is twice as high as for Apple and Microsoft stock share U.S. dollar price, but the related rate of return is almost three times higher. The risk level for the Litecoin car and the Microsoft share is approximately 0.6, but the level of profitability of the cryptocurrency is 2 percentage points higher. On other hand, Tether/USDT coin has a low volatility level and approximately zero returns rate. In general, over shorter periods, the level of variation in cryptocurrency prices is lower, while maintaining significant profitability. Thus, the results of the study showes that we cannot accept the H2 hypothesis, since some of the top 8 cryptocurrencies can be efficient investment assets.

The impact of the USA economy indices on Bitcoin price. The decentralized blockchain network and Bitcoin are independent tools from state emission. However, market trends affect both fundamental economic indicators and cryptocurrency prices.

To confirm these dependencies, we will estimate the correlation between the price of Bitcoin (the first in terms of cryptocurrency capitalization) and individual indicators of the development of the US economy (*Fig. 3*).

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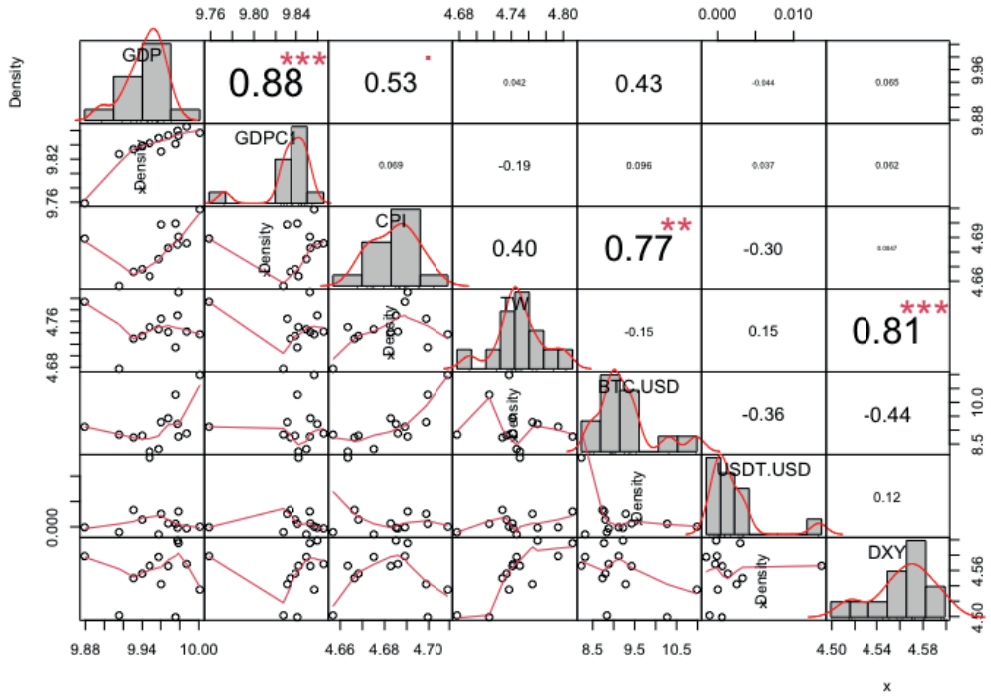

Fig. 3. **Pearson's linear correlation matrix between the basic cryptocurrencies the fundamental macroeconomic indicators for the USA economy**

In accordance with *Fig. 3*, there is only one macroeconomic indicator for the USA economy has a significant correlation with Bitcoin U.S. dollar price. There is a Consumer Price Index for All Items for the United States (*CPI*). Furthermore, *CPI* positive correlation and *DXY* negative correlation with Bitcoin U.S. dollar price confirm the outpacing growth of the value of the cryptocurrency concerning the real value of the USD.

However, the correlation analyzes result does not allow to either confirm or to refute the hypothesis H3. Thus, further research is required on the correlation between fundamental economic indicators (except for inflation indicators) and prices for currencies.

Conclusion. Correlation analysis and multiple regression modeling results, which are based on data of financial and stock markets for the last few years, show their significant impact on cryptocurrency prices and other contemporary investment vehicles. The USA economy fundamental indices have low correlation with the Bitcoin U.S. dollar price. It has been proven that cryptocurrency can be an effective investment asset with high rate of returns and high volatility. The direction of further research consists of improving the classical models of investment management, adopting strategies for an effective investment portfolio.

Література

1. Фантаццини Д., Нигматуллин Э. М., Сухановская В. Н., Ивлиев С. В. Все, что вы хотели знать о моделировании биткойна, но боялись спросить. Ч. 2. *Прикладная эконометрика.* 2017. № 1 (45). С. 5—28. URL : https://cyberleninka.ru/article/n/vse-chto-vy-hoteli-znat-o-modelirovanii-bitkoyna-no-boyalis-sprosit-chast-2.
2. Фантаццини Д., Нигматуллин Э. М., Сухановская В. Н., Ивлиев С. В. Все, что вы хотели знать о моделировании биткойна, но боялись спросить. Ч. 1. *Прикладная эконометрика.* 2016. № 4 (44). С. 5—24. URL : https://cyberleninka.ru/article/n/vse-chto-vy-hoteli-znat-o-modelirovanii-bitkoyna-no-boyalis-sprosit-chast-i.
3. Aghion P., Bacchetta P., Ranciere R., Rogoff K. Exchange rate volatility and productivity growth: The role of financial development. *Journal of Monetary Economics.* 2009. № 56 (4). P. 494—513.
4. Baranovskyi O. I., Kuzheliev M. O., Zherlitsyn D. M., Sokyrko O. S., Nechyporenko A. V. Econometric models of monetary policy effectiveness in Ukraine. *Financial and Credit Activity-Problems of Theory and Practice.* 2019. № 3 (30). P. 226—235.
5. Choudhry T., Ul Hassan S. S., Papadimitriou F. I. UK imports, third country effect and the global financial crisis: Evidence from the asymmetric ARDL method. *International Review of Financial Analysis.* 2014. № 32. P. 199—208.
6. CoinMarketCap. Pice-tracking website for cryptoassets in the rapidly growing cryptocurrency space. 2021. Retrieved from https://coinmarketcap.com.
7. da Silva A. C., Maganini N. D., de Almeida E. F. Multifractal analysis of Bitcoin market. *Physica a-Statistical Mechanics and Its Applications.* 2018. № 512. P. 954—967.

8. Derbentseva V., Babenko V., Khrustalevc K., Obruchd H., Khrustalova S. Comparative performance of machine learning ensemble algorithms for forecasting cryptocurrency prices. *International Journal of Engineering.* 2021. Vol. 34. № 1. P. 140—148. URL : http://www.ije.ir/article_122162.html.
9. Baur D. G., Hong KiHoon, Lee A. D. Bitcoin: Medium of exchange or speculative assets? *Journal of International Financial Markets, Institutions and Money.* 2018. Vol. 54. P. 177—189.
10. FRED. Federal Reserve Economic Data since 1991. 2021. URL : https://fred.stlouisfed.org.
11. Garcia D., Tessone C. J., Mavrodiev P., Perony N. The digital traces of bubbles: feedback cycles between socio-economic signals in the Bitcoin economy. *Journal of the Royal Society Interface.* 2014. № 11 (99). Article 20140623.
12. Hryhoruk P., Khrushch N., Grygoruk S. An Approach to Design a Composite Index of Economic Development and Identifying the Bounds of its Levels. *2019 9th International Conference on Advanced Computer Information Technologies (Acit'2019).* 2019. (pp. 48—51).
13. Hunter G. W., Kerr C. Virtual Money Illusion and the Fundamental Value of Non-Fiat Anonymous Digital Payment Methods: Coining a (Bit of) Theory to Describe and Measure the Bitcoin Phenomenon. *International Advances in Economic Research.* 2019. № 25 (2). P. 151—164.
14. Kandilov I. T. The effects of exchange rate volatility on agricultural trade. *American Journal of Agricultural Economics.* 2008. № 90 (4). P. 1028—1043.
15. Kozlovskyi S., Bilenko D., Kuzheliev M., Lavrov R., Kozlovskyi V., Mazur H., Taranych A. The system dynamic model of the labor migrant policy in economic growth affected by COVID-19. *Global Journal of Environmental Science and Management.* 2020. № 6 (SI). P. 95—106.
16. Kristoufek L. BitCoin meets Google Trends and Wikipedia: Quantifying the relationship between phenomena of the Internet era. *Scientific Reports.* 2013. № 3. Article 3415.
17. Kuzheliev M. O., Zherlitsyn D. M., Nechyporenko A. V. Bioresources Price Trend and GDP Growth Adjustment. *International Journal of Advanced Biotechnology and Research.* 2019. Vol. 10. Special Issue 1. P. 379—383. URL : https://bipublication.com/files/ijabr2019sp154Mykhailo.pdf.
18. Li J. P., Naqvi B., Rizvi S. K. A., Chang H. L. Bitcoin: The biggest financial innovation of fourth industrial revolution and a portfolio's efficiency booster. *Technological Forecasting and Social Change.* 2021. № 162. Article 120383.
19. May J. B. International financial volatility and commodity exports: evidence from the thai agricultural sector. *American Journal of Agricultural Economics.* 2010. № 92 (3). P. 763—775.
20. Morina F., Hysa E., Ergun U., Panait M., Voica M. C. The Effect of Exchange Rate Volatility on Economic Growth: Case of the CEE Countries [Article]. *Journal of Risk and Financial Management.* 2020. № 13 (8). P. 13. Article 177.
21. Omane-Adjepong M., Alagidede I. P. Dynamic Linkages and Economic Role of Leading Cryptocurrencies in an Emerging Market. *Asia-Pacific Financial Markets.* 2020. № 27 (4). P. 537—585.
22. Perchuk O. V., Makarchuk I. M., Yaremenko L. M. The prospects of using cryptocurrency bitcoin as a financial innovation in the information economy of Ukraine. *Financial and Credit Activity-Problems of Theory and Practice.* 2019. № 4 (31). P. 419—427.
23. Regenstein J. K. Reproducible finance with R: Code flows and shiny apps for portfolio analysis. *CRC Press.* 2019. 230 p.
24. Serenis D., Tsounis N. A new approach for measuring volatility of the exchange rate. N. Tsounis, A. Vlahvei (Eds.). *International Conference on Applied Economics.* 2012. Vol. 1. (pp. 374—382).
25. Symitsi E., Chalvatzis K. J. The economic value of Bitcoin: A portfolio analysis of currencies, gold, oil and stocks. *Research in International Business and Finance.* 2019. № 48. P. 97—110.
26. Tasca P., Hayes A., Liu S. W. The evolution of the bitcoin economy: Extracting and analyzing the network of payment relationships. *Journal of Risk Finance.* 2018. № 19 (2). P. 94—126.
27. Telnova H., Kolodiziev O., Kuzheliev M., Krupka I., Boiko N. Foreign direct investment in the eurozone countries: stochasticity of the financial influence factors. *Financial and Credit Activity-Problems of Theory and Practice.* 2020. № 4 (35). P. 107—120.
28. Tunc C., Babuscu S., Hazar A., Solakoglu M. N. Exchange Rate Volatility and Trade: External Exchange Rate Volatility Matters. *Journal of International Commerce Economics and Policy.* 2020. № 11 (2). P. 19. Article 2050006.
29. Voronenko I., Skrypnyk A., Klymenko N., Zherlitsyn D., Starychenko Y. Food security risk in Ukraine: assessment and forecast. *Agricultural and Resource Economics.* 2020. № 6 (4). P. 63—75. URL : https://are-journal.com/index.php/are/article/view/364.
30. Yahoo! Finance Data (by quantmod). 2021. URL : https://finance.yahoo.com.
31. Yuzvovich L. I., Isakova N. Y., Mokeeva N. N. Bitcoin financial bubbles: digitalization and modeling. A. Nazarov (Ed.). *Proceedings of the 1st International Scientific Conference Modern Management Trends and the Digital Economy: from Regional Development to Global Economic Growth.* 2019. Vol. 81. P. 63—68.

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References

1. Fantaccini, D., Nigmatullin, E. M., Suhanovskaya, V. N., & Ivliev, S. V. (2017). Vse, chto vy hoteli znat' o modelirovanii bitkojna, no boyalis' sprosit'. Ch. 2 [Everything you wanted to know about Bitcoin modeling, but were afraid to ask. Part 2]. *Prikladnaya ekonometrika — Applied Econometrics, 1* (45), 5—28. Retrieved from https://cyberleninka.ru/article/n/vse-chto-vy-hoteli-znat-o-modelirovanii-bitkoyna-no-boyalis-sprosit-chast-2 [in Russian].
2. Fantaccini, D., Nigmatullin, E. M., Sukhanovskaya, V. N., & Ivliev, S. V. (2016). Vse, chto vy hoteli znat' o modelirovanii bitkojna, no boyalis' sprosit'. Ch. 1 [Everything you wanted to know about Bitcoin Simulation but were afraid to ask. Part 1]. *Prikladnaya ekonometrika — Applied Econometrics, 4* (44)), 5—24. Retrieved from https://cyberleninka.ru/article/n/vse-chto-vy-hoteli-znat-o-modelirovanii-bitkoyna-no-boyalis-sprosit-chast-i [in Russian].
3. Aghion, P., Bacchetta, P., Ranciere, R., & Rogoff, K. (2009). Exchange rate volatility and productivity growth: The role of financial development. *Journal of Monetary Economics, 56* (4), 494—513. https://doi.org/10.1016/j.jmoneco.2009.03.015.

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4. Baranovskyi, O. I., Kuzheliev, M. O., Zherlitsyn, D. M., Sokyrko, O. S., & Nechyporenko, A. V. (2019). Econometric models of monetary policy effectiveness in Ukraine. *Financial and Credit Activity-Problems of Theory and Practice, 3* (30), 226—235. https://doi.org/10.18371/fcaptp.v3i30.179546.
5. Choudhry, T., Ul Hassan, S. S., & Papadimitriou, F. I. (2014). UK imports, third country effect and the global financial crisis: Evidence from the asymmetric ARDL method. *International Review of Financial Analysis, 32*, 199—208. https://doi.org/10.1016/j.irfa.2013.11.003.
6. CoinMarketCap. (2021). Pice-tracking website for cryptoassets in the rapidly growing cryptocurrency space. Retrieved from https://coinmarketcap.com.
7. da Silva, A. C., Maganini, N. D., & de Almeida, E. F. (2018). Multifractal analysis of Bitcoin market. *Physica a-Statistical Mechanics and Its Applications, 512,* 954—967. https://doi.org/10.1016/j.physa.2018.08.076.
8. Derbentseva, V., Babenko, V., Khrustalevc, K., Obruchd, H., & Khrustalova, S. (2021). Comparative performance of machine learning ensemble algorithms for forecasting cryptocurrency prices. *International Journal of Engineering. Vol. 34,* 1, 140—148. Retrieved from http://www.ije.ir/article_122162.html.
9. Baur, D. G., Hong, KiHoon, Lee, A. D. (2018). Bitcoin: Medium of exchange or speculative assets? *Journal of International Financial Markets, Institutions and Money, Vol. 54,* 177—189. https://doi.org/10.1016/j.intfin.2017.12.004.
10. FRED. (2021). Federal Reserve Economic Data since 1991. Retrieved from https://fred.stlouisfed.org.
11. Garcia, D., Tessone, C. J., Mavrodiev, P., & Perony, N. (2014). The digital traces of bubbles: feedback cycles between socio-economic signals in the Bitcoin economy. *Journal of the Royal Society Interface, 11* (99), Article 20140623. https://doi.org/10.1098/rsif.2014.0623.
12. Hryhoruk, P., Khrushch, N., & Grygoruk, S. (2019). An Approach to Design a Composite Index of Economic Development and Identifying the Bounds of its Levels. *2019 9th International Conference on Advanced Computer Information Technologies (Acit'2019).* (pp. 48—51).
13. Hunter, G. W., & Kerr, C. (2019). Virtual Money Illusion and the Fundamental Value of Non-Fiat Anonymous Digital Payment Methods: Coining a (Bit of) Theory to Describe and Measure the Bitcoin Phenomenon. *International Advances in Economic Research, 25* (2), 151—164. https://doi.org/10.1007/s11294-019-09737-4.
14. Kandilov, I. T. (2008). The effects of exchange rate volatility on agricultural trade. *American Journal of Agricultural Economics, 90* (4), 1028—1043. https://doi.org/10.1111/j.1467-8276.2008.01167.x.
15. Kozlovskyi, S., Bilenko, D., Kuzheliev, M., Lavrov, R., Kozlovskyi, V., Mazur, H., & Taranych, A. (2020). The system dynamic model of the labor migrant policy in economic growth affected by COVID-19. *Global Journal of Environmental Science and Management, 6* (SI), 95—106. https://doi.org/10.22034/GJESM.2019.06.SI.09.
16. Kristoufek, L. (2013). BitCoin meets Google Trends and Wikipedia: Quantifying the relationship between phenomena of the Internet era. *Scientific Reports, 3*, Article 3415. https://doi.org/10.1038/srep03415.
17. Kuzheliev, M. O., Zherlitsyn, D. M., & Nechyporenko, A. V. (2019). Bioresources Price Trend and GDP Growth Adjustment. *International Journal of Advanced Biotechnology and Research (IJABR), Vol. 10*, Special Issue 1, 379—383. Retrieved from https://bipublication.com/files/ijabr2019sp154Mykhailo.pdf.
18. Li, J. P., Naqvi, B., Rizvi, S. K. A., & Chang, H. L. (2021). Bitcoin: The biggest financial innovation of fourth industrial revolution and a portfolio's efficiency booster. *Technological Forecasting and Social Change, 162*, Article 120383. https://doi.org/10.1016/j.techfore.2020.120383.
19. May, J. B. (2010). International financial volatility and commodity exports: evidence from the thai agricultural sector. *American Journal of Agricultural Economics, 92* (3), 763—775. https://doi.org/10.1093/ajae/aap033.
20. Morina, F., Hysa, E., Ergun, U., Panait, M., & Voica, M. C. (2020). The Effect of Exchange Rate Volatility on Economic Growth: Case of the CEE Countries. *Journal of Risk and Financial Management, 13* (8), 13, Article 177. https://doi.org/10.3390/jrfm13080177.
21. Omane-Adjepong, M., & Alagidede, I. P. (2020). Dynamic Linkages and Economic Role of Leading Cryptocurrencies in an Emerging Market. *Asia-Pacific Financial Markets, 27* (4), 537—585. https://doi.org/10.1007/s10690-020-09306-4.
22. Perchuk, O. V., Makarchuk, I. M., & Yaremenko, L. M. (2019). The prospects of using cryptocurrency bitcoin as a financial innovation in the information economy of Ukraine. *Financial and Credit Activity-Problems of Theory and Practice, 4* (31), 419—427. https://doi.org/10.18371/fcaptp.v4i31.190971.
23. Regenstein, J. K. (2019). Reproducible finance with R: Code flows and shiny apps for portfolio analysis. *CRC Press*. 230 p.
24. Serenis, D., & Tsounis, N. (2012). A new approach for measuring volatility of the exchange rate. N. Tsounis, A. Vlahvei (Eds.). *International Conference on Applied Economics, Vol. 1.* (pp. 374—382). https://doi.org/10.1016/s2212-5671(12)00043-3.
25. Symitsi, E., & Chalvatzis, K. J. (2019). The economic value of Bitcoin: A portfolio analysis of currencies, gold, oil and stocks. *Research in International Business and Finance, 48,* 97—110. https://doi.org/10.1016/j.ribaf.2018.12.001.
26. Tasca, P., Hayes, A., & Liu, S. W. (2018). The evolution of the bitcoin economy: Extracting and analyzing the network of payment relationships. *Journal of Risk Finance, 19* (2), 94—126. https://doi.org/10.1108/jrf-03-2017-0059.
27. Telnova, H., Kolodiziev, O., Kuzheliev, M., Krupka, I., & Boiko, N. (2020). Foreign direct investment in the eurozone countries: stochasticity of the financial influence factors. *Financial and Credit Activity-Problems of Theory and Practice, 4* (35), 107—120.
28. Tunc, C., Babuscu, S., Hazar, A., & Solakoglu, M. N. (2020). Exchange Rate Volatility and Trade: External Exchange Rate Volatility Matters. *Journal of International Commerce Economics and Policy, 11* (2), 19, Article 2050006. https://doi.org/10.1142/s1793993320500064.
29. Voronenko, I., Skrypnyk, A., Klymenko, N., Zherlitsyn, D., & Starychenko, Y. (2020). Food security risk in Ukraine: assessment and forecast. *Agricultural and Resource Economics, 6* (4), 63—75. Retrieved from https://are-journal.com/index.php/are/article/view/364.
30. Yahoo! Finance Data (by quantmod). (2021). Retrieved from https://finance.yahoo.com.
31. Yuzvovich, L. I., Isakova, N. Y., & Mokeeva, N. N. (2019). Bitcoin financial bubbles: digitalization and modeling. A. Nazarov (Ed.). *Proceedings of the 1st International Scientific Conference Modern Management Trends and the Digital Economy: from Regional Development to Global Economic Growth, Vol. 81.* (pp. 3—68). https://doi.org/10.2991/mtde-19.2019.12.

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