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FORECASTING THE DYNAMICS OF BITCOIN BASED ON CRYPTOCURRENCY PRICE FORMATION FACTORS

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Abstract. *Cryptocurrencies have become one of the most relevant topics in recent financial and economic issues. Today, the main features of cryptocurrency are decentralization, ability to be considered as means of payment, high liquidity, absence of an issuer as any central authority, irreversibility of payments and transparency. The growth of cryptocurrencies among other world currencies allows them to be a highly profitable asset to invest in and stimulates the interest of new miners. However, there are some risks arising. Firstly, the risk related to governmental restriction and regulating laws about usage of cryptocurrency. Secondly, there is a risk of fraud and no opportunity to accuse those responsible due to the anonymity of users. And last but not least, high volatility of cryptomarket.*

Keywords: *bitcoin exchange rate, cryptocurrency, financial index, currency pair, metal futures, correlation-regression analysis, forecast of bitcoin value dynamics.*

Setting the problem. Due to the latest world events, the economies of many countries are in a state of recession, which inevitably damages the countries' financial system. Due to the instability on the money market, society is looking for new alternatives to replace world currencies based on information. One of the options for solving this problem is cryptocurrency. These means of payment are gaining popularity in many developed countries. That is why there is a need to analyze the phenomenon of cryptocurrency as a powerful financial instrument in the world market and predict its further development.

The analysis of recent researches and publications. Currently the cryptomarket is still new and not fully explored market. More and more countries consider cryptocurrency as a new means of payment. For example EU started developing a digital euro to keep up with the digitalisation processes. As a result in recent years due to the growing interest in the phenomenon of cryptocurrencies, there are more and more scientific papers written by domestic and foreign scientists that study this topic. Foreign authors S. Athey, I. Parashkevov, and V. Sarukkai [1] studied the pricing of bitcoin and its interaction with fiat money; D. Lukoshkina and D. Goroshevych [2] studied the factors that affect the exchange rate of the cryptocurrencies in general and the bitcoin in particular. As for Ukrainian scientists, O. Osipova [3] studied the forecasting of bitcoin prices using neural networks, P. Rubanov, A. Novikova, V. Ogienko studied Blockchain technology and its application in the creation of cryptocurrencies. N. Milyukova and S. Tsyhanov [4] observe cryptocurrencies in the world monetary system.

Today, there are very few scientific papers in the domestic literature which simulate and predict the pricing of bitcoin based on statistically related factors.

Setting the objectives. The aim of the article is to find the factors that affect the value of bitcoin cryptocurrency and to make a forecast based on these factors. There are 17 factors selected for the study, among which are: other known and popular cryptocurrencies, currency pairs of traditional currencies, prices for precious and industrial metals, world financial indices. The study used methods of econometric analysis to assess the correlations between the factors and the rate of bitcoin and to build a multiple correlation-regression model of the value of bitcoin. Methods of statistical analysis were used to identify trends for further changes in the rate of bitcoin. The results of the study showed four main factors. The impact of the latter on the price of the bitcoin is the greatest and statistically significant one, allowing to predict the dynamics of its exchange rate.

Presentation of the main research material. The value of any currency is affected by a wide range of factors. With the constant development of trade and economic relations, the factors themselves, as well as their importance, have changed. Cryptocurrencies, despite the legal status in many countries, are still a kind of money. The market capitalization of the most popular and widely used currency at present time - bitcoin - is about 36 billion US dollars. To date, its exchange rate is 19 thousand US dollars [5]. Several tasks were set to explore the impact of other assets on its exchange rate. In order to determine which of the selected factors will affect its exchange rate to the greatest extent, we apply their step-by-step analysis to obtain the minimum set excluding the irrelevant factors. Each factor included in the final model must meet the following requirements: the factor must be quantitative; there shouldn't be close relationship between several factors - in this situation, one of the factors will be excluded; the factor must be statistically significant.

The first assumption says that the value of the bitcoin strongly depends on the price of other cryptocurrencies. Using a regression-correlation model, a dependence between such cryptocurrencies as Bitcoin / Litecoin, Bitcoin / Ripple, Bitcoin / Etherum was determined. All data were collected on the site of the cryptocurrency exchange CoinMarketCap at the beginning of each month for the period from 01.11.2019 to 01.11.2020 [5]. According to the results of the correlation analysis, the data presented in Table 1 were obtained. As can be seen from the table, Ethereum (almost functional relationship at r = 0.89) and Ripple (r = 0.60) have the strongest correlations with respect to bitcoin.

Table 1

Pair correlations between cryptocurrencies matrix

	Bitcoin	Litecoin	Ripple	Ethereum
Bitcoin	1.00			
Litecoin	0.49	1.00		
Ripple	0.60	0.78	1.00	
Ethereum	0.89	0.39	0.59	1.00

Source: created by author on the basis of [5]

To test the statistical significance of this model, the data presented in Table 2 were grouped. The reliability of this model on the level of significance of the Fisher criterion (Significance F) is much less than 0.05, so the model is significant. The degree of accuracy of the description of the process model - the coefficient of determination is 0.81, which means high accuracy of model approximation. Of all the variables (cryptocurrencies), the Bitcoin exchange rate is affected only by Ethereum, whose P-Value is less than 0.05. Therefore,

among the selected cryptocurrencies, only Ethereum can be selected for further analysis and forecasting as an independent factor.

Table 2

Results of multiple regression of cryptocurrencies

Regression statistics				
Coefficient of determination	Significance F	P-Value		
		Ethereum	Litecoin	Ripple
0.81	0.001	0.001	0.388	0.081

Source: created by author on the basis of [5]

The second assumption says that the bitcoin exchange rate depends on popular traditional currencies rates. To verify the impact on the value of the cryptocurrency of pairs of influential world currencies, an analysis was performed, for which the currency pairs euro / US dollar (EUR/USD), British pound / US dollar (GBR/USD), US dollar / Japanese yen (USD/JPY) and the US dollar / Chinese yuan (USD/CNY) were taken at the beginning of each month for the period from 01.11.2019 to 01.11.2020. The results of the correlation model analysis are shown in table 3.

Table 3

Pair correlations between the bitcoin and currency pairs matrix

	Bitcoin	**EUR/USD**	**GBR/USD**	**USD/JPY**	**USD/CNY**
Bitcoin	1.00				
EUR/USD	0.80	1.00			
GBR/USD	0.36	0.55	1.00		
USD/JPY	-0.82	-0.78	-0.13	1.00	
USD/CNY	0.75	-0.12	-0.61	0.64	1.00

Source: created by author on the basis of [5, 6]

The table shows that most of the selected currency pairs have a strong correlation with the value of bitcoin. The studied currency pairs EUR/USD and USD/CNY with the value of pair correlation r = 0.80 and r = 0.75, respectively, show a close positive correlation. Instead, the currency pair USD/JPY shows a negative correlation coefficient r = -0.82. Table 4 shows the result of multiple regression analysis. The reliability of this model on the level of significance (Significance F) is less than 0.05, so the model is significant. The degree of accuracy of the description of the process model - the coefficient of determination is 0.78, which indicates the high accuracy of the model approximation. P-Value for any of the currency pairs does not exceed 0.05. This indicates that none of the currencies depicted has an impact on the bitcoin exchange rate, despite the high correlation rates for some of them. Therefore, no currency pair will be used as an independent factor for further analysis and forecasting.

Table 4

Results of multiple regression between the bitcoin and currency pairs

Regression statistics					
Coefficient of determination	Significance F	P-Value			
		EUR/USD	GBR/USD	USD/JPY	USD/CNY
0.78	0.009	0.479	0.886	0.344	0.321

Source: created by author on the basis of [5, 6]

The third assumption says that market prices for metals have an impact on the value of bitcoin. According to the London Stock Exchange, prices on the futures market for metals such as gold, silver, platinum, aluminum, copper and nickel were used for analysis at the beginning of each month for the period from 01.11.2019 to 01.11.2020. The results of the correlation model study were presented in Table 5. As can be seen from the table, almost all analyzed prices of metals have strong correlations with the bitcoin exchange rate. Among the metals, the highest coefficients has gold (r = 0.80), silver (r = 0.81) and copper (0.83).

Table 5

Pair correlations between the bitcoin and metal prices matrix

	Bitcoin	**Gold**	**Silver**	**Platinum**	**Aluminum**	**Nickel**	**Copper**
Bitcoin	1.00						
Gold	0.80	1.00					
Silver	0.81	0.83	1.00				
Platinum	0.20	0.01	0.42	1.00			
Aluminum	0.68	0.36	0.63	0.45	1.00		
Nickel	0.78	0.66	0.76	0.19	0.89	1.00	
Copper	0.83	0.71	0.79	0.22	0.87	0.96	1.00

Source: created by author on the basis of [5, 6]

Considering the results of the regression model (Table 6), we can draw a conclusion that the model is significant because the reliability of the model (Significance F) is less than 0.05; the coefficient of determination is 0.86, which indicates the high accuracy of the model approximation; The P-value does not exceed 0.05 for metals such as copper, silver and gold, and is 0.028, 0.042 and 0.013, respectively. Therefore, the effect of the value of these three metals is confirmed. Also, it is worth mentioning the high correlation coefficient between gold and silver. Despite their high influence on the formation of the bitcoin exchange rate, the simultaneous inclusion of these two factors for further analysis is not relevant because of their close relation.

Table 6

Results of multiple regression between the bitcoin and metal prices

Regression statistics							
Coefficient of determination	Significance F	P-Value					
		Gold	Silver	Platinum	Aluminum	Nickel	Copper
0.86	0.022	0.013	0.042	0.359	0.130	0.230	0.028

Source: created by author on the basis of [5, 6]

However, there is another significant property of gold as a precious metal. In addition to bitcoin, there are cryptocurrencies whose value is tied to real values. For example, a cryptocurrency called Hayek, issued by Anthem Vault, is backed by gold. The price of a cryptocurrency depends on the market price of 1 gram of gold [7]. That is we can conclude that the price of some cryptocurrencies directly depends on the price of gold as an asset to which it is secured. That is why we choose gold to study its further impact. Copper is used in the manufacture of computer components, which in turn are used both for cryptocurrency mining and for the maintenance of the blockchain system and transactions. Therefore, it should also be included as an independent factor

The fourth assumption is that global stock indices are also factors influencing the cryptocurrency rate. To show the dependence of the price of the bitcoin on stock indices, statistics were collected at the beginning of each month for the period from 01.11.2019 to 01.11.2020: the Dow Jones industrial index, the American NASDAQ and S&P 500 indices and the Japanese Nikkei 225. All index values are shown in US dollars. The results obtained from the study are presented in table 7.

Table 7

Pair correlations between the bitcoin and world financial indices matrix

	Bitcoin	NASDAQ	S&P 500	Dow-Jones	Nikkei 225
Bitcoin	1.00				
NASDAQ	0.84	1.00			
S&P 500	0.67	0.84	1.00		
Dow-Jones	0.36	0.52	0.90	1.00	
Nikkei 225	0.46	0.56	0.88	0.94	1.00

Source: created by author on the basis of [5, 6]

As you can see, among the selected stock indices, American index NASDAQ has the highest correlation connection (r = 0.84) with the bitcoin rate. In the second place there is also the American S&P 500 (r = 0.67). However, when considering the results of the regression model (Table 8), the P-Value among all the presented indices only for the Dow Jones Index is below 0.05, which indicates its real, albeit insignificant impact on bitcoin. Because of this, it is still appropriate to include this index as an independent factor for further analysis. The reliability of the model on the level of significance of the Fisher criterion (Significance F) is less than 0.05, which indicates the significance of the model. The coefficient of determination for this model is 0.84, which indicates the high accuracy of its approximation.

Table 8

Results of multiple regression between the bitcoin and world financial indices

Regression statistics					
Coefficient of determination	Significance F	P-Value			
		NASDAQ	S&P 500	Dow Jones	Nikkei 225
0.84	0.003	0.141	0.061	0.042	0.138

Source: created by author on the basis of [5, 6]

Thus, after testing all the assumptions and successively excluding the factors, it is possible to build a forecast model based on the four most relevant factors remaining. To improve the accuracy and effectiveness of the prediction, we can use a multiple correlation-regression model. The dependent variable in the model will be the bitcoin exchange rate, shown in US dollars. For the independent variables, the selected factors that most affect the bitcoin exchange rate were used. These include: the Ethereum cryptocurrency rate, expressed in US dollars, the value of the gold futures exchange, USD. US for 1 troy ounce, and copper, US dollars for 1 ton; the Dow Jones index, which is reflected in US dollars. The general form of the regression equation for this model will look like:

$$Y = b_0 + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 \quad (1)$$

where Y is the value of the bitcoin exchange rate; X1, X2, X3, X4 - the value of the Ethereum exchange rate, the value of futures for gold, copper and the Dow Jones index,

respectively; b0, b1, b2, b3, b4 - estimates of model parameters. Using the statistical data collected for the analyzed period from November 1, 2019 to November 1, 2020, we will form a matrix of input data for the model. The obtained regression equation has the following form:

$$Y = 1942{,}19 + 13{,}04X_1 + 1{,}36X_2 + 1{,}04X_3 + 0{,}01X_4 \quad (2)$$

where Y is the value of the bitcoin exchange rate; X1, X2, X3, X4 are the values of the Ethereum exchange rate, the value of futures for gold, copper and the Dow Jones index, respectively. From this regression equation we can conclude that the greatest influence on the rate of bitcoin has the price of Ethereum, with a coefficient of 13.04. The value of bitcoin is much less affected by gold (1.36) and copper (1.04). The Dow Jones Index with a coefficient of about zero (0.01) is almost insignificant.

According to the regression statistics of the constructed model (table 9), we can draw conclusions: the coefficient of determination is 0.85, which indicates a high accuracy of approximation of the model; the model is significant because the Fisher criterion is less than 0.05; P-Values of all variables are less than 0.05, which indicates the correct choice of these factors. Thus, the regression statistics of this model is close to reality according to its characteristics, which allows to use it in the subsequent forecast model.

Table 9

Results of multiple regression between the bitcoin and the remaining factors

Regression statistics					
Coefficient of determination	Significance F	P-Value			
		Ethereum	Gold	Copper	Dow Jones
0.85	0.002	0.013	0.047	0.012	0.049

Source: created by author on the basis of [5, 6]

To determine the further dynamics of the bitcoin exchange rate, the forecast values of each of the factors at the beginning of each month for the period from 01.12.2020 to 01.06.2021 were collected. Next, substituting the obtained values in the previously obtained regression equation, we obtain the theoretical predicted values of the dependent variable (bitcoin rate) for the first day of each analyzed month. The input data used for the analysis and the results of the calculations are presented in table 10.

Table 10

Predictive factor values and bitcoin rates for the next six month

Date	Bitcoin, USD	Ethereum, USD	Золото, USD	Мідь, USD	Dow Jones index, USD
01.12.2020	15721,18	606	1814	7694	27905
01.01.2021	17825,79	747	1804	7938	27776
01.02.2021	19248,43	867	1771	7743	29164
01.03.2021	21161,69	1006	1710	7776	27785
01.04.2021	21977,47	1093	1685	7447	26981
01.05.2021	19853,78	918	1630	7511	28330
01.06.2021	21513,05	1065	1628	7253	29093

Source: created by author on the basis of [8]

It can be concluded that among all the factors, the value of the cryptocurrency Ethereum has the greatest influence on the change in the exchange rate. Each time the projected cost of airtime exceeds $1,000, the rate of bitcoin also increases to more than $21,000. For the following periods the volatility of the bitcoin exchange rate, will still remain as it is present

today. Presenting the obtained forecast values in Figure 1, thus continuing today's statistics, we can conclude that the rate of bitcoin, in general, will continue to grow. According to this forecast model, the value of bitcoin will reach $20,000 by mid-February. The forecast also shows that in April 2021 the value of bitcoin will increase to a maximum value of about $22,000, after which its value will fluctuate within ± 2,000 dollars. Similar trends were observed in previous, already known periods.

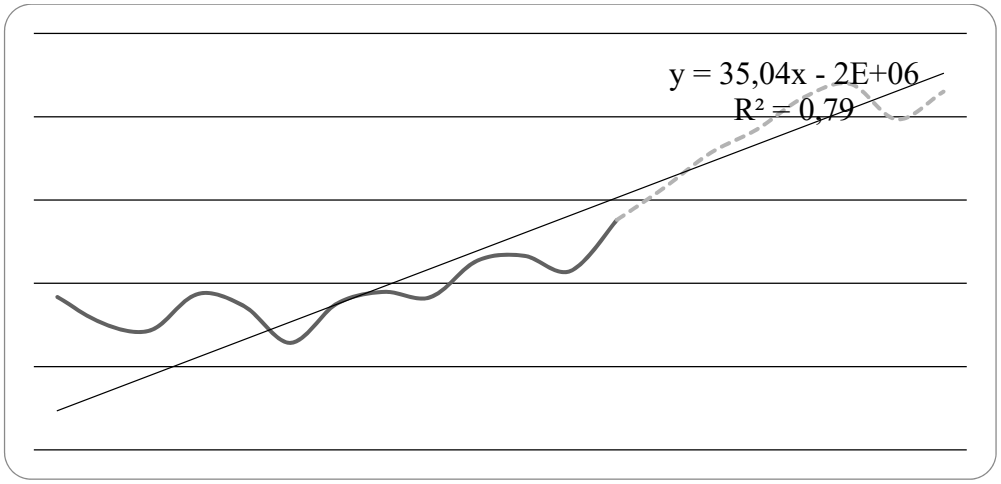

Fig. 1 Forecasting the bitcoin pricing according to the correlation-regression model for the first half of 2021 , US dollars

Source: created by author on the basis of table 10

Conclusions and prospects for further research. The analysis made it possible to choose from 17 financial indicators the four main factors (out of 17) that affect the bitcoin pricing. These include the Ethereum cryptocurrency, the value of gold and copper futures, and the Dow Jones financial index. According to the results of correlation-regression analysis, the dependence between factors and the value of bitcoin and the power of their impact were studied. The constructed multiple correlation-regression model made it possible to determine the trend of bitcoin exchange rate dynamics and predict its value for the near future. The prospect of further research is the application of forecast models to factors that significantly affect the rate of bitcoin. With this data it will be possible to simulate the future value of bitcoin. It is also worth carring out similar research for other popular cryptocurrencies and / or expanding the list of factors influencing their price to improve the forecast results. But we need to state some precautions. Despite factors mentioned in current model there are those factors that cannot be measured. For example the activity of high rollers such as big investors or speculators is unpredictable. So the situation on the cryptomarket can change in short period of time. This creates major problems when forecasting future bitcoin price.

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ВПЛИВ ФАКТОРІВ НА ФОРМУВАННЯ ЦІНИ БІТКОЇНУ

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Анотація. Криптовалюти стали однією з найбільш популярних тем останніх фінансово-економічних наукових робіт. Сьогодні основними рисами криптовалюти є децентралізація даних, наявність властивостей платіжного засобу, висока ліквідність, відсутність прямого контролю емісії зі сторони органів влади, незворотність платежів та прозорість трансакцій . Зростання популярності криптовалют серед інших світових валют дозволяє їм стати високоприбутковим активом для інвестування та стимулює інтерес нових майнерів. Однак виникають певні ризики, пов'язані з популяризацією використання даних цифрових грошей. По-перше, ризик, пов'язаний з державними обмеженнями та правовим регулюванням використання криптовалюти. По-друге, анонімність користувачів приваблює все більшу кількість осіб, в тому числі й тих, що займаються нелегальною діяльністю, що підвищує ризик шахрайства. І останнім, але не менш важливим є висока мінливість крипторинку.

Метою статті є пошук факторів, що впливають на вартість біткоїну. Для дослідження було відібрано сімнадцять факторів, серед яких є такі, як: інші відомі криптовалюти, валютні пари традиційних валют, ціни на дорогоцінні та промислові метали, світові фінансові індекси. У дослідженні використано методи економетричного аналізу для оцінки кореляційних зв'язків між факторами і курсом біткоїну та побудови множинної кореляційно-регресійної моделі вартості біткоїну. Для визначення трендів щодо подальшої зміни курсу біткоїну було використано методи статистичного аналізу. Результати дослідження показали чотири основні фактори, вплив яких на ціну біткоїну є найбільшим та статистично значущим, що дало змогу здійснити прогноз динаміки його курсу. На основі проведених досліджень сформульовано висновок, що вартість біткоїну, незважаючи на велику волатильність, продовжуватиме зростати. При аналізі наведеної статистики можна стверджувати, що ціна біткоїну дуже нестабільна. Курс BTC/USD різко зростає і спадає у короткостроковому періоді. Незважаючи на волатильність біткоїну, ціна на долар США впевнено зростає. Прогноз, зроблений на основі моделі тренду, показує, що ціна біткоїну стане вищою протягом наступного півроку. Якщо ситуація, що склалася на крипторинку, залишиться незмінною, на кінець поточного 2020 року біткоїн буде коштувати приблизно 20 000 доларів США.

Ключові слова: курс біткоїну, криптовалюти, фінансовий індекс, валютна пара, ф'ючерс на метал, кореляційно-регресійний аналіз, прогноз динаміки вартості біткоїну.

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