ANALYSIS OF APPROACHES AND THEIR FEATURES TO RESEARCH THE DYNAMICS OF CRYPTOCURRENCIES

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Abstract. The purpose of the study is to provide a comparative analysis of approaches to analyzing the trends in cryptocurrency dynamics. The paper analyzes the trends in cryptocurrency development, which has shown an increase in the influence of cryptocurrency on the structure of the financial market. It has been determined that from 2013 to 2023, the capitalization of cryptocurrency market increased almost 1 000 times. However, in recent years, the number of "fake" cryptocurrencies has also increased, so the total number of cryptocurrencies has almost not changed in the last two years. The works of researchers on the analysis of the trends in cryptocurrency exchange rates have been studied, and three main approaches to the analysis have been formed. The main components of the first approach have been investigated, the influence of miners, mining costs, blockchains, and the interaction of mining participants on the formation of exchange rates has been determined. It is found that the necessity to analyze the cryptocurrency market in conjunction with other elements of the financial market is the key aspect of the second approach to the study of trends in the exchange rate of cryptocurrencies. In this approach, cryptocurrency acts as an alternative to centralized components of the financial market and as an element of financial freedom. The study of the works of the third approach allows to identify the main methods and models for analyzing the dynamics of exchange rates, among which the main place is occupied by: models of time series analysis taking into account sentiments (Sentiment-Enriched Time Series Forecasting – SETS models), deep learning models for forecasting of processes with long and short-term memory, recurrent neural networks, and gated recurrent unit models.

Keywords: cryptocurrency, exchange rate, trend, methods, models, forecasting, miners, blockchain

Introduction

The modern development of the financial market indicates a paradigm shift in the management of financial resources within it. Cryptocurrencies are starting to have a significant impact on the financial market. Unlike fiat currencies, they have certain advantages in the dynamically developed environment that the modern financial market represents. One such advantage consists in decentralization, which, in the context of increased state control over the individual, provides a certain element of freedom. Despite the high volatility of crypto assets, the instability of existing algorithms, and their lack of commodity backing, they are attracting more and more attention from investors and researchers. Cryptocurrency trading in the modern world is gradually displacing other types of trading such as stock trading and the Forex market for trading fiat currencies.

In 2013, the share of cryptocurrency capitalization was at the level of 1.58 billion dollars, in 2020, – 637 billion dollars, then in 2023, the capitalization of twenty largest cryptocurrencies amounted to 1 160.3 billion dollars (Howarth, 2024). Cryptocurrencies in an investor's portfolio have two purposes. On one hand, they are used as an element of accumulation when stored for further value growth. On the other, they form a speculative portfolio. Their high volatility provides opportunities for obtaining a high level of profits with effective investment portfolio

management. Since volatility is associated with cyclical fluctuations, it is very important to study the cyclical component in the dynamics of cryptocurrencies and to determine the periods of growth or decline in their value.

Bitcoin (BTC) is the very first and largest in terms of market capitalization. This currency was first introduced in 2008 as a "peer-to-peer electronic cash system" that is formed by a "chain of digital signatures", at the centre of which is blockchain technology (Kelly, 2014).

The most important feature of Bitcoin consists in its "decentralized" structure, which cannot be controlled by authorities such as the central government or banks. BTC offers a system based on encryption, which allows transactions between parties in a peer-to-peer mode. This allows to avoid the use of financial institutions as intermediaries. BTC does not have underlying assets and state support, which allows a certain degree of freedom from the government of any country. Bitcoin can be obtained in two ways, either through mining or through operations of buying and selling cryptocurrency (Bystrom & Krygier, 2018). Thanks to the success of BTC, many alternative cryptocurrencies – altcoins (Charles & Darné, 2019) have been invented, the number of which now reaches more than 10 000 units which is displayed graphically in Fig. 1 (Howarth, 2024).
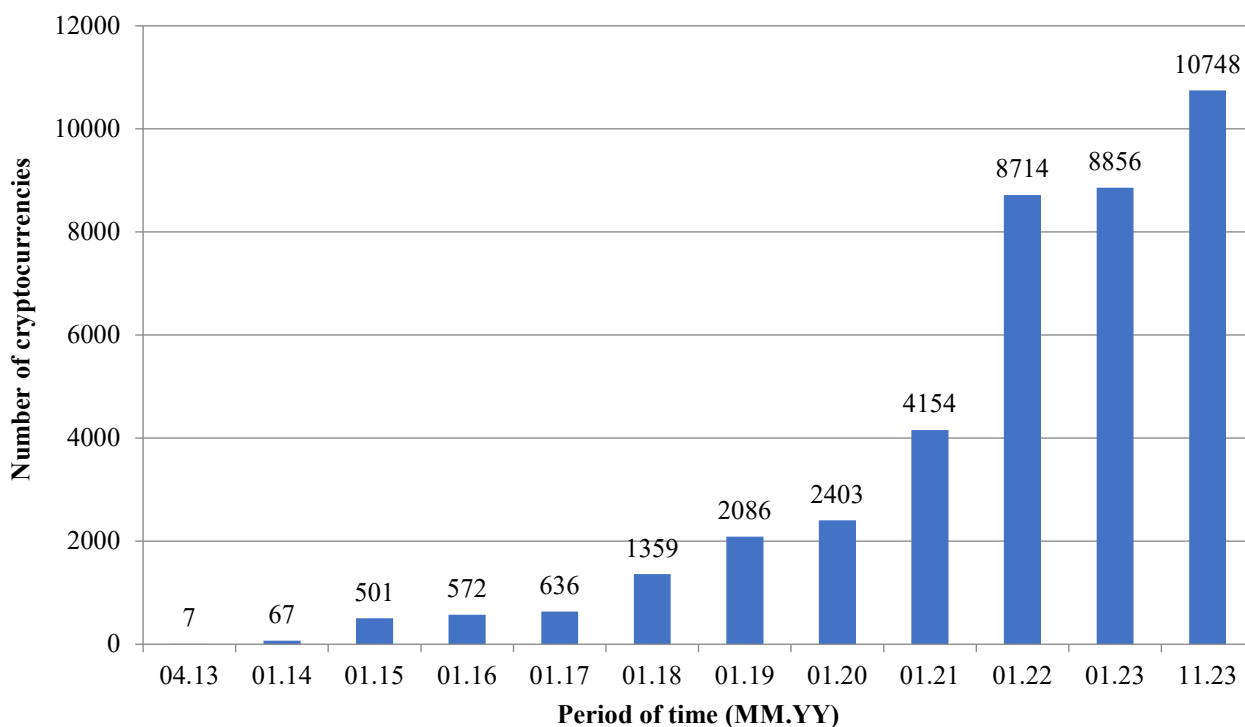

Figure 1. Dynamics of the cryptocurrencies number (Howarth, 2024)

This dynamics indicates a significant increase in the number of cryptocurrencies until 2022, however, in 2022-2023 a slowdown in growth is observed. Taking into account that there are "dead" cryptocurrencies, the number of which is constantly increasing, as of November 2023, the number of active cryptocurrencies is about 8 800 units (Howarth, 2024). That means their number has an unchanged level starting from January 2022.

Ethereum (ETH) is the most common altcoin. The algorithms for constructing this altcoin differ from the algorithms for constructing BTC. The capitalization of altcoins, ETH, and BTC is shown in Fig. 2 (Howarth, 2024).
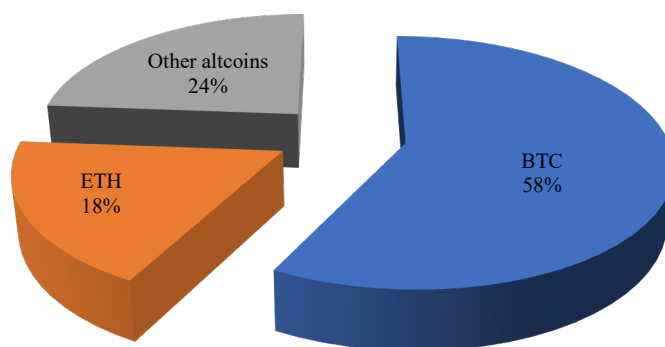
Figure 2. Capitalization of the main cryptocurrencies

Literature review

The exploration of cryptocurrency dynamics has been a focal point of recent financial research, with particular emphasis on the volatility, risks, and predictive modelling of Bitcoin and other digital currencies. The transformative potential of cryptocurrencies has been highlighted, setting the stage for a deeper understanding of their impact on the global financial landscape. Studies have delved into the volatility of Bitcoin, revealing the complexities of its market behaviour. The risks and returns associated with cryptocurrencies have been scrutinized, shedding light on the factors that influence investor decisions. The evolution of Bitcoin transaction fees and the mechanisms of market operation have been analyzed, offering insights into the underlying economic processes. Theoretical contributions have provided a framework for understanding blockchain economics, while empirical analyses have focused on Bitcoin pricing and adoption. Advances in predictive modelling have employed machine learning techniques to forecast cryptocurrency prices, reflecting the integration of finance and technology in this burgeoning field.

The purpose of this paper is to provide a comparative analysis of approaches to analyzing the trends in cryptocurrency dynamics. The processes of forming the exchange value of cryptocurrencies and identifying the factors that influence the dynamics of the exchange value are the object of the research.

Materials and methods

This study has used a combination of analytical methods, comparative analysis, and an extensive literature overview to investigate the cryptocurrency recent landscape. The paper starts by assessing the proliferation of digital currencies, drawing on data from online platforms to describe the current state of the market. Comparative analysis contrasts the foundational theories of cryptocurrency's impact on global finance with recent empirical research on market volatility and transaction dynamics. The literature review encompassed a broad spectrum of sources, from theoretical discussions on blockchain economics to empirical studies on risk factors and machine learning models for price prediction.

Results and discussion

The modern development of cryptocurrencies and the implementation of blockchain technologies in contemporary life have led to increased attention among researchers to the problem of exchange rate fluctuations.

The analysis of recent research (Liu & Tsyvinski, 2019; Liu *et al*., 2022; Easley *et al*., 2019; Biais *et al*., 2019; 2023; Athey *et al*., 2016; Cong *et al*., 2021; 2022; Schilling & Uhlig, 2019; Pagnotta,

2022; Mudassir *et al.*, 2020; Frohmann *et al.*, 2023; Liu *et al.*, 2021; Gers *et al.*, 2001; Jaquart *et al.*, 2022; Uras *et al.*, 2020; Hamayel & Owda, 2021; Zakharova *et al.*, 2020; Kovalenko *et al.*, 2021; Telnova *et al.*, 2023) has allowed to identify three main approaches to the study of the exchange value of cryptocurrency, which are based on the analysis of different factor types. These approaches are represented in Fig. 3.
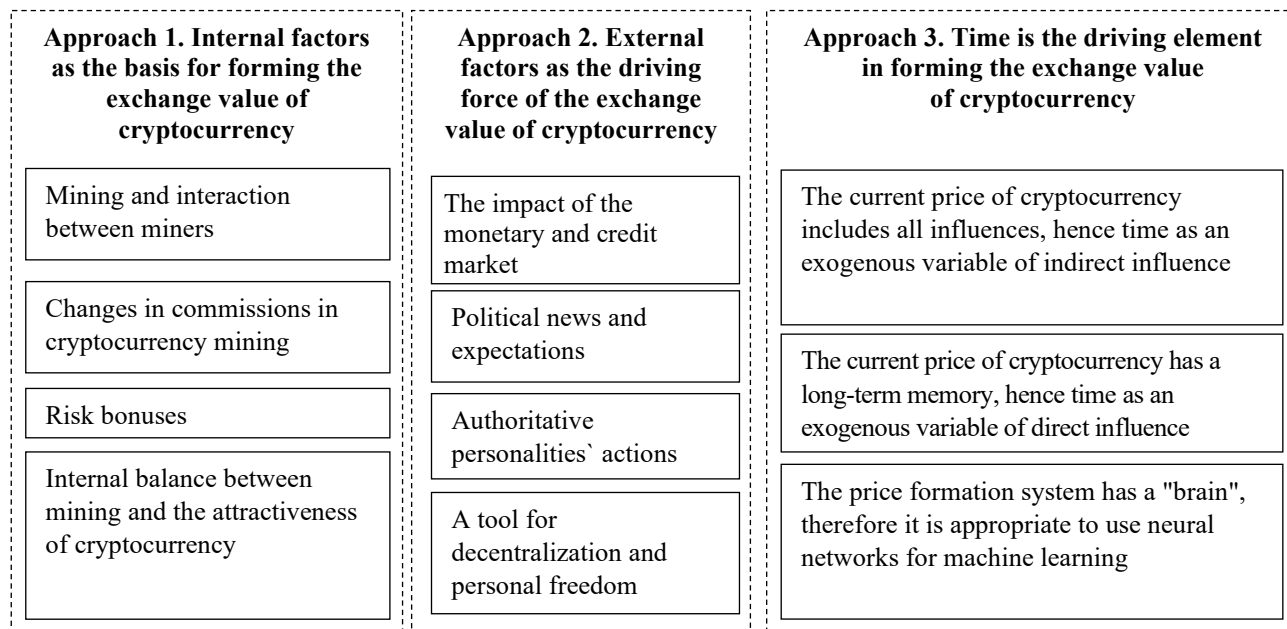
Approach 1. Internal factors as the basis for forming the exchange value of cryptocurrency	**Approach 2. External factors as the driving force of the exchange value of cryptocurrency**	**Approach 3. Time is the driving element in forming the exchange value of cryptocurrency**
Mining and interaction between miners	The impact of the monetary and credit market	The current price of cryptocurrency includes all influences, hence time as an exogenous variable of indirect influence
Changes in commissions in cryptocurrency mining	Political news and expectations	The current price of cryptocurrency has a long-term memory, hence time as an exogenous variable of direct influence
Risk bonuses	Authoritative personalities` actions	The price formation system has a "brain", therefore it is appropriate to use neural networks for machine learning
Internal balance between mining and the attractiveness of cryptocurrency	A tool for decentralization and personal freedom	

Figure 3. Approaches to the study of cryptocurrency price dynamics

Approach 1. Internal factors as the basis for forming the exchange value of cryptocurrency. This approach is based on the concept that the price of cryptocurrency is formed exclusively on the mining of cryptocurrency and its usage possibilities. The assumption that over time the costs of mining cryptocurrencies increase is an important element of this approach. Combining this factor with the fact that most cryptocurrencies are limited in quantity leads to a scarcity of cryptocurrency, and as a result, an increase in its value. The advantage of this approach consists in economic substantiation of the "cost price" of cryptocurrencies and the establishment of market equilibrium based on supply and demand. However, this approach has a significant drawback as the value of cryptocurrency also depends on its "publicity", which is not taken into account in mining procedures.

In the context of research on the element of forming the value of cryptocurrency, there is a commission for transactions and cooperation between miners. Scholars such as Easley, O'Hara, Basu, Bisiere, Bouvard, Casamatta, Biais, Cong, Li, Wang, Liu, Tsyvinski, Pagnotta, and Buraschi pay attention to this direction.

In the works of Liu & Tsyvinski (2019; 2022) a developed model takes into account the marginal profit from operations with cryptocurrencies and predicts the impact of news on investor sentiment. Such influence is realized through the management of risk premiums. However, news is a subjective factor, as investors may interpret it differently, and then the market will reflect not the objective impact of the news and fundamental factors, but the interpretation of this impact by the main market players. This will form a short-term trend in the market, while long-term investors do not receive reliable information.

In the work of Easley *et al.* (2019), the role of increasing fees that affect the interaction of cryptocurrency users and its miners is determined. In most cryptocurrencies, the efficiency of their mining decreases over time, leading to a slowdown in the free accumulation of cryptocurrency, and as a result, leads to an increase in its price.

The interaction between miners is also considered in the works of Biais *et al.* (2019; 2023). The works (Biais *et al.*, 2019; Kovalenko *et al.*, 2021) define the formation of blockchains through the interaction of miners. The works (Biais *et al.*, 2023; Telnova *et al.*, 2023) show approaches to forming an equilibrium price for Bitcoin but take into account the internal factors of the blockchain, which excludes the element of external influence.

Cong *et al.* (2022) focus on the interaction of participants in crypto platforms and determination of the relationship between the efficiency of platforms and the growth of token prices. Each trading platform or venue has its rating, and as a result, the more highly rated the platform is, the greater the attractiveness and trust in the cryptocurrency, and accordingly, there is an increase in the price of the token.

Pagnotta (2022) has developed a model that investigates the equilibrium of Bitcoin. The interaction between users and the support of network security through miner investments are the basis of this equilibrium. Such interaction, on the one hand, can lead to an increase in the volatility of the Bitcoin price, because investments increase in the case of BTC attractiveness. However, on the other hand, in the absence of investment support, the vulnerability of the platform increases, leading to a fall in BTC price.

Approach 2. External factors as the driving force of the exchange value of cryptocurrency. For this approach, cryptocurrency is not considered as a commodity that is produced and can be used for payment (as it has been determined in Approach 1), but as an element of interaction in the general financial market system. The cryptocurrency market has become an equal component of the financial market structure, and the proponents of this approach consider the exchange value of cryptocurrency as a result of the interaction of monetary, credit, and stock markets. Accordingly, events from fiat markets, monetary policy and other financial activities influence cryptocurrencies.

Authors such as Athey *et al.* (2016) emphasize that Bitcoin is a payment instrument that gives the user the right to be anonymous and avoid banking commissions, which underscores the freedom of the individual. This has led to the recognition of the fundamental principle of cryptocurrency creation: freedom from banking institutions. However, the disadvantage of such a payment instrument is that the price of goods when buying with cryptocurrency should have a dynamic character that would take into account fluctuations in the exchange value of cryptocurrency, which is quite difficult to achieve.

Also, in this direction, there are studies by Cong *et al.* (2021), in which cryptocurrency is considered a tool to counter oligopolistic agreements in the cryptocurrency market through the management of smart contracts. However, in the author`s opinion, like any market, the cryptocurrency market depends on the actions of popular investors, which sometimes leads to agreements between the key players of this market. Cryptocurrency has an element of decentralization, however, with the appearance of oligopolistic agreement, it becomes a centralized currency in the circle of oligopolists.

In the movement of Bitcoin as an alternative payment instrument, the works of Schilling & Uhlig (2019) should be considered. In addition, they investigate the impact of monetary policy on the use of cryptocurrency as an alternative to fiat currencies. However, the disadvantage of using cryptocurrency in this sense is that fiat currencies are backed by goods, while cryptocurrencies operate with information and blockchains, which are not goods in the general sense of the word.

Approach 3. Time is a driving element in forming the exchange value of cryptocurrency. The third group of works devoted to the study of the exchange value of cryptocurrencies uses various variations of time series analysis, in which time has both a direct and an indirect influence.

For instance, in the work of Frohmann *et al.* (2023), models of time series analysis were used that took into account sentiments (Sentiment-Enriched Time Series Forecasting – SETS models). This

approach is becoming popular and involves combining the study of historical prices with sentiment assessments obtained through sentiment analysis methods.

Mudassir *et al.* (2020) demonstrated highly effective classification and regression models based on machine learning for predicting the movement of Bitcoin prices and prices in the short- and medium-term perspective.

Authors Liu *et al.* (2021) attempted to cover existing modelling methods for time series and classify them. In addition, a comparison was made between different methods, and some potential directions for forecasting the time series dynamics of cryptocurrency rates were identified. Moreover, these authors and Gers *et al.* (2001) demonstrated the possibility of using deep learning models to forecast processes with long and short-term memory (LSTM), which includes the time series of BTC price.

In this direction, research was also conducted by Jaquart, Köpke, Weinhardt, Uras, Marchesi, L.. Marchesi, M.. Tonelli, Hamayel, Owda.

Jaquart *et al.* (2022) in their work analyzed various machine learning models for daily forecasting and trading in the cryptocurrency market. The basis of the study consists of LSTM models, recurrent neural networks (RNN), and Gated Recurrent Unit (GRU) models. Their paper forecasts daily market dynamics of the top 100 cryptocurrencies. As a result of the study, it was determined that the used models make statistically viable forecasts, according to which the average accuracy values calculated for all cryptocurrencies range from 52.9% to 54.1%.

In the work of Uras *et al.* (2020), closing prices for cryptocurrencies such as Bitcoin, Litecoin, and Ethereum were used as input data. These authors simultaneously adhered to different approaches, implementing both statistical methods and machine learning algorithms: a simple linear regression (SLR) model for forecasting one-dimensional series, using only closing prices, and a multiple linear regression (MLR) model for multi-dimensional series, using both prices and volume data. In addition, two artificial neural networks were used: a multilayer perceptron (MLP) and LSTM.

Hamayel & Owda (2021) proposed three types of RNN algorithms for researching cryptocurrency prices, which are used to predict prices for three types of cryptocurrencies, namely BTC, Litecoin, and ETH. The models show excellent forecasts depending on the mean absolute percentage error. The results obtained using these models show that the GRU showed better results in forecasting for all types of cryptocurrency than the LSTM and the bidirectional LSTM model bi-LSTM (Zakharova *et al.*, 2020).

Thus, based on the analysis conducted, a table of comparative characteristics of each approach was constructed, which allows for the systematization of research achievements and the selection of the best methods for forecasting the exchange value of cryptocurrency. The results are reflected in Table 1.

Table 1. Comparative characteristics of approaches to forecasting the exchange value of cryptocurrencies

Approach	Key findings	Researchers	Papers
Approach 1. Internal factors as the basis for forming the exchange value of cryptocurrency	Risk bonus management	Liu, Tsyvinski	(Liu & Tsyvinski, 2019; Liu *et al.*, 2022)
	Interaction of cryptocurrency users and miners	Easley. O'Hara Pagnotta, Buraschi	(Easley *et al.*, 2019; Pagnotta, 2022)
	Interaction between miners	Biais, Bisiere, Bouvard, Casamatta	(Biais *et al.*, 2019; 2023)
	Efficiency of platforms and the growth of token prices	Cong and Wang	(Cong *et al.*, 2022)
Approach 2. External factors as the driving force of the cryptocurrency exchange value	Bitcoin as a payment instrument that allows the user to remain anonymous and avoid banking commissions	Athey Parashkevov, Sarukkai, Xia	(Athey *et al.*, 2016)
	A tool to counter oligopolistic agreements	Cong, He, Li	(Cong *et al.*, 2021)
	The impact of monetary policy	Schilling, Uhlig	(Schilling & Uhlig, 2019)

Approach 3. Time is a driving element in forming the exchange value of cryptocurrency	Time series analysis models considering sentiments (Sentiment-Enriched Time Series Forecasting – SETS models)	Frohmann, Karner, Khudoyan, Wagner, Schedl	(Frohmann et al., 2023)
	Classification and regression models based on machine learning	Mudassir, Bennbaia, Unal	(Mudassir et al., 2020)
	Deep learning models for forecasting processes with LSTM	Gers, Eck, Schmidhuber, Jaquart, Uras, Hamayel, Owda	(Gers et al., 2001; Jaquart et al., 2022; Uras et al., 2020; Hamayel & Owda, 2021)
	RNN and GRU models	Jaquart, P.	(Jaquart et al., 2022)
	SLR for forecasting unidimensional series, MLR for multidimensional series, MLP	Uras, Marchesi, Marchesi, Tonelli	(Uras et al., 2020)

Conclusions. The study of cryptocurrency exchange rates is an interesting and relevant topic for research due to the novelty of the processes of forming exchange rates, a new paradigm of understanding the functions of money, new approaches to pricing in the financial market, etc. Based on the conducted research, the following results have been obtained:

• The rapid development of the cryptocurrency market has been identified, as well as its prospects as a payment instrument and an element of accumulation.

• The research on the dynamics of cryptocurrency exchange rates has been analyzed, and three main approaches to analysis have been identified. Within each approach, the prevailing factors and methods of analysis have been determined.

• A three-component state of cryptocurrency exchange rates has been investigated, which includes the internal environment (miners, risks, premiums, mining costs, etc.), the external environment (monetary policy, fiat currencies, oligopolies, payment instruments), and the temporal dynamics, which are studied using various types of models.

Thus, achieving the goal of this research, the systematization of approaches to studying the trends of cryptocurrency dynamics allows to use these approaches in future empirical studies and to determine their effectiveness, which is the basis for forecasting the dynamics of cryptocurrency exchange rates.

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Conflict of interest
None.

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АНАЛІЗ ПІДХОДІВ Й ЇХ ОСОБЛИВОСТЕЙ ДО ДОСЛІДЖЕННЯ ДИНАМІКИ КУРСІВ КРИПТОВАЛЮТ

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Анотація. Метою дослідження виступає порівняльний аналіз підходів до аналізу тенденцій динаміки криптовалют. В статті проведено аналіз тенденцій розвитку криптовалют, який показав збільшення впливу криптовалюти в структурі фінансового ринку. Визначено, що за період 2013–2023 рр. капіталізація ринку криптовалют збільшилась майже в 1000 разів. Однак за останні роки збільшилася також кількість «фейкових» криптовалют, тому за останні два роки загальна кількість криптовалют майже не змінилася. Досліджено праці науковців щодо аналізу тенденцій курсової вартості криптовалют, сформовано три основні підходи до аналізу. Досліджено основні складові першого підходу, визначено вплив майнерів, вартості майнингу, блокчейнів, взаємодії учасників майнингу на формування курсової вартості. Визначено, що основною рисою другого підходу до дослідження тенденцій курсової вартості криптовалют є необхідність розглядати ринок криптовалют у взаємодії з іншими складовими фінансового ринку. В цьому підході криптовалюта виступає як альтернатива централізованим складовим фінансового ринку й як елемент фінансової свободи. Дослідження праць третього підходу дозволило визначити основні методи та моделі аналізу динаміки курсової вартості, серед яких основне місце займають: моделі аналізу часових рядів з урахуванням настроїв (Sentiment-Enriched Time Series Forecasting – SETS models), моделі глибокого навчання для прогнозування процесів з довго- та короткостроковою пам'яттю (LSTM), рекурентні нейронні мережі (RNN) та моделі GRU (Gated Recurrent Unit).

Ключові слова: криптовалюта, курсова вартість, тенденція, методи, моделі, прогнозування, майнери, блокчейн