Forecasting the Prices of Cryptocurrencies Using GM(1,1) Rolling Model

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Contributions to Economics

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Blockchain Economics and Financial Market Innovation

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Dash, Ethereum, Litecoin, Nem, Stellar, Monero, and Ripple. The results suggest rejecting the null hypothesis of no causality, indicating bidirectional causality between trading volume and returns for Bitcoin and the altcoins except Nem and Stellar. The findings also highlight that the causal relations in cryptocurrency markets are subject to change over time. The chapter may conclude that trading volume has predictive power on returns in cryptocurrency markets, implying the potential benefits of constructing volume-based trading strategies for investors and considering trading volume information in developing pricing models to determine the fundamental value of the cryptocurrencies.

Chapter 10 underlines a piece of empirical evidence from unit root tests with different approximations on the assessment of the crypto-market efficiency. Dr. Iltas and his colleagues examine whether the weak form of the efficient market hypothesis (EMH) is valid for the Bitcoin market. To that end, they consider the recent developments in unit root analysis utilizing daily data from February 2, 2012, to November 23, 2018. More specifically, they employ unit root tests with and without sharp breaks and also a unit root test with gradual breaks in order to obtain the efficient and unbiased output. Major findings show that the EMH appears to be valid for the Bitcoin market. We discuss the theoretical and practical implications of these findings.

Chapter 11 develops a critical approach to forecasting the prices of cryptocurrencies using GM(1,1) Rolling Model. Dr. Kartal and Dr. Bayramoglu explain the functioning of the cryptocurrencies as an investment tool in the market and to share information about the types of investors who have transferred their funds to cryptocurrencies by providing statistical information. Then, it is aimed to share the theoretical knowledge about GM(1,1) Rolling Model which has been proved by the literature in which it produces successful results especially in forecasting problems in an uncertainty environment. The results may be considered that the model was successful in forecasting the prices but unsuccessful in the direction forecasting.

Chapter 12 questions the possibility to understand the dynamics of cryptocurrency markets using econophysics in crypto-econophysics. Dr. Ulusoy and Dr. Celik advocate that following the second law of thermodynamics, the Carnot cycle was written from a new point of view: whether the amount of work given to the system in the cryptocurrency reserve can explain the possible trading (exchange) prices that occur or are likely to occur with the exchange of money.

Chapter 13 initially evaluates the linkages between cryptocurrencies and macro-financial parameters: a data mining approach. Dr. Arzu Bayramoglu and Dr. Basarir address the importance of digital currencies which have increased their effectiveness in recent years and have started to see significant demand in international markets. Bitcoin stands out from the other cryptocurrencies in considering the transaction volume and the rate of return. In this study, Bitcoin is estimated by using a decision tree method which is among the data mining methodologies.

Chapter 14 assesses the impact of digital technology and the use of blockchain technology from the consumer perspective. In this chapter, cryptocurrencies, specifically Bitcoin and the underlying technology blockchain, are discussed by

Part II
Crypto-Currency Investment Strategies and Crypto-Markets

Chapter 11
Forecasting the Prices of Cryptocurrencies Using GM(1,1) Rolling Model

Cem Kartal and Mehmet Fatih Bayramoglu

Abstract Although cryptocurrencies initially emerged as a transnational payment instrument, it has become an investment tool by attracting the attention of investors within the functioning of the capitalist system. In this chapter, the use of cryptocurrencies as an investment tool rather than in commercial transactions is discussed. As is known, most investors remain in a dilemma between the risk of risk aversion and the maximization of returns. Investors in this dilemma try to predict the future price or returns of the financial instruments through various analyzes and thus make an effort to give direction to their investments. These analyses are generally carried out by analyzing the past values of prices or returns by adopting a technical analysis approach. However, since the cryptocurrencies are a relatively new investment tool, it is not possible to reach the previous period price and yield information for an extended period.

For this reason, the scope of the chapter is to explain the functioning of the cryptocurrencies as an investment tool in the market and to share information about the types of investors who have transferred their funds to cryptocurrencies by providing statistical information. Then, it is aimed to share the theoretical knowledge about GM(1,1) Rolling Model which has been proved by the literature in which it produces successful results especially in forecasting problems in uncertainty environment. Finally, the price forecasting of popular cryptocurrencies which are Bitcoin, Ethereum, Litecoin, and Ripple was made using the GM(1,1) Rolling Model, and it was tested whether this model is advisable for price forecasting of cryptocurrencies. Results of the Model show that the forecasting errors ranged from 1.35% to 7.76% for 10-days period. Also, direction forecasting results are between 40% and 50% in the same period. Also, returns of the bitcoin investment which

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made by trusting the results are ranged from −0.60% to −8.18. The results may be considered that the model was successful in forecasting the prices but unsuccessful in the direction forecasting. Even though the estimates are made with low percentages, the time series analyzes made with the lagged data of Bitcoin prices are not successful. Therefore, the technical analysis approach can be interpreted as not sufficient for modeling Bitcoin prices. So, these results show that defining bitcoin price movements is not only a forecasting problem but also a classification problem.

11.1 Introduction

The blockchain is a technology used to read, store and verify transactions in a distributed database system. The first form of Blockchain began with a mixed tree, also known as the Merkle Tree. This data structure, patented by Ralph Merkle in 1979, was used to validate and use data from computer systems. In 1991, the Merkle tree was used to form a secure blockchain, each with a series of data records connected to the former. The newest record in this chain contains the history of the entire chain. Verification of data in a peer-to-peer computer network is essential to ensure that nothing changes during the transfer. This data structure also prevented the sending of incorrect data. This data structure is used to preserve the integrity of the shared data and to verify the accuracy of the data (Zheng, Xie, Dai, Chen, & Wang, 2017: 558).

Blockchain can be defined as a technology designed to securely store and manage data (such as currency, identity, valuable papers) with value. In the blockchain approach, the structures in which data is stored are called blocks. These block structures are arranged in the form of a chain (in the form of a linear array in time) called the "Blockchain" (FinTech Istanbul, 2019).

When a new block with operations is created, the miners process the information in this block. The mathematical formulas applied to this information, and the long list of transactions in the block is compiled with a *hash* of the figures. This hush is added to the end of the blockchain with the newly added block. *Hushes* help to minimize the information in the long list of transactions. Every hash produced is unique. If any character changes within a Bitcoin block, this will cause the entire *hash* to change Blockchain Bitcoin is the technology selected to run the process data structure. Some countries are even considering harmonization of such technologies with public infrastructures. With the success of Bitcoin, interest in the blockchain has increased in order to be used in different processing systems for use in multiple potential application areas. Recently, especially in the field of a communication network, many studies have been carried out in this direction (NRI, 2016: 3–4).

Global integration, deregulation, developments in Internet technologies significantly change the nature of financial services. Internet and related technologies enable new financial service providers to compete more effectively for investors. Technological changes accelerate the development of the financial sector by reducing costs, increasing width and quality, and expanding access to financial services (Shahrokhi, 2008: 366.) Cryptocurrencies are one of the most significant financial

technologies emerging in recent years. In 2009, a Japanese programmer named Nakamoto entered the world of finance with the creation of Bitcoin. Although they emerged as a means of payment, some of the investors saw cryptocurrencies as an investment tool.

The Bitcoin system has never been suspended (called no/zero downtime), and Bitcoin users are increasing not only in the United States but also across the globe. In January 2009, the first block (Genesis block) was created by Nakamoto and mining, and transfers started. What makes Bitcoin different from the virtual coins before it is that it can be transferred from person to person (P2P) directly and no tool is needed, and it is based on blockchain technology. In Japan, the development of money change in early 2014 attracted the attention of people, and in 2015, people began to be interested in blockchains because of the growing momentum in the FinTech area (NRI, 2016: 5–10).

The organization of the rest of the chapter is as follows. Second section provides a general, albeit, a brief, theoretical background of the cryptocurrencies and also provides a brief literature review. Third section provides definition and description of the concept of the GM(1,1) Rolling Model. Fourth section consists of the motivation of the application, the data, modeling, and application of the Model. Fifth section presents the empirical findings and discussion. Lastly, Sixth section provides conclusions.

11.2 Theoretical Background and Literature Review

Brassard (1988) described cryptology as the art and science of safe communication over unsafe channels. Cryptology consists of the process of data re-emergence as a result of decoding the data (number, text or an encrypted message) in a system frame, sending the encrypted data through a security-based environment and decoding the sent passwords. Cryptology is defined as a science of cryptography. In the Blockchain approach, the data is kept in the structures called blocks. The concept of security for the block structure is used not to hide the information it contains from the outside world, but it cannot be changed without knowing the information it contains after being created. Cryptographic hashing and time information are used to provide this.

The cryptocurrency is the currency that uses cryptography in its structure. Cryptocurrencies can be evaluated in the virtual currencies category, which cannot be edited by the currency matrix laid down by the European Central Bank and in digital format. In other words, it is not structured by any central bank, government or similar official institution. The cryptocurrency has a digital format that is theoretically not represented by any physical material. Although there is no need for any central authority to be printed, an electronic money transfer company is not required for the existence and transfer of a commercial bank to be stored (Gültekin & Bulut, 2016: 83).

11.2.1 Blockchain

The block body consists of a process counter and operations. The maximum number of operations a block can contain depends on the size of the block and its size. Blockchain uses an asymmetric encryption path to verify that transactions are validated. A digital signature based on asymmetric encryption is used in an undependable environment (NRI, 2016: 8). Each user has a public key and a pair of private keys. A private key is used to keep transactions secret. Digitally signed transactions are broadcast across the whole network. The typical digital signature is in two stages: the verification phase and the signing phase (Zheng et al., 2017: 555–556).

In Blockchain, a blockchain network node with the role of approving new transactions is called a miner. After a miner verifies a transaction, it places it in a new block that he publishes to other nodes in the network. The blockchain is a block array that contains a complete list of transaction records, such as a traditional public book. The blockchain must be reliable and should not be damaged by any power. At this stage, miners are activated to ensure the reliability of the blockchain (Swanson, 2015: 5).

Figure 11.1 shows an example of a blockchain. The block consists of two main sections as a block header for controlling the data integrity within the block and data within the block. A block comprises the block body and block header as shown in Fig. 11.2. A block header contains the following information (Zheng et al., 2017: 558):

1. Block version: Indicates which block validation rules are followed.
2. Merkle tree root hash: Indicates the hash value of all transactions in the block.
3. Timestamp: The current time in seconds in the universal time since January 1, 1970.
4. nBits: The target threshold value of a valid block hash.
5. Nonce: An area of four bytes usually starting with 0 and increasing for each hash calculation.
6. Parent block hash: the 256-bit hash value that points to the previous block.

Due to the nature of its design, there are some disadvantages as well as the advantages of adopting a blockchain solution. The blockchain has strong and weak

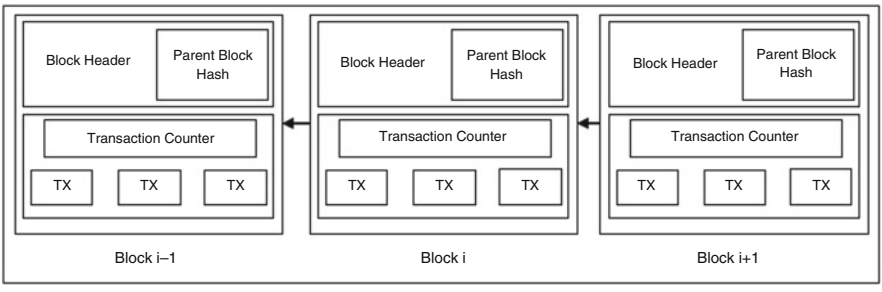


Fig. 11.1 Blockchain which involves a continuous sequence of blocks (Source: Zheng et al., 2017)

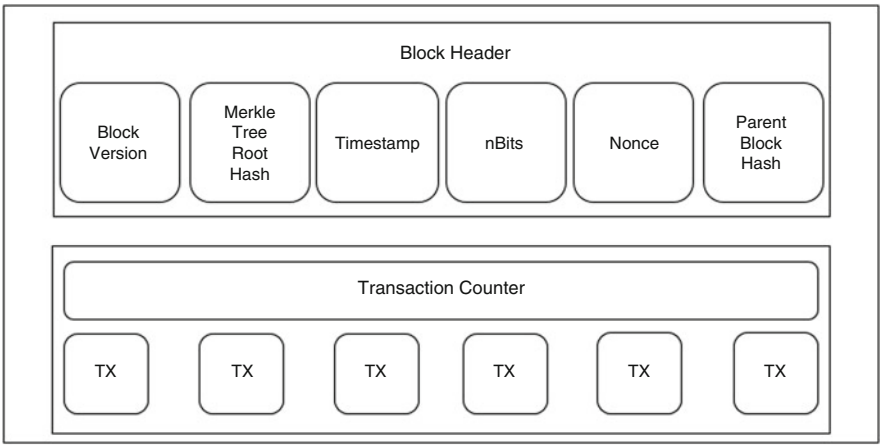


Fig. 11.2 Block structure (Source: Zheng et al., 2017)

Table 11.1 Blockchain vs. distributed databases and legacy centralized

Features	Blockchain	Distributed databases	Legacy centralized
Accessibility	High	Medium	Low
Records integrity	High	Medium	Medium
Fault tolerance	High	High	Low
Privacy	Low	Medium	High
Trustless nodes collaboration	High	Low	Low
Computing time	Low	Medium	High

Source: Bozic, Pujolle, and Secci (2016)

points compared to distributed and legacy database systems. Table 11.1 contains the key differences between blockchain, distributed databases, and legacy centralized.

The main differences between blockchain, legacy databases and distributed databases are summarized in Table 11.1. Positioning concerning legacy database systems are based on centralized databases, relying on central integrity, all nodes in a database scenario deployed in the blockchain are reliable. It is important to note that data storage in legacy database systems can depend on a trusted third-party stakeholder, that they can access and corrupt or destroy the data. In Blockchain, high availability and integrity have its unique guarantee: the blockchain consensus mechanism, which forces all records to be processed separately, to be validated by additional nodes and keep these nodes in sync. Compared to distributed database systems, it can be said that a blockchain can be as error-free as the old distributed database system. All computers involved in the system must approve any changes to Blockchain technology. However, the data transfer requires the approval of the whole system, and this situation improves more slowly than expected (Bozic et al., 2016: 3–4).

The basic value of a blockchain allows a database to be shared directly across trust boundaries without requiring a centralized administrator. This is likely because the blockchain operations do not require some centralized application logic to

implement these constraints, rather than their proof of authorization and the proof of their validity. Thus, the processes can be independently verified and processed by multiple nodes that serve as a consensus mechanism to ensure that these nodes remain synchronized. Privacy is much lower than older systems, and especially those that are central to all database content requests being forwarded by database administrators. Public blockages benefiting from a public book are potentially accessible to internet users, unlike distributed/central databases, where the central authority determines access. However, there are recommendations on how to mitigate this problem; when processing under multiple blockchain addresses, zero information evidence is recommended as a way to mitigate privacy issues. These alternatives have additional disadvantages by making the blockchain more complex or less scalable. The contents of the database are stored in the memory of a specific computer or the memory of the computer system. Anyone with access to this system may corrupt the data within it. In summary, when data are entrusted to a regular database, a particular human organization is depended on it. If an organization checks a primary database, it needs a large number of people and processes to prevent interference with this database. Recruitment and design processes are time-consuming and costly. Therefore, block chains offer a way to replace these organizations with a distributed database that is locked by smart cryptography. When performing operations, a blockchain has to perform the same operations as a regular database but has three problems (Multichain, 2019).

- Signature verification; each block chain process since the processes are spread across peers; it must be digitally signed using a private-public encryption scheme, such as the ECDSA (Elliptic Curved Digital Signature Algorithm). This is necessary, so resources cannot be proven otherwise. Creating and verifying these signatures is difficult and complex for calculators and creates primary congestion in products like ours. However, once a connection is established in central databases, it is not necessary to verify each incoming request individually.
- Consensus mechanisms; efforts should be made to ensure that the nodes in the network reach consensus in a distributed database, such as a blockchain. According to the consensus mechanism used, this may include dealing with important forward-looking communications and/or forks and their consequent rollbacks. Though it is true that central databases should also manage conflicting and revoked transactions, they are less likely to occur where operations are queued and processed in one place.
- Redundancy; this is related to the total amount of calculation required by a blockchain rather than the performance of a single node. When central databases perform operations once (or twice), a blockchain must be processed freely by each node on the network. This requires the blockchain to perform much more for the same result.

11.2.2 Cryptocurrencies

In 2008, Satoshi Nakamoto conceptualized the distributed blockchain. This blockchain would include a secure data exchange history, benefit from a peer-to-peer network to stamp and validate the change of time and be autonomously managed without a central authority. It became the backbone of the Bitcoin, and it was born in the world of the blockchain, cryptocurrencies that we know today. At the end of November 2008, Nakamoto published a thesis with the title "Bitcoin: A Peer-to-Peer Electronic Cash System." In his thesis, Bitcoin's features are (NRI, 2016: 4–5):

- Enable direct transactions without the need for reliable third parties;
- Activate non-return operations;
- Reduce the cost of credit in small temporary transactions;
- Reduce transaction fees and
- Avoid double spending.

Bitcoin was first introduced to a closed e-mail group from Japan in 2008 by Satoshi Nakamoto. However, there is no information about who is Satoshi Nakamoto. Therefore, it is unclear what bitcoin is done by (Aslantaş, 2016: 354–355).

Bitcoin has been used to enable a payment system released as an open source project for the cryptocurrency. Bitcoin has been rapidly spreading and developing worldwide. After world economic crises, Bitcoin had the goal of running an independent payment system capable of storing and monitoring all transactions using distributed nodes (or notebooks) performed by participants of such a geographically distributed system. The purpose of Bitcoin is to ensure that transactions related to money transfers are legible, secure and transparent. Security is the ability to prevent fraudulent payments or at least reduce the likelihood of unauthorized and fraudulent payments. The entire process is managed between the nodes of the Bitcoin network, no need for the third trusted parties, such as banks or other financial institutions. Accomplishing this, it was necessary to found a system where records could be securely locked, stored and verified (Bozic et al., 2016: 2–3).

Bitcoin is a decentralized open-source electronic currency and monetary system that cannot be controlled by any state, company or authority that allows any person from anywhere in the world to make online payments (Atik, Köse, Yılmaz, & Sağlam, 2015: 248). The first Bitcoin production was started in 2009. Bitcoin supply is not carried out from a center. It is carried out by the processing powers of the volunteer computers in the global network. An open-source miner software is run to include the Bitcoin network, and anyone involved in the network can generate Bitcoin as a miner. Those involved in the Bitcoin production process are called *"Bitcoin Miner."* Bitcoins are supplied by Bitcoin Mining Software, a process called mining based on the solution of a complex mathematical problem. This production information is transmitted to all individuals in the P2P (Peer to Peer to Peer to Peer) network. Bitcoin miners try to solve this problem by competing with each other.

Bitcoin miners who produce the first solution are given as a reward in the amount of Bitcoin produced automatically (Çarkacıoğlu, 2016: 13). After the solution of the problem, a more difficult problem than the previous software is presented to the miners to be solved.

On the other hand, the prize is reduced by about half every 4 years. This production acceleration following a logarithmic course is defined in such a way that a total of 21,000,000 Bitcoins can be produced. No one and no authority can supply money to the Bitcoin system. Bitcoins are also called crypto-money because of the crypto technique used in Bitcoin production and circulation (Atik et al., 2015: 249–250).

Bitcoin is one of the examples of the degree of abstraction that money has reached today. Bitcoin expresses all of the concepts, definitions, and issues that make up the digital money market. It is digital and not physically represented (Antonopoulos, 2014: 3–4). The costs of Bitcoin operations are meager and have a global usage network. For these reasons, its use is rapidly increasing. To be able to trade with Bitcoin, one of the wallet programs must be installed. A Bitcoin wallet is a virtual wallet, and this application enables Bitcoin trading, transfer, and storage (Hileman & Rauchs, 2017: 50–51). Bitcoin can be converted to USD, Euro, and all other regular coins when requested (Weusecoins, 2019). There is no leverage effect in Bitcoin transactions, and the purchase is a full ballot, which is not the balloon. The price is determined in the market conditions, and there are unpredictable profits and losses due to the volatility in the price. The existence of Bitcoin is entirely virtual because it is not a person or institution, it has no representation, and it does not belong to the central bank of any country. For these reasons, it is not influenced by any regional situation (Velde, 2013: 4–5).

The Bitcoin system is generally classified as six sub-systems:

(a) Mining companies: These companies provide computational power for the mathematical operations required to verify the security of the transactions and also serve as a mint for adding Bitcoins as a reward to the system. An important point to consider here is that at any given moment theoretically it is known how much Bitcoin is or will be in the market. Accordingly, the new Bitcoins are driven as a result of the mining process at a decreasing rate.
(b) Companies providing e-wallet services: E-wallet is the application that allows the person to store the personal keys required for his/her Bitcoins. The e-wallet can be found in many different formats. The critical point is that the data stored here is not the money itself but the data that allows validation of transactions and access to publicly available Bitcoin addresses. Wallets can be found in desktop, mobile, online, paper, and hardware.
(c) Financial service providers: The financial services provided in the classical sense are also provided as a result of the transactions made through Bitcoin. The sub-group of companies that provide services such as buying and selling of financial assets, forex trading, buying and selling of securities, buying and selling of stock, stock exchanges, buying and selling of options, and giving interest to Bitcoin for their investment.

(d) Exchange markets: Only Bitcoin, or, in some cases, all predetermined cryptocurrencies in the classical sense of all other currencies that have the task to exchange markets. These companies receive a commission as a result of the change process, and users have the opportunity to change the crypto money and the classic coins with each other at any time.
(e) Payment processors: these companies are companies that can make payments and receive payments to Bitcoin or other parties who want to trade with other cryptocurrencies. The companies provide their customers with an exchange of goods and services by using Bitcoin while minimizing the possible risk of transactions by offering online exchange points to corporate customers and by offering instant exchange services in the currency they want as a result of the sales transaction.
(f) Universal companies: these companies offer more than one of the aforementioned services in different variations. For example, a multi-purpose company also serves as an e-wallet service and as a payment processor (Gültekin & Bulut, 2016: 87–88).

The Bitcoin Wallet is defined by users in the Bitcoin ecosystem, expressing several tremendous and complex characters, such as an account number. When a new Bitcoin account is requested, a password is requested from the user by generating credentials with another open source software called Bitcoin Wallet. After this process, the Bitcoin account is ready for use. The fact that Bitcoin is spreading and all account holders can track transfer transactions and that it offers a secure and global payment network has led to the emergence of Bitcoin payment service companies. Although Bitcoin transfer does not require intermediary institutions, these companies provide services in order to enable safe trade. Nowadays, only the equipment developed for Bitcoin mining has been produced. Since the first production in 2009, the total amount had exceeded 13,750,000 Bitcoin as of January 2015. However, in the Mt.Gox (Mount Gox) 750,000 Bitcoins (about $500 million) were considered to be very difficult to break with the stealing of crypto money, and there is no longer a future for Bitcoin, as it explains the bankruptcy of Mt.Gox. (Atik et al., 2015: 250).

Today, there are hundreds of cryptocurrencies with traded market values and thousands of cryptocurrencies that exist at some point. The common element of these different encryption parasitic systems is the shared public book (blockchain) between the uses of natural markers as a way of encouraging collaborators to run the network in the absence of a central authority with network participants.

Cryptocurrencies, especially Bitcoin, are one of the examples of the degree of abstraction that money has reached today. Cryptocurrencies represent the full range of concepts, definitions, and issues that make up the digital money market. It is digital and not physically represented (Antonopoulos, 2014). The cost of crypto money transactions is meager and has a global network of uses. For these reasons, its use is rapidly increasing; many investors are trying to define how to invest in this new asset class. There are many things to consider when investing in cryptocurrencies with an increase in the popularity of cryptocurrencies. The steady

increase in Bitcoin's trading volume and the volatility of its value against the USD have attracted attention in financial markets and enabled investment as an investment tool. Although there are many types of cryptocurrencies today, Bitcoin has been the most well-known and widely used cryptocurrency since its inception.

Cryptocurrencies developed after Bitcoin, which are alternative to Bitcoin, are called Altcoin, which means Alternative Coin. Hundreds of sub-circulates such as Anoncoin, Bitshares Ripple, Counterparty, Darkcoin, Dogecoin, Ethereum, Litecoin, Namecoin, and Nextcoin are circulated, and new subcoins are circulated every day. The world's open source subcoins, such as Bitcoin, are made, and profit and loss are generated according to demand and demand. In addition to the exchanges that enable Bitcoin swap with traditional currencies, there are only exchanges (Bitcoin Exchange) that mediate an exchange between Bitcoin and Altcoins. The value of the altcoins is based on Bitcoin. Therefore, the changes in the market value of Bitcoin directly affect the market value of Altcoins (Aslantaş, 2016: 360).

However, there are significant differences between some cryptocurrencies regarding the level of innovation displayed (Fig. 11.3). The vast majority of cryptocurrencies are mainly clones of Bitcoin or other cryptocurrencies and have different parameter values (e.g., different block time foreign exchange supply and regulatory scheme). These cryptocurrencies do not contain any novelty and are called "altcoins." Examples include Dogecoin and Ethereum Classic. Blockchain and cryptocurrency innovations' can be classified two categories: new (public) blockchain systems that feature their blockchain (e.g., Zcash, Peercoin, Ethereum), and dApps (decentralized applications) /other that existing additional layers built on top of existing blockchain systems (Fig. 11.4).

The first Bitcoin operation took place on 12 January 2009 between Nakamoto and Hal Finney, who contributed to the project. As a test, Nakamoto sent 10 BTC to Finney. Ten months later, on October 5, 2009, New Liberty Standard set the first

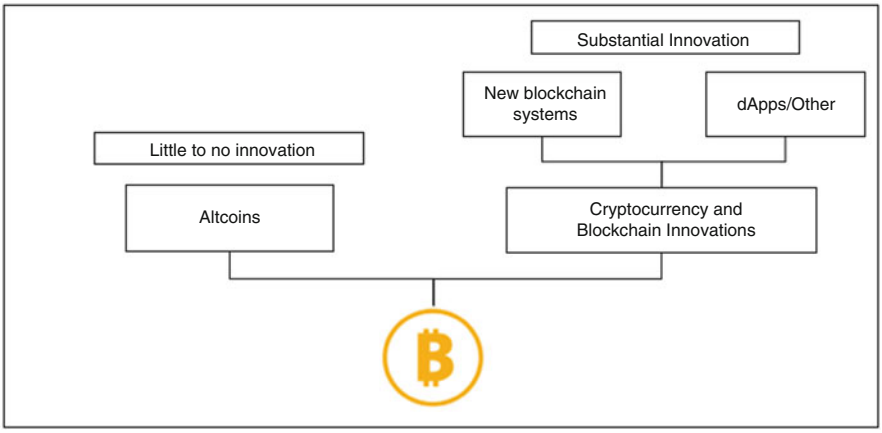


Fig. 11.3 The world of cryptocurrencies beyond Bitcoin (Source: Hileman & Rauchs, 2017)

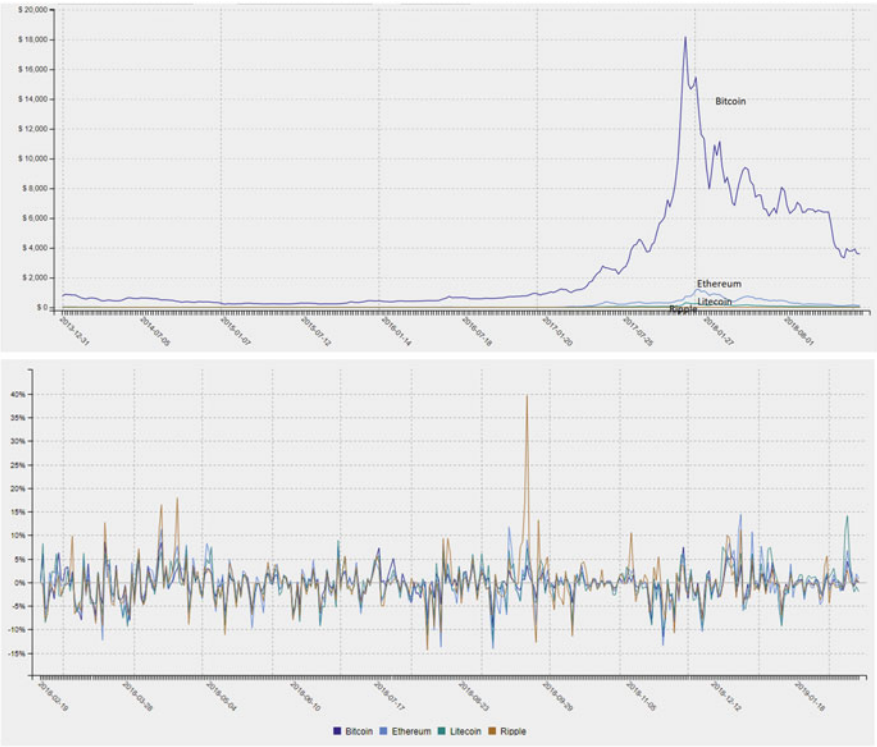


Fig. 11.4 31.12.2013–23.01.2019 date range Bitcoin, Ethereum, Litecoin and Ripple price movements (Source: Cryptocurrency Chart, 2019)

Bitcoin exchange rate as $12,300.03 BTC. Bitcoin's first transaction for physical goods took place on May 22, 2010. The process is a turning point for Bitcoin, but what is amazing today is that it can buy with the same amount of BTC and is often used as a reference point for the increase in the value of the cryptocurrency. On February 9, 2011, Bitcoin reached 1: 1 with the US dollar. After only 4 months, Bitcoin jumped from $1 to $31.91. In 2012, Bitcoin increased its value by 161.15% against the Dollar and the BTC price of 2012 ended at $13.58. In 2013, the value increased by 5290.86% against the Dollar and the BTC price of the year 2013 reached $731. In 2015, Bitcoin increased its value by 36% against the USD and by 122.03% against the US Dollar in 2016. In 2016, the average BTC price was $567.27. At the beginning of 2016, the price of 1 BTC was $432.32, and at the end of 2016, 1 BTC price was $959.87. Bitcoin gained 1319.79% in 2017 against the Dollar. In 2017, the average BTC price was $4001,16. At the beginning of 2017, the price of 1 BTC was $997.72, while at the end of 2017 1 BTC price was $14,165.57. Bitcoin depreciated by −72.55% against the US dollar in 2018. The value at the beginning of 2018 was $3791.5458, while the year-end value was $3791.5458. Bitcoin depreciated by about −6.75% against the Dollar in 2019 compared to the

previous year. The value at the beginning of 2018 was $3752.2717 (Coin Market Cap, 2019).

Ethereum (ETH) is a smart contract platform that renders possible developers to build decentralized applications (dApps) conceptualized by Vitalik Buterin in 2013, a programmer working on Bitcoin in late 2013 to generate decentralized applications. Buterin argued that a different software language was needed for the development of Bitcoin. When the agreement could not be reached, he proposed to develop a platform with a more general software language. In January 2014, the announcement was made public by the core Ethereum team, Vitalik Buterin, Charles Hoskinson, Anthony Di Iorio, and Mihai Alisie. The official development of the Ethereum software project began in early 2014 through a Swiss company, Ethereum Switzerland GmbH (EthSuisse). The Ethereum Foundation (Stiftung Ethereum), a Swiss non-profit organization, was founded. An online public subsidized development during the period July–August 2014; participants purchased the Ethereum value coin (ether) with another digital currency, Bitcoin. Although Ethereum's early technical praise was praised, there were problems with security and scalability. ETH is the local currency for the Ethereum platform and also works as a processing fee for miners in the Ethereum network. Ethereum is a pioneer in smart contracts based on the blockchain. When working on the Blockchain, a smart contract is like a computer program that runs automatically after certain conditions are encountered. In the blockchain, smart contracts enable the code to be executed precisely as programmed, deprived of any interruption, censorship, fraud or third-party intervention. Money can facilitate the exchange of stocks, bonds, assets, content or anything of value (Coin Market Cap, 2019).

The price of Ethereum fluctuates wildly in short history. In July 2015, the price of an Ethereum token (Ether) was only $0.43. In the following years, Ethereum's price would see an increase of $1.422.47 in January 2018, before it fell below 80% after 9 months. This striking volatility has attracted global attention with its mainstream media, which publishes daily reports on Ether's price. The introduction was a great blessing for thousands of new developers and commercial enterprises. In 2018, the amount collected through Ethereum ICOs increased by more than $90 million in 2016 to $8 billion. Ethereum's price has increased over the years as it faces extreme volatility. After each explosion and bust cycle, Ethereum is on the other side with a stronger platform and a broader developer community that supports it. These key developments will bring a long-term positive outlook to the Ethereum price (Coin Market Cap, 2019).

Litecoin (LTC) is a peer-to-peer encrypted synchronization and open source software project that is available under the MIT/X11 license. The creation and transmission of coins are based on the open-source encryption protocol and is not governed by any central authority. Although Litecoin is technically the same as Bitcoin (BTC), it differs from Bitcoin and other cryptocurrencies by technical features such as Acceptance of Discrete Witnesses ile and ile Lightning Network Lit. These can effectively reduce the potential bottlenecks in Bitcoin, allowing the network to process more transactions within a certain period. The payment cost of Litecoin is almost zero and is paid about four times faster than Bitcoin. Litecoin was

released on October 7, 2011, by former Google employee Charlie Lee through an open source client at GitHub. As a branch of the Bitcoin Core client; first, the block generation time was reduced, and then the maximum number of coins, the different hash algorithm (instead of scrypt, SHA-256) and a slightly modified GUI. In November 2013, the total value of Litecoin experienced massive growth of 100% in 24 h. Litecoin's value reached $1 billion in November 2013. As of May 9, 2017, the market value was approximately US $1,542,657,077, which was approximately US $30 per crypto money. In May 2017, Litecoin was the first crypto money to adopt the Detained Witness from the top five market-valued currencies. The first Lightning Network transaction was accomplished by transferring 0.00000001 LTC from Zurich to San Francisco in under a second in the same year (Litecoin, 2019).

Ripple XRP was launched in 2012 as a payment network (RippleNet) and also as crypto money. Unlike many public crypto money, Ripple is a coin that is entirely managed by a company whose blockchain-based notebooks are called mining. With the difference of finding a center, especially the big companies and banks that provide payment systems, they can find a contact for a common choice is a coin and network. Ripple has offices in San Francisco, New York, London, Singapore, Luxembourg Sydney, and India. American Express, Santander, UBS and Turkey's Akbank as a strong partner to more than 100 corporate and asset manages money transfers Ripple, blockchain technology offers the ability to process high-speed and at low cost on a global scale thanks. With Ripple, it is possible to send 4 s from one end to the other. The Ripple network can now perform up to 1500 transactions per second, and the company claims that the Ripple Network can handle the same number of transactions as Visa (50,000 per second). Ripple is the 4th largest digital currency after Bitcoin, Ethereum and Bitcoin Cash among the cryptocurrencies with a market share of $35 Billion. Ripple, which is traded on more than 50 crypto money exchanges globally, stands out as a highly accessible coin. It is not valid for Ripple, which is the point where centralized cryptocurrencies like Bitcoin are criticized most. Ripple differentiates itself from other cryptocurrencies by basing its value on a profit-making company. Currently working on 55 different processor networks, Ripple is aiming to develop its centerless structure by opening blockchain to third-party processors in the long term. In this way, Ripple itself is intended to adopt a structure that can not be manipulated on genius blocks and to increase confidence in its customers. The total number of Ripple produced is 99,993,093,880 XRP. However, for the moment, only 38,739,144,847 XRPs are in circulation in the market. The remaining coins are offered to the market at regular intervals by the company. This provides a different production strategy from mining, allowing the blockchain to run without the need for Bitcoin, Ethereum or Litecoin processing power (Ripple, 2019).

11.2.3 Cryptocurrencies as an Investment Tool

Investment means a permanent use of savings in order to generate income. The difference in consumption is that the source or value is not exhausted at the end of

the process. Individuals consume a particular portion of their income in order to survive after their income. The remaining part of the consumed part is called savings. Many individuals want to evaluate their savings with investment. For individuals who want to invest their savings by investing, there are two options, capital investment, and financial investment. Capital Investments are generally investments in fixed assets. Financial Investment is to invest in financial instruments with specific maturities in order to provide a certain return. The investor should make some investment decisions before investing in financial investment instruments. First of all, it is necessary to answer questions such as which financial instruments to invest in, and how much risk they will take. With the globalization, the need for new financial instruments and financial transfer methods has emerged in order to make capital transfer faster and in different ways. Advances in information technology and widespread use of computers have led to the emergence of new financial instruments. Financial instruments contain a variety of risks, and therefore it is crucial to examine the nature of the financial instrument before deciding to invest. In the capital market, investors can invest directly in financial instruments such as government bonds, private sector bonds, and bonds, stock certificates, stock exchange traded funds, warrants, certificates, repo treasury bills, asset-based or asset-secured securities, lease certificates, futures, and options. They can also invest indirectly in capital market instruments by acquiring investment funds or in the private pension system (Investing, 2019).

Investors who do not like risk generally prefer to invest in fixed-income securities, such as government bonds and treasury bills, which are safer but lower. Liquid funds, repo and short-term investment instruments such as deposits are among the most preferred investment instruments in order to maintain the value of savings against inflation. Risk acceptant investors can achieve high rates of leverage by leveraging Forex, which is a popular type of investment in recent years. Investors with a high level of knowledge can use derivative products to hedge or increase their yields by taking a certain level of risk.

After the 2008 financial crisis, many financial firms and their customers agreed to the importance of asset allocation and the need to diversify their customer portfolios. This led portfolio managers to add alternative investments to customer asset allocation models. The most recent alternative investment on the stage is the cryptocurrency, and it seems to be as easy for US investors to buy a cryptocurrency exchange-traded fund (ETF) or some other stocks, traded in cryptocurrency before entering this alternative investment. For those who are not familiar with them, alternative investments are defined as non-correlated assets, which means that their performance does not match those of more traditional asset classes, such as stocks and bonds. As these assets move in the opposite direction of traditional investments, they can provide adequate protection against market declines. Even if the portfolio is looked at and anything is not seen directly that is known as an alternative investment, they can be many large corporate funds, such as ETFs or funds, as well as pensions and even pension fund proposals. Retail companies such as Morgan Stanley and Merrill Lynch have proposed allocation models for customers with alternatives that are close to or above 20% of the portfolio. Each customer is different, and the

allocations will vary depending on their needs, but a current discussion with a financial advisor will probably include the subject of alternative investments in a portfolio. It is true that many people often associate with a hedge fund as the most common alternative investment and for many investors. However, most hedge funds can only be used by large investors and require considerable amounts of paperwork, high fees, and tax shortages. Many investors are achieving exposed to alternative investments through liquid alternatives such as mutual funds, ETFs and closed-end funds that provide daily liquidity, but have sophisticated investment strategies that seek to maintain their non-correlated status. Some financial advisors may consider that the inclusion of alternative investments is a prudent aspect of asset allocation for retirement accounts. A consultant may allocate five to 10% of the pension portfolio to this non-related investment class. If the alternative investment is wanted to be in a kind of cryptocurrency or related asset, this cryptocurrency market can be a risky investment until it matures. Investment performance will also vary depending on how cryptocurrency is invested in. An investment can be done directly in Bitcoin, Ethereum, or more than 2000 cryptocurrencies or companies with specialized equipment that specializes in the development of existing blockchain technology or specialized in mining cryptography (The Balance, 2019).

As an alternative investment option, it will not take long to see an ETF of companies that follow Blockchain technology. Some of the hedge funds' portfolios include Bitcoin and other crypto coins. If hedge funds are invested in crypto coins and considered as an alternative investment, then firms and media will start to publicize crypto coins as an alternative investment instrument. A risk-loving investor may want to invest in other cryptocurrencies other than Bitcoins. Bitcoin is not only a digital currency but also an investment tool. Some exchanges buy and sell most of these different cryptocurrencies, including the XRP used in blockchain projects such as Ripple Labs and ETH (Ethereum), which cause price movement every day. Due to the complex nature of the Blockchain technology (the underlying infrastructure of Bitcoin), many do not yet understand it and feel it is not very valuable, but financial companies such as Credit Suisse, Citi, Merrill Lynch, Bank of America and JPMorgan are conducting tests to improve their existing processes. Investments and financial firms' investments in Bitcoin are classified as alternative investments in cryptocurrencies and blockchain-based technologies, so it is time to take part in an appropriately assigned investment portfolio. In a few years, it is clear that there will be more opportunities to invest in them. As these investment opportunities are opened, they must be classified appropriately to be placed in the investor portfolios using appropriate asset allocation models (The Balance, 2019).

There are many studies about Bitcoin and cryptocurrencies in Turkish and foreign literature. Bitcoin, a cryptocurrency, is considered as a financial investment tool and some of the following are:

Sönmez (2014), the rise of Bitcoin, featured its place in the development of the economy in the world and Turkey and examined, researched the method of operation, has analyzed the current situation related to the new virtual currency. An innovative and successful technological design, Bitcoin, which is defined as a technological design, examines its weaknesses and strengths by examining it from different perspectives and discusses its opportunities and threats.

Pirinççi (2018) evaluated the historical development of digital money, the concept of virtual money and crypto money by reconsidering the definition, features, and functions of money. Bitcoin's historical background, its positive and negative aspects, and its market have been handled, and the particular server of Bitcoin cannot be found and therefore it cannot be intervened by the authorities and can provide investors with high earnings in the short term. It has even identified the risk of becoming a global crisis in the long run.

In a study conducted by Çalışır and Şanver (2018), they looked for answers to the question of how central banks will play a role in the implementation of monetary policy in the medium and long term. In the study, debates were discussed whether Bitcoin was a balloon or a commodity, currency or financial investment instrument in national and international platforms. Although the use of it as an alternative currency has been discussed, it is stated that cryptocurrencies are a challenge to the monopoly of money, which is one of the most influential forces of the nation-state. However, it is stated that the inability to fully penetrate payment systems and, more specifically, the appearance of the speculative asset tool in the short term will have an impact on the monetary policies and the weakening effect will be weak.

Elendner, Trimborn, Ong, and Lee (2017) investigated the value generating approaches of subcoins and their trade and information platforms. By investigating cryptocurrencies as alternative investment assets, they examined their returns and joint actions of the subcoin prices against Bitcoin and each other and evaluated their contributions to the investor portfolio. They evaluated the portfolios as one based on an equal weight, a value-weighted one and one based on the Cryptocurrency Index (CRIX). They determined that the CRIX portfolio has a lower risk than all liquid cryptocurrencies.

Liu (2019) examined the investment feasibility and diversity of the cryptographic currency as an alternative class of assets in the article. For this purpose, the cryptocurrencies, traded on the market, including Bitcoin, Dash, Ethereum, Litecoin, Monero, NEM, Ripple, Stellar, Tether, Verge and whose market value is more than 1 billion, were examined. The data set covers the periods from 07 August to 15 and 09-Apr-18 with 977 trading days in total. The study also shows whether the portfolio choice theory can benefit the cryptocurrency market. It has been found that the diversity between the cryptocurrencies can significantly increase the Sharpe rate and utility.

Troster, Tiwari, Shahbaz, and Macedo (2018) conducted a general GARCH and GAS analysis to model and estimate Bitcoin returns and risk. According to the results obtained from the econometric analysis carried out within the scope of the study, the strongly biased GAS models have the best fit for Bitcoin returns. According to the results of the study, GAS models provide the best protection for Bitcoin risk.

Symitsi and Chalvatzis (2019) using traditional performance measures to estimate the value-added of Bitcoin, it explored as a mainstream financial asset in the risky portfolios of various assets and, as a result of the econometric analysis, the Bitcoin portfolios, in most cases, did not require a statistically significant increase in variance or they have acquired.

Salisu, Isah, and Akanni (2019) examined the role of Bitcoin prices in G7 countries in estimating stock returns. For this purpose, the current forecasting models for stock returns taking country-specific and common factors into account are compared singly and commonly according to the Bitcoin-based forecasting model. According to the results of the econometric analysis conducted in the study, the predictive power of Bitcoin can be used during the modeling of stock returns especially in coincident periods with high volume Bitcoin operations.

Branvold, Molnar, Vagstad, and Valstad (2015) investigated the role of different stock exchanges in Bitcoin's price discovery process. The exchange of information on the stock exchange measures the actual price discovery rate. As the rate of price discovery is higher in the stock exchanges with high trading volume, the ratio between information sharing and share of activity is also examined. According to the results obtained from the econometric analysis carried out within the scope of the study, the market leaders with the highest share of knowledge during the sample period are Mt.Gox and BTC-e. The rest of the exchanges are relatively less informative.

Briere, Oosterlinck, and Szafarz (2015) examined the Bitcoin investment from a US investor perspective with a diversified portfolio, including both traditional assets and alternative investments. According to the results of the statistical analysis, it is obtained that Bitcoin investment provides significant diversification benefits. The inclusion of a small Bitcoin ratio can significantly increase the risk-return variation of well-diversified portfolios.

Wu and Pandey (2014) included Bitcoin in the portfolio of financial instruments such as major currencies, US equities, US bonds, and commodities in the world and examined the value of Bitcoin as an investment asset. According to the results of the statistical analysis carried out within the scope of the study, Bitcoins have the potential to increase the performance of an investor's portfolio. It can, therefore, be useful to keep Bitcoins as a component in a diversified investment portfolio.

Moore and Stephan (2016) aimed to provide an assessment of the potential benefits and costs of keeping Bitcoin as part of the international reserves portfolio using the Barbados example. According to the findings of the empirical analysis, as the ratio of the reserves held in Bitcoin increases, the variability of the reserves also increases. The transactions carried out by Barbados in the digital currency do not exceed 10% of all transactions in the short term. It is therefore recommended that Bitcoin should be relatively small if the Central Bank of Barbados is included in the foreign currency balances portfolio.

Lo and Wang (2014), in their work, analyzed how the various intermediary organizations emerged and developed in the Bitcoin network and the impact on the blockchain and the long run if the regulatory system did not improve the deficiencies of the digital system network due to the severe design errors and the mining cost of the Bitcoin network. They cannot be a permanent system.

Parker (2014) compared Bitcoin to electronic money and found that Bitcoin was an asset away from the banking system. He believed that Bitcoin would only create a generation of his financial services over time. Bitcoin's lack of legal clarity, such as electronic coins, was highly risky and therefore argued that cryptocurrencies should be included in the formal financial system.

Velde (2013) stated that people are betting with Bitcoin and that the reason is that they want to convert Bitcoin into a fully equipped money. He stated that Bitcoin, as such, is limited in its use as an exchange tool.

Gandal and Halaburda (2014) investigated the competition between cryptocurrencies and showed that the prices of some other cryptocurrencies increased more than the US dollar compared to Bitcoin. This leads to an increase in the demand for cryptocurrencies and the expansion of the market, rather than the popularity of Bitcoin.

Jonker (2018) stated in his study in the Netherlands that only 2% of the online payment method is in Bitcoin. He stated that currently those who have a cryptocurrencies account have the expectation of increasing the future value of money rather than using it for shopping and they have the purpose of investing.

Briere et al. (2015) stated that Bitcoin's return and volatility are high and that it is low about other known investment tools when it is considered as an investment tool, and therefore it would benefit in portfolio diversification to minimize risk.

Kristoufek (2015) examined the factors affecting the prices of Bitcoin and argued that the volume of use as a means of change is useful in the price of real money as the means of exchange is useful in price formation. Contrary to the general view, he stated that it was not a speculative formation.

Cheah and Fry (2015) pointed out that the extreme fluctuations in Bitcoin prices were remarkable because they were unstable due to their instability and that the price of balloons was in question.

Kanat and Öget (2018), the relationship between one of the cryptocurrency in working with Bitcoin prices, which stock indexes belonging to Turkey and the G7 countries examined using VECM Granger Causality/WALD testing, with long-term Bitcoin cannot be mentioned any relationship between other countries stock indexes in the short term with Bitcoin prices on the UK Stock Exchange (FTSE) index, S&P 500 and the Canadian Stock Exchange (CSE) index has been found to have a relationship between the results.

Baur, Hong, and Lee (2018) investigated whether Bitcoin was used as an alternative currency in the payment of goods and services or as an investment. According to the results of the statistical analysis done in the study, Bitcoin; it is not related to traditional asset classes such as stocks, bonds, and commodities. Analysis of the transaction data of Bitcoin accounts shows that Bitcoins are mainly used as a speculative investment and not used as an alternative currency and exchange tool.

Chu, Nadarajah, and Chan (2015) conducted a statistical analysis of the Bitcoin exchange rate against the US dollar using various parametric distributions known in the field of finance. According to the results of the statistical analysis conducted in the 2011–2014 period, Bitcoin investment yields very high returns with high fluctuations.

Karaağaç and Altınırmak (2018) investigated the effect of the prices of the crypto coins traded in many and various markets. In the study, total market values were taken into consideration in the selection of Bitcoin, Bitcoin Cash, Cardano, Ethereum, Litecoin, NEM, NEO, Ripple, Stellar and IOTA crypto coins and ten

cryptocurrencies with the highest total market value were included in the analysis. Between December 15, 2017, and January 17, 2018, Johansen Cointegration Test and Granger Causality Test were applied to the series in order to examine the relationship between the daily price movements of the crypto coins. As a result of the study, Cardano is the reason for NEO Granger; Bitcoin is the reason for Bitcoin Cash's Granger, Litecoin is the Granger cause of Bitcoin Cash, NEM is the Bitcoin Cash Granger cause. It was revealed that NEO and Ethereum are Granger causes of each other, NEO and Litecoin are the Granger causes of each other and NEM is the Granger cause of Stellar and the price movements of these variables affect each other in the short term.

Sovbetov (2018), using the weekly data in his paper, examined the factors affecting the prices of the five most popular cryptocurrencies, such as Bitcoin, Dash, Ethereum, Litecoin and Monero during 2010–2018. ARDL technique was used in the study, and it was seen that cryptomarket-related factors such as market beta, transaction volume, and volatility were essential determinants for all five cryptocurrencies in both short and long term.

Dyhrberg (2016) analyzed the relationship between Bitcoin, gold and US dollar, and states that Bitcoin can be classified as something between gold and US dollars. Findings based on the original sample and extended sample time. It also shows that Bitcoin is very different from gold and other currencies. Bitcoin shows significantly different returns, volatility and correlation characteristics compared to other assets, including gold and US dollars. They found that Bitcoin had unique risk-return characteristics, followed a different volatility process compared to other assets, and had no relationship with other assets.

11.3 GM(1,1) Rolling Model

Gray System Theory was developed by Deng in 1982. By Deng, systems about which there is deficient information are defined as gray systems. In another saying, gray refers to cases characterized by uncertainty. Deng specifies that there must be one of four states with incomplete information to identify a system as gray (Lin, Chen, & Liu, 2004:197):

1. incompleteness of information about the parameters of a system,
2. incompleteness of information about the structure of a system,
3. incompleteness of information about the boundaries of a system, and/or
4. incompleteness of information about the behavior of variances in a system.

In Gray System Theory, GM (h,N) refers to a gray model. In a GM(h,N) model, the "GM" refers to Gray Model, the "h" in parentheses is the degree of the model and "N" is the number of variables in the model. Although there are several gray models used in the context of Gray System Theory, most of the empirical studies using the gray model prefer to use GM(1,1) Rolling Model because the model is simple to program and provides practical outputs.

GM(1,1) refers to a first-order gray model with one variable. The Model is used to explore relationships within time series, to model according to these relationships and to forecast using this model. The GM(1,1) Rolling Model can make effective forecasting by adapting new relevant data to the model. In order to use the GM(1,1) Rolling Model, the data to be used in the model must have a positive value and the same frequency. Also the forecasting with the GM(1,1) Rolling Model follows three main steps. These are, (i) Accumulated Generating Operation (AGO), (ii) Gray Modeling (GM) and (iii) Inverse Accumulative Generating Operation (IAGO). The GM(1,1) Rolling Model applies these steps in order to model and to forecast a system. These three steps can be shown with the following equations (Zhou & He, 2013:6235–6239):

Assume that time series of the price of Cryptocurrency denoted as P.

Step 1: AGO Process

Assuming $P^{(0)}$ is an original time series of the cryptocurrency;

$$P^{(0)} = \{P(1), P(2), \ldots, P(n)\} \tag{11.1}$$

where $P(k) \geq 0$, $k = 1, 2, \ldots, n$ and $n > 4$.

AGO process is done to reduce the randomness of the original series. The AGO process is applied to the original series to obtain the accumulated series. The GM (1,1) Rolling Model converts the original series to a series with an even increase. Thanks to this transformation created by AGO, the randomness in the original series is effectively reduced. This process can be shown as in Eq. (11.2):

$$P^{(0)} = \left[P^{(1)}(1), P^{(1)}(2), \ldots, P^{(1)}(n)\right] \tag{11.2}$$

where $P^{(1)}(k) = \sum_{i=1}^{k} P(i)$, $\widehat{P}(k) \geq 0$, $k = 1, 2, \ldots, n$ and $n > 4$.

Step 2: Gray Modeling

As the solution of first-order differential equations is in exponential form, new time series obtained from the AGO process are used to generate the first-order differential equation. The resulting equation is used to forecast the future behavior of the system. The first-order gray differential equation can be shown as in Eq. (11.3):

$$\frac{dP^{(1)}}{dt} + aP^{(1)} = b \tag{11.3}$$

Where b is the gray action quantity and a is the development coefficient.

The forecasting model for the gray system can be obtained by solving Eq. (11.4):

$$\widehat{P}^{(1)}(k+1) = \left[P(1) - \frac{b}{a}\right] \exp(-ak) + \frac{b}{a}, \quad k = 1, 2, \ldots, n \tag{11.4}$$

Where $\widehat{P}^{(1)}(k+1)$ represents an estimation of $P^{(1)}$.

The primary form of GM(1,1) Rolling Model corresponding to the unit t can be expressed as Eq. (11.5):

$$P(k) + \frac{a}{2}\left(P^{(1)}(k) + P^{(1)}(k-1)\right) = b \tag{11.5}$$

Optimal a and b are calculated by Least Squares Method.

$$\begin{bmatrix} \hat{a} \\ \hat{b} \end{bmatrix} = \left(Z^T Z\right)^{-1} Z^T Y \tag{11.6}$$

where

$$Y = \begin{bmatrix} P(2) \\ P(3) \\ \cdots \\ P(n) \end{bmatrix}, \quad Z = \begin{bmatrix} -\frac{1}{2}\left(P^{(1)}(2) + P^{(1)}(1)\right) & 1 \\ -\frac{1}{2}\left(P^{(1)}(3) + P^{(1)}(2)\right) & 1 \\ \cdots & \cdots \\ -\frac{1}{2}\left(P^{(1)}(n) + P^{(1)}(n-1)\right) & 1 \end{bmatrix} \tag{11.7}$$

Step 3: IAGO Process
Forecasted values for the original series are obtained by IAGO process. The forecasting of P can be calculated by using Eq. (11.8):

$$\widehat{P}^{(1)}(k+1) = \widehat{P}^{(1)}(k+1) - \widehat{P}^{(1)}(k) \;\; k = 1, 2, \ldots, n \tag{11.8}$$

After the IAGO process, error analysis for gray predictions is performed using the Mean Absolute Percentage Error (MAPE) is shown in Eq. (11.9).

$$MAPE = e(k) = \left| \frac{P^{(0)}(k) - \widehat{P}^{(0)}(k)}{P^{(0)}(k)} \right| \times 100 \tag{11.9}$$

11.4 Application

11.4.1 The motivation of the Application

Although cryptocurrencies initially emerged as a transnational payment instrument, it has become an investment tool by attracting the attention of investors within the functioning of the capitalist system. As is known, most investors remain in a

dilemma between the risk of risk aversion and the maximization of returns. Investors in this dilemma try to predict the future price or returns of the financial instruments through various analyzes and thus make an effort to give a path to their investments. These analyses are generally carried out by analyzing the past values of prices or returns by adopting a technical analysis approach. However, since the cryptocurrencies are a relatively new investment tool, it is not possible to reach the previous period price and yield information for an extended period. For this reason, in this application, GM(1,1) Rolling Model developed under the Gray System Theory which is recommended to be used in the short term forecasting is used. The price forecasting of popular cryptocurrencies which are Bitcoin (BTC), Ethereum (ETH), Litecoin (LTC), and Ripple (XRP) was calculated using the GM (1,1) Rolling Model, and it was tested whether this model is advisable for price forecasting of cryptocurrencies.

11.4.2 Data, Parameters, and Modeling

The data employed in this chapter includes only one variable which is the price of the cryptocurrency for each on a daily basis, taken from the Coin Desk (2019). The data are sectionalized into two parts named training dataset and forecasting dataset. The training dataset is used to determine the best GM(1,1) Rolling Model and to generalize k and alfa predictions.

The horizontal adjustment coefficient (α) and the length of subsequences (k) which are relevant factors in developing a successful model have been determined. The forecasting performance of the GM(1,1) Rolling Model is affected by α and k parameters. According to the theory of Gray Systems, these parameters are used as $\alpha = 0.5$ and $k = 4$. Besides, different values of these parameters may increase the forecasting performance of GM(1,1) Rolling Model. At this moment, the best value of these parameters is studied by the writers. This process is named as optimization of the Grey Rolling Model. α and k parameters are optimized by using Matlab R2018b. Table 11.2 shows the parameters of each optimized model.

In light of the parameters in Table 11.2, time series forecasting was made based on the technical analysis approach for each cryptocurrency.

11.5 Empirical Findings and Evaluation

Since the analysis by GM(1,1) Rolling Model is performed for four cryptocurrencies, the findings of the application should be evaluated separately for each. In Table 11.3, the results of the 10-day forecasts made with the GM(1,1) Rolling Models are shown according to Mean Absolute Percentage Error (MAPE) criteria.

Table 11.2 The parameters of the optimized GM(1,1) Rolling Models

		Cryptocurrencies			
		BTC	ETH	LTC	XRP
Parameters	Best α (The horizontal adjustment coefficient)	0.4	0.4	0.4	0.4
	Best k (The length of subsequences)	5	5	5	4
	Length of training data	749 days	1258 days	231 days	231 days
	Beginning of the training set	31.12.2016	9.8.2015	31.5.2018	31.5.2018
	Ending of the training set	25.1.2019	25.1.2019	25.1.2019	25.1.2019
	MAPE of the training process (%)	0.0252	0.0561	0.0724	0.0064
	Length of the forecasting period	10 days	10 days	10 days	10 days
	Beginning of forecasting period	26.1.2019	26.1.2019	26.1.2019	26.1.2019
	Ending of the forecasting period	4.2.2019	4.2.2019	4.2.2019	4.2.2019

Table 11.3 shows that the error percentages of forecasting of cryptocurrencies ranged from 1.35% to 7.76%. According to these results, it can be said that the model gives a high performance in terms of forecasted percentages for short-term forecasting.

Graph 11.1 shows daily and 10-days average errors. In Graph 11.1, daily errors are represented by APE (Absolute Percentage Error) and mean errors are represented by MAPE (Mean Absolute Percentage Error). As can be seen from Graph 11.1, APE values often have an error value equal to or lower than the MAPE values except for the LTC. This means that APE values are low, except for the large deviations over a few trading days.

However, it is not possible to make the same interpretation for 10-days direction forecasting, which is between 40% and 50% accurate. Although low deviations have obtained the results, the direction signals of the forecasting show that the signals cannot reach an acceptable success. In other words, despite the forecasting with low error percentages, if investors invest in these forecasting reliably, there is a high probability of losses in their portfolios. Therefore, investors may not have the opportunity to obtain a return above the average.

Also, Graph 11.2 support the comments about the findings of direction forecasting. When Graph 11.2 is analyzed, it can be seen that the actual directions (real values) and the forecasted directions (forecasted values) usually show different direction movements daily. Therefore, it can be stated that the forecasting results made by GM(1,1) Rolling Model is not reliable enough for investors.

Table 11.4 provides information about the yields that can be obtained in the 10-days investment period. When the data about the returns in the relevant investment period is analyzed from Table 11.4, it is seen that all of the investments made

Table 11.3 Forecasting result of the GM(1,1) Rolling Models

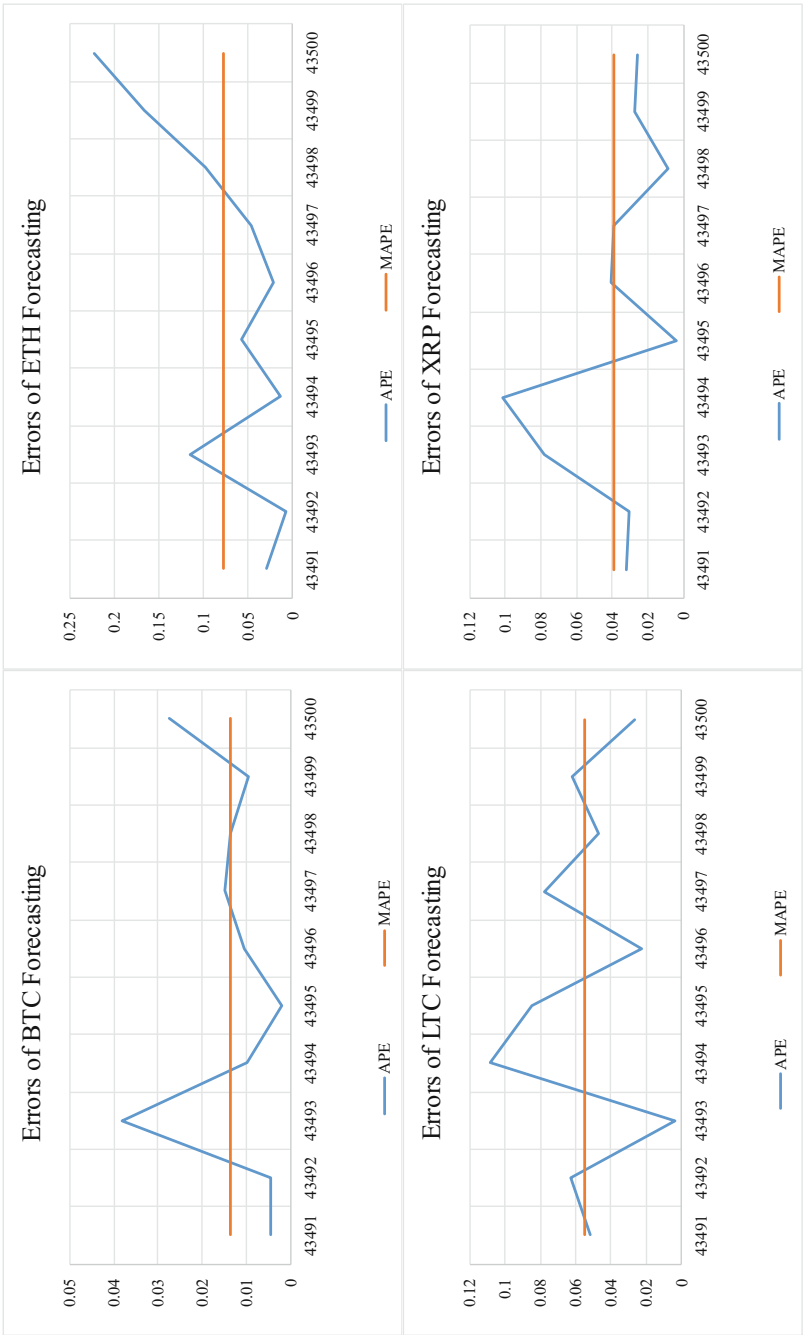
BTC				ETH			
Date	Real values	Forecasted values	MAPE (%)	Date	Real values	Forecasted values	MAPE (%)
26.1.2019	3563.28	3579.85	0.0047	26.1.2019	115.24	118.61	0.0292
27.1.2019	3539.62	3523.66	0.0045	27.1.2019	112.63	113.57	0.0083
28.1.2019	3425.26	3555.81	0.0381	28.1.2019	105.01	117.02	0.1144
29.1.2019	3395.02	3361.80	0.0098	29.1.2019	104.14	105.62	0.0143
30.1.2019	3441.03	3433.79	0.0021	30.1.2019	107.57	101.43	0.0571
31.1.2019	3420.63	3456.45	0.0105	31.1.2019	106.17	108.40	0.0209
1.2.2019	3439.81	3388.40	0.0149	1.2.2019	106.12	111.02	0.0461
2.2.2019	3433.04	3480.00	0.0137	2.2.2019	106.73	117.12	0.0974
3.2.2019	3404.50	3436.89	0.0095	3.2.2019	106.09	123.73	0.1662
4.2.2019	3412.23	3505.86	0.0274	4.2.2019	106.24	129.88	0.2225
Mean			0.0135	Mean			0.0776
Accuracy of direction forecasting			0.5000	Accuracy of direction forecasting			0.4000
LTC				**XRP**			
26.1.2019	32.96	31.27	0.0515	26.1.2019	0.31	0.32	0.0319
27.1.2019	32.34	30.30	0.0630	27.1.2019	0.31	0.32	0.0308
28.1.2019	30.58	30.69	0.0038	28.1.2019	0.29	0.31	0.0781
29.1.2019	30.60	27.28	0.1085	29.1.2019	0.29	0.32	0.1018
30.1.2019	31.58	28.90	0.0849	30.1.2019	0.31	0.31	0.0040
31.1.2019	31.26	30.54	0.0228	31.1.2019	0.31	0.30	0.0407
1.2.2019	32.70	30.15	0.0779	1.2.2019	0.30	0.29	0.0391
2.2.2019	32.82	31.27	0.0472	2.2.2019	0.30	0.30	0.0088
3.2.2019	33.05	31.01	0.0618	3.2.2019	0.30	0.29	0.0272
4.2.2019	33.62	32.71	0.0269	4.2.2019	0.30	0.30	0.0259
Mean			0.0548	Mean			0.0388
Accuracy of direction forecasting			0.4000	Accuracy of direction forecasting			0.5000

by relying on the forecasting results of GM(1,1) Rolling Models have a negative return despite being above the average.

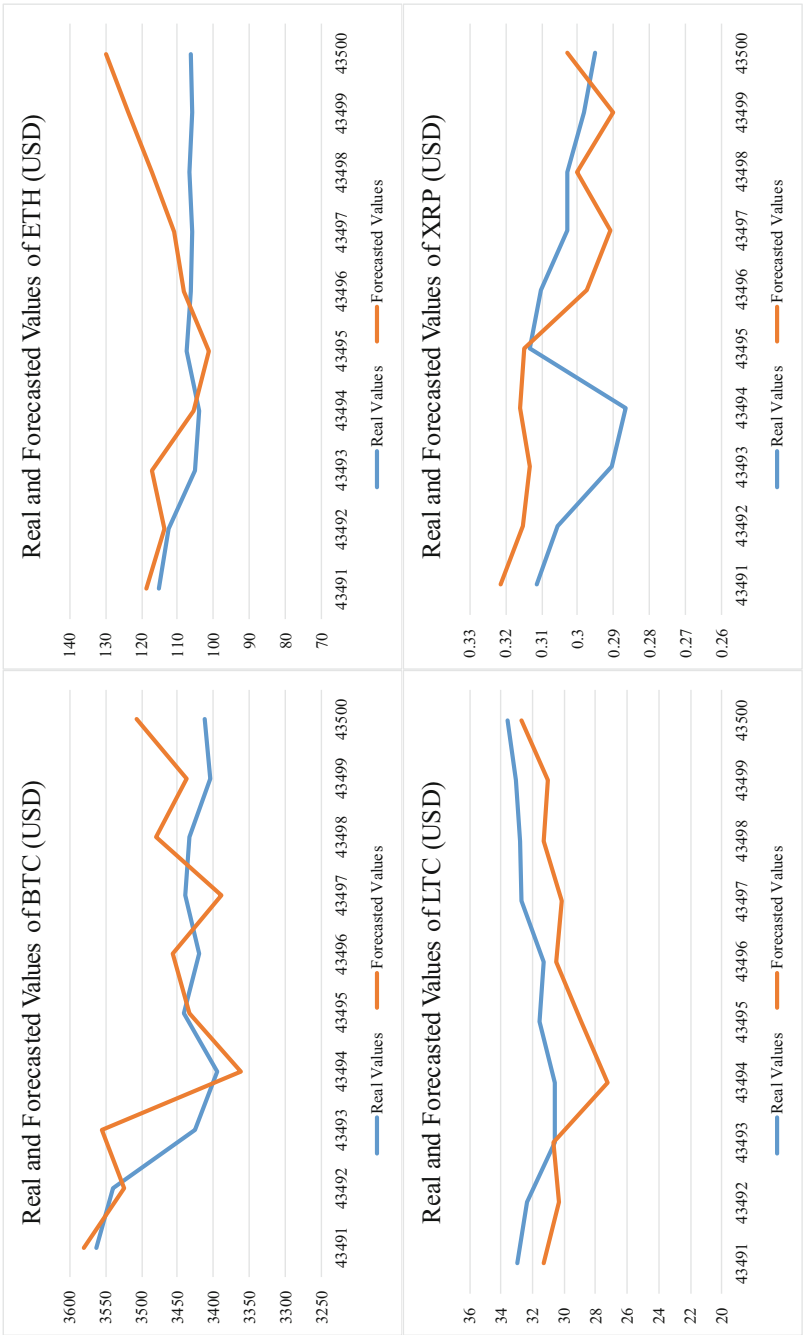
As a result, the findings are important in terms of showing that not only price forecasting with low error percentages but also high accuracy direction forecasting should be made.

11.6 Conclusion

Although cryptocurrencies have been developed primarily as a means of payment, it has also become an investment instrument for portfolio investors and speculators to be interested in because of its rapid price increases and high return potential. In this



Graph 11.1 Errors in the forecasting of cryptocurrencies



Graph 11.2 Real and forecasted values of cryptocurrencies

Table 11.4 Yields of the investment period

%	BTC	ETH	LTC	XRP
Potential maximum positive return of the investment period	2.14	3.98	12.15	8.93
Potential maximum negative return of the investment period	−6.41	−11.66	−8.35	−13.96
Average return of the investment period	−4.40	−8.15	2.78	−6.28
Average return of following the signals of the GM(1,1) Rolling Model	−2.63	−8.18	−0.60	−2.97

chapter, time series forecasting based on the technical analysis approach was made to forecast the prices of cryptocurrencies in the light of the Gray System Theory.

In the application, GM(1,1) Rolling Model developed under the Gray System Theory which is recommended to be used in the short-term time series forecasting is used. The price forecasting of popular cryptocurrencies which are Bitcoin (BTC), Ethereum (ETH), Litecoin (LTC), and Ripple (XRP) was made using the GM(1,1) Rolling Model, and it was tested whether this model is advisable for modeling of price movements cryptocurrencies.

Results of the Model show that the forecasting errors ranged from 1.35% to 7.76% for 10-days period. Also, direction forecasting results are between 40% and 50% in the same period. Also, returns of the bitcoin investment which made by trusting the results are ranged from −0.60% to −8.18.

The results may be considered that the model was successful in forecasting the prices but unsuccessful in the direction forecasting. Even though the estimates are made with low percentages, the time series analyzes made with the lagged data of Bitcoin prices are not successful. Therefore, the technical analysis approach can be interpreted as not sufficient for modeling Bitcoin prices. So, these results show that defining bitcoin price movements is not only a forecasting problem but also a classification problem.

Glossary

Bitcoin Bitcoin is a digital or virtual currency that uses peer-to-peer technology to facilitate instant payments.

Blockchain The blockchain is a technology used to read, store and verify transactions in a distributed database system.

Cryptocurrency A cryptocurrency (or crypto currency) is a digital asset designed to work as a medium of exchange that uses strong cryptography to secure financial transactions, control the creation of additional units, and verify the transfer of assets.

GM(1,1) Model GM(1,1) refers to a first-order gray model with one variable. The Model is used to explore relationships within time series, to model according to these relationships and to forecast using this model.

Gray System Theory A method which measures the degree of similarity between two systems.

Technical Analysis Technical analysis is a trading discipline employed to evaluate investments and identify trading opportunities by analyzing demographic trends gathered from trading activity, such as price movement and volume.

Time Series Analysis Time series analysis comprises methods for analyzing time series data in order to extract meaningful statistics and other characteristics of the data.

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