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EXPLORING BUBBLES IN THE ALTCOIN MARKETS

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I hereby declare that all information in this thesis has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all information that is not original to this work.

[Signature]

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ABSTRACT

EXPLORING BUBBLES IN THE ALTCOIN MARKETS

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The purpose of this study is to investigate the existence of economic bubbles in altcoin currencies such as Dogecoin (DOGE), Crypto.com (CRO), Binance Coin (BNB) and Polygon (MATIC), which showed high market capitalisation during the periods 2018-2021. The existence of bubbles in these altcoins are examined by utilizing the Supremum Augmented Dickey-Fuller (SADF) right-tailed unit root test. As a result of this study, a bubble formation was detected in the altcoin prices, which was carefully examined, especially in 2020Q4, and 2021Q4. When the periods in which the economic bubble was detected were evaluated, it was concluded that the bubbles were based on news-related manipulations and Covid-19 fear. This study sheds new light on the existence of bubbles in the altcoin markets in the post-pandemic period.

Keywords: cryptocurrency, altcoin market, financial bubble, SADF test, dogecoin, crypto.com, bnb, polygon

ÖZET

ALTCOİN PİYASALARINDA FİYAT BALONU OLUŞUMU

Adeviye ERDOĞAN

İşletme Yönetimi Anabilim Dalı

Danışman: Doç. Dr. Ömer Tuğsal DORUK

Ocak 2023, 25 sayfa

Bu çalışmanın amacı 2018-2021 yılı dönemleri yüksek piyasa değeri gösteren Dogecoin (DOGE), Crypto.com (CRO), Binance Coin (BNB) ve Polygon (MATIC) gibi altcoin para birimlerinde ekonomik balonların varlığını araştırmaktır. Altcoinlerde finansal balonların varlığını tespit etmek için Supremum Augmented Dickey-Fuller (SADF) sağ kuyruklu birim kök testi kullanıldı. Çalışma sonucunda özellikle 2020Ç4 ve 2021Ç4'te incelenen altcoin fiyatlarında balon oluşumu tespit edildi. Ekonomik balonun tespit edildiği dönemler değerlendirildiğinde balonların haber kaynaklı manipülasyonlara ve Covid-19 korkusuna dayandığı sonucuna varıldı. Çalışma, pandemi sonrası dönemde altcoin piyasalarında balonların varlığına yeni bir ışık tutuyor.

Anahtar Kelimeler: kripto para birimi, altcoin piyasası, finansal balonlar, SADF test, dogecoin, crypto.com, bnb, polygon

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NOMENCLATURE

Doge	: Dogecoin
Cro	: Crypto.com
Bnb	: Binance Coin
Matic	: Polygon
Q	: Quarterly
SADF	: Supremum Augmented Dickey–Fuller
B.C.	: Before Christ
DeFi	: Decentralized Finance
P2P	: Peer to Peer
T\$	: Trillion Dollars
BTC	: Bitcoin

1. INTRODUCTION

At the beginning of the 6th century, the Lydians used money as a means of commerce. Added to the medium of trade, dating back to the Egyptian Pharaohs around 3000 B.C., gold was used as a medium of exchange (Eiteman et al., 2016). Gold, which existed in natural formations, was mostly used and carried by the Greeks and Romans, until the 19th century. Money, whose physical existence changes over time, has the characteristics of 'Representative Money' (the paper equivalent of a metal such as gold and silver), 'Commodity Money' (the same value as the raw material used), and 'Fiat Money' (the money announced by the central bank and the state) (Şahin,2020). With developing technological structures and software programs, money is now available to us as digital and virtual currencies as well. Digital currencies are intangible and can be transferred completely electronically. In 2021, the European Central Bank (ECB) announced that virtual money is the following; “A regulated digital currency used by a particular group member, controlled and created by the person/entities” (see ECB, 2021). Digital currencies have been scrutinized since their introduction and they have come with many questions and are contrary to the conventional concept of money. With digital currencies, Decentralized Finance (DeFi) will also be another concept that investors will likely focus on in the future.

DeFi has since become popular for investors around the world with digital currencies. The communication system used for the circulation and distribution of data in two or more transmissions is called a peer to peer (P2P) lending system and these are at the core of the DeFi concept. A computer in the network represents a peer and when a peer fails, only that peer's connection is lost and the system continues to work. Therefore, it reduces transaction costs and increases trust in the network, thanks to a centralized system. No matter how reliable it is by the user, it is possible to obtain copyrighted data because the data sent between peers is unlimited (Baran ,1964); (Yaga et al., 2019). While the origins of the blockchain system date back to the 1990s¹, with cryptocurrencies, the blockchain system now deserves the attention of investors, especially during the pandemic

In October 2008, the popular era of cryptography technology began with the article “Bitcoin: A Peer-to-Peer Electronic Cash System,” published under the pseudonym Satoshi Nakamoto. Nakamoto did not wish to reveal his real identity at that time (Nakamoto, 2008). In his article, Nakamoto (2008) stated that Bitcoin is a new, digital coin that represents an international currency that may be used around the world (Nakamoto, 2008). Cryptocurrency has prioritized the birth of altcoins (alternative coins) in the same technological structure by providing security in the cryptography system. These are exchanged between peers as an alternative to the

currencies used that belong to a central system after the popularization of Bitcoin (Houben and Snyers, 2018).

In January 2021, there were 3981 different cryptocurrencies available on the CoinMarketCap website, whereas by December 2021, there were 7933 types of cryptocurrencies on the same site. Table 1 shows the release date, market value, circulation amounts and transaction volume of the top ten cryptocurrencies, according to their market value. Trading volume datas are for the last 24 hours (CoinMarketCap, 2021).

Altcoins are usually created based on Bitcoin's blockchain technology. A blockchain is a data structure consisting of a series of interconnected blocks, within which transactions and other data are stored. Altcoins utilize this blockchain technology to provide a secure and complete record of transactions made on the network. Some altcoins modify or enhance blockchain technology to offer different features and functionalities (Ciaian, 2018).

Bitcoin is most commonly used for financial transactions and investment purposes. Altcoins, on the other hand, are designed for different purposes, such as data storage, secure communication and many other uses. From a functional point of view, many limitations in the structure of Bitcoin may be eliminated or improved by altcoins. For example, an altcoin may offer faster transactions, stronger privacy, or more flexible programming options (Mustafa and Adiyaman, 2022). As Bitcoin is the most valuable cryptocurrency, the value of other altcoins may be lower than Bitcoin. However, some altcoins may increase or decrease in value faster than Bitcoin. Apart from these differences, both currencies are based on the same basic principle and use blockchain technology (Gandal, 2016).

Ethereum is a blockchain-based open-source platform. Ethereum was designed not only to transfer money, but also as a platform that allows decentralized applications to be developed and run. Ethereum supports smart contracts written in Solidity, a unique programming language.

Ethereum has a Proof-of-Work (PoW) consensus mechanism like Bitcoin, where network members use computing power to verify transactions and update the blockchain (Öztürk, 2021). However, Ethereum is planned to move to a Proof-of-Stake (PoS) mechanism in the future. Proof-of-Stake (PoS) is a consensus mechanism used in cryptocurrency networks to validate transactions and add new blocks to the blockchain. Unlike Proof-of-Work (PoW), where validators (miners) compete to solve a computational puzzle to earn the right to validate transactions and add blocks, in PoS validators are chosen based on the number of coins they "stake" or lock up as collateral. The validators are then randomly selected to validate transactions and add blocks proportional to their stake. PoS is considered to be more energy efficient and scalable compared to PoW (ethereum.org, 2023).

Cryptography coins linked to Bitcoin include digital currencies, such as Bitcoin Cash (BCH), Bitcoin Gold (BTG), Bitcoin Diamond (BCG), Bitcoin Private (BTCP), Bitcoin SV (BSV). These coins are other cryptocurrencies created by using or cloning Bitcoin's code. However, they aren't the original Bitcoin. Their prices, features and legal status may differ from Bitcoin.

Altcoins (sub-crypto coins) that run on the Ethereum platform are called ERC-20 tokens. These are digital currencies that run on the Ethereum blockchain and are used by decentralized applications or digital assets. The most common ones include tokens such as Binance Coin (BNB), Chainlink (LINK), Uniswap (UNI) and Tether (USDT) ([wikipedia.org](https://www.wikipedia.org), 2023).

Dogecoin, Crypto.com, Binance Coin (BNB) and Polygon (MATIC) are based on different blockchain technologies.

Dogecoin is based on the Litecoin blockchain, an open-source variant of Bitcoin. Crypto.com is based on Chain technology, its own proprietary blockchain technology. Binance Coin (BNB) is based on the Ethereum blockchain and operates as an ERC-20 token. Polygon (MATIC) is a blockchain network running on the Ethereum blockchain, designed primarily to support low latency and high performance dapps (applications).

It can be stated that Bitcoin, Ethereum and Ripple are among the most popular cryptocurrencies. As of December 4th, 2021, the total market value of cryptocurrencies is 2.3 Trillion dollars. Bitcoin BTC constitutes 90% of the total market capitalization (Investing.com, 2021). Bitcoin is designed to have a total of 21,000,000 Bitcoins. Therefore, a deflationary trend awaits Bitcoin (Altay, 2017). Algorithmically, Bitcoin's limited production raises deflationary concerns.

Table 1.1. Most Popular Coins

RELEASE DATE	CRYPTO CURRENCY	MARKET VALUE(\$) AS OF DECEMBER 04,2021	PRICE (\$) AS OF DECEMBER 04, 2021	TRADING VOLUME (\$) AS OF DECEMBER 04,2021
03.01.2009	BITCOIN (BTC)	931,511,058,738	49,217.80	38,960,388,159
30.07.2015	ETHEREUM (ETH)	493,737,099,253	4,152.72	27,644,587,108
26.06.2017	BINANCE COIN (BNB)	93,000,051,434	554.61	2,442,331,636
06.10.2014	TETHER (USDT)	75,216,549,177	1.00	86,248,980,823
31.03.2020	SOLANA (SOL)	58,019,846,438	189.00	3,359,200,243
29.09.2017	CARDANO (ADA)	44,883,165,017	1,34	2,945,913,268
26.09.2018	USD COIN (USDO)	40,613,981,445	0,9997	5,760,718,094
02.02.2013	XRP (XRP)	37,954,062,233	0,7991	3,737,705,435
19.03.2020	POLKADOT (DOT)	27,755,229,440	27,94	1,520,167,523
22.04.2019	TERRA (LUNA)	26,281,841,878	67,15	5,309,168,424

Source: www.investing.com, (2022).

The figures in Table 1 are constantly changing. In order to evaluate this volatility in cryptocurrencies, the price volatility of the Bitcoin should be evaluated.

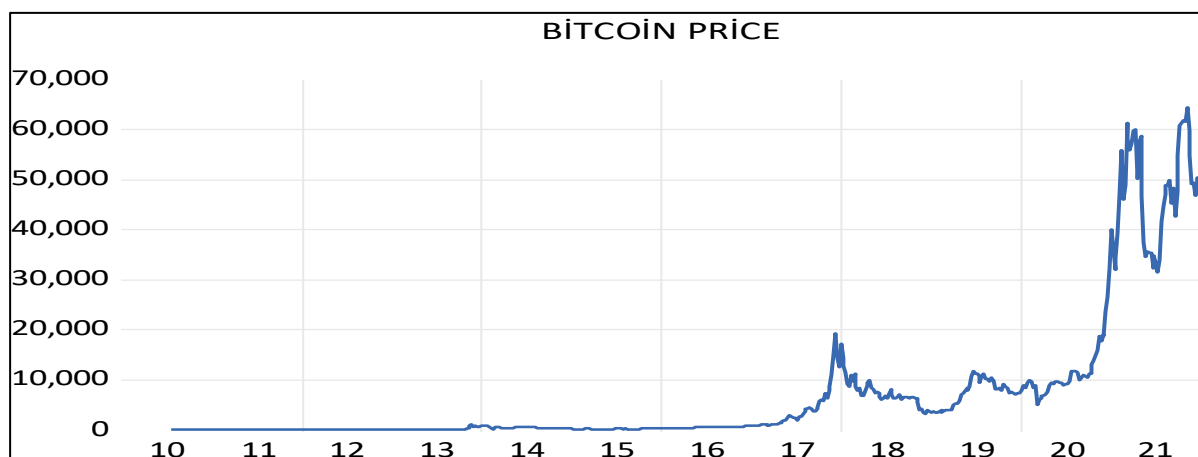


Figure 1.1. Price of Bitcoin BTC (\$) (2010-2021)

Source: The figure was created by the author with data from [Investing.com](https://www.investing.com) (2022).

Bitcoin, which progressed at the standard level for the first 3 years, started to rise in 2013 and rose significantly between 2017 and 2018, and its market value exceeded the level of \$19,000. Then, at the beginning of 2019, it followed a low-price trend and started to rise in the 2nd quarter of the year. The same trend continued until 2020, and the price of Bitcoin reached \$60,000 when entering 2021, with a sudden price increase. As seen in Figure 1, the severe decreases and spikes in the Bitcoin price have encouraged investors to invest in Bitcoin as an investment tool with the hope of gaining profit in the short term. These sudden price changes represent price volatility in other cryptocurrencies such as Bitcoin, and the same investment behavior has been observed.

With the increasing demand for bitcoin, the price of less than \$1,000 will rise to \$20,000 in a year, and those who see bitcoin as "digital gold" hope that the price of bitcoin will reach \$1 million. Discussions continue about the real price of an intangible and unknown digital currency. Media organizations and processors that cause the price volatility of cryptocurrencies also affect the shares and will create speculation on social media. A situation that affects the price of Bitcoin is when famous people talk about crypto-money on their social media accounts and sudden price fluctuations in the price of Bitcoin have been seen, affecting the decisions of investors (blockchair.com, 2021).

Speculative price changes and economic crises have existed all throughout world history (Reinhart and Rogoff, 2009). Economic bubbles exist when the price of an asset increases and it doesn't measure up to the true value of the asset (Phillips and Yu, 2011). Financial bubbles have long been the focus of the attention of investors, researchers and market regulators (Diba & Grossman, 1988). For this reason, stock markets, agricultural prices, house prices, sterling-dollar exchange rates, oil prices, exchange rates, housing prices, gold futures market and agricultural land prices demonstrate the existence of bubbles and can be given as examples of these in specific markets.

In recent years, the rising demand in the crypto money market has led to examining the existence of economic bubbles in altcoin and crypto prices. Speculative bubbles in cryptocurrencies occur when investors buy the limited supply digital currency and then sell it at a higher price (Geuder vd., 2019).

In academic research, two different definitions of the concept of a bubble have emerged, in order to better understand the price changes of cryptocurrencies (Oran, 2011). They show that the concept of a bubble emerged when the collapse occurred. In order to better identify the bubbles, it should also be examined after the price collapse.

Table 1.2. The Definition of Bubbles

First Group of Definitions	
"Crashes after price fluctuation"	(Brunnermeier,2016)
Second Group of Definitions	
"Prices that exceed the fundamental values of assets due to the expectation of selling at a higher price and making a greater profit from the future price change."	(Brunnermeier,2016)
"Buying an asset with the expectation of being able to sell it to a victim, rather than taking advantage of the market rate of return."	(Kindleberger& Aliber, 2005)
"Sudden collapse after prolonged price increase."	(Kindleberger, 1996)

Source: The table was created by the author with database from book of Kindleberger and Brunnermeier, (2022)

It is seen that the concept of a balloon is formed according to the concept of basic value mentioned in the second stage.

Table 1.3. The Formation of the Bubble Concept According to the Basic Value Concept

If the market price of the asset is bigger than the sum of the discounted cash flows and risk-free interest rate,	Demarzo et al., (2008)
If cash flows have a positive or non-negative correlation with the market,	
Despite the first two items, if the risk-averse investors continue to buy this asset, there is a bubble asset.	

Source: The table was created by the author with database from book of Demarzo, (2022)

There are many examples of crises that we can call bubbles in history. There are a few examples of these: (Kindleberger and Aliber, 1996). The big ten financial bubbles (with their dates) include the Dutch Tulip Bulb Bubble (1636), the South Sea Bubble (1720), the Mississippi Bubble (1720), the late 1920s stock price bubble (1927–1929), the surge in bank loans to Mexico in the (1970s), the bubble in real estate and stocks in Japan (1985–1989), the bubble in real estate and stocks in Finland, Norway, and Sweden (1985–1989), the bubble in real estate and stocks in Thailand, Malaysia, Indonesia and Asian countries (1992–1997), the surge in foreign investment in Mexico (1990–1993), and the bubble in counter stocks in the United States (1995–2000).

This thesis explores price bubbles in price behavior of different altcoin assets. We add to the body of knowledge by examining its variation in relation to price data. There is proof for the formation of speculative bubbles in the analyzes made in dissimilar altcoin and crypto markets in dissimilar periods.

These examples of evidence demonstrate that long-term rises and sudden price drops in cryptocurrency prices are identified as bubbles in academic studies. Unlike the research in the related literature, in this thesis, we investigated the data of cryptocurrencies such as Dogecoin, Binance Coin, Polygon, which are famous and show high market value in the altcoin market.

The conclusion acquired from the work can prohibit the loss of value that dynamic investors who create portfolios from risky and risk-free investment instruments may match. Due to some environmental interactions, the over-pricing of altcoins may cause cryptocurrency users to gamble on the stock market.

However, since rising prices conclude in major collapses, this work may persuade investors not to choose financial assets during bubble periods.

In Chapter 2, we have added the work of academic researchers who have had a great influence on the literature on economic bubbles in the past with diverse testing methods in different sectors.

In Chapter 3 and 4, we define the data used and the methodology implemented to explore the link between economic bubble formation and altcoins.

We define and commend the test implemented in Chapter 5 with graphical data and statistical figures.

In Chapter 6, we complete the work by presenting the conclusion reached and adding the thesis to the existing body of literature.

2. LITERATURE REVIEW

Digital currencies have increased significantly in terms of trading volumes, market caps and their total number (Ferroni, 2022). Generally, there has been a fast-growing cryptocurrency literature (Chen et.al. 2022). It has demonstrated the existence of copycat exchanges with the development of fake trading volume resulting from the rapid growth of crypto exchanges where cryptocurrencies are traded. This phenomenon, referred to as a bubble burst, results in a drastic price decrease and causes significant psychological and financial losses for investors. For instance, after a year of sharp rises, Bitcoin's price fell towards the end of 2017, with a collapse of about 65% after its price peaked on February 6th, 2018 (Agosto and Cafferata, 2020).

The World Health Organization declared Covid-19 is a pandemic in April 2020. By spreading to the majority of the world in a short time, it has caused the death of 4 million people (Ögütçen, 2021). In addition to the social and political impact of the Covid-19 virus pandemic on the world, it has had a great impact on cryptocurrencies, in the financial markets.

According to the research of Kayral, (2021), a systematic analysis of some cryptocurrencies (such as Chainlink, Bitcoin, Ethereum) has revealed price fluctuations of approximately 75% during the Covid period. To analyze these instances, it is important to understand the concept of an economic bubble in the literature, and consider the risk posed by the volatility in cryptocurrency prices, particularly for new investors.

According to Samut and Yamak (2021), in their study, they investigated the Covid-19 pandemic's effects on the relationship between return volatility and transaction volume in the cryptocurrency market. It is necessary to have 707 kilowatt-hours of electricity generation in a single transaction of cryptocurrencies. According to the report of the Bitcoin Energy Consumption Index, the power that comes out of a Bitcoin buying-selling transaction is the same as the power used by an average US citizen for 73 days. According to a study published in the journal Nature in 2018, it was stated that the use of Bitcoin could increase the global temperature change above 2 degrees Celsius by 2048 (Thier & Hadas, 2022). Rotermann and Wilfing (2014) stated in their study that the bursting of bubbles caused by the economic crisis and the price volatility in financial markets are consistent with each other. Uncertainty of the underlying value leads to high uncertainty by investors and encourages herd behavior (Devenow and Welch, 1996; Trueman, 1994). A price bubble is an upward price increase that is not driven by economic variables. (Case and Shiller, 2003; Dreger and Zhang 2013).

Some of the studies examine the bubble in the bitcoin market. According to the study of Agosto and Cafferata (2020), the Dickey-Fuller (BSADF) test was used to measure explosive behaviors at the start and end time as well. To determine the presence of potential bubbles and their bursting, the BSADF statistic was calculated and compared to its corresponding critical value at a 5% significance level for each of the 10 cryptocurrencies. The results indicated the presence of a bubble between 2017 and 2018. After applying the right-tailed unit root test, it found evidence of bubbles in all five cryptocurrencies.

According to the findings of Doruk and Önal, (2021) related to the general course of the Bitcoin Market in the Covid-19 Period, they stated that Bitcoin has a structure that can bring more volatility in prices in the market during the COVID-19 period. According to the GARCH Model, the volatility of Bitcoin \$ parity was found to be higher before COVID-19 than after COVID-19. No price bubble has been encountered in the COVID-19 period regarding the Bitcoin price. Although a price bubble was not found in the period before the COVID-19 period, it was determined, as a result of the analyzes, that the price development was considerably higher than before the COVID-19 period..

According to the research of Kamacı and Özden (2019), the relationship between tulip mania and Bitcoin was investigated, and as a result, it was seen that no similarity could be found between the two. While the production of cryptocurrencies with a high-tech hardware infrastructure increases the production costs, the necessity of importing this technological infrastructure increases the costs, according to the exchange rate, and it has been shown that this causes a decrease in demand in Turkey due to the cost disadvantage from the very beginning

According to Turan and Demircan, (2021), it has been shown that Bitcoin is still the widely preferred tool for the financing of terrorism on the blockchain. It is clear that the use of mixer programs that mix dirty crypto money with clean money makes it impossible to follow dirty money. Şahin (2020) stated that the methods and legal infrastructure developed against the use of blockchains in financing illegal activities that describe user privacy as the most important condition, are insufficient.

Within the scope of the study, Phillips et al., (2013) (Sup) ADF (GSADF) used a unit root test. As a result, a bubble was detected in the prices of all three cryptocurrencies in the last quarter of 2017. When the periods in which bubble formation was detected were evaluated, it was observed that news manipulations also had an effect.

Özdemir (2021) investigated the bubble behavior of the prices of the first five cryptocurrencies (Bitcoin, Ethereum, Ripple, Stellar and Tether) of the COVID-19 pandemic between the periods of 02.01.2020 and 02.01.2021. Generalized Supremum Augmented Dickey-Fuller-GSADF and Supremum Augmented Dickey-Fuller-SADF test statistics were used to detect balloons. As a result, it has been determined that there is a potential crisis outside Tether and a recurrent and continuous bubble in Bitcoin, Ethereum, Ripple and Stellar prices.

According to the research of Buğan, (2021), Financial bubbles were detected by using the data of Litecoin, Ripple, Bitcoin, Chainlink, Ethereum and Cardano in the GSADF test. Statistically, the bubbles detected for Ethereum, Chainlink, Bitcoin and Ripple are significant, but statistically, financial bubbles are not significant for Cardano and Bitcoin.

In a Sefa et. all (2019) study, he detected an economic bubble in Ripple (XRP) and Ethereum (ETH) cryptocurrencies using Generalized Sup Augmented Dickey Fuller (GSADF) and Sup Augmented Dickey Fuller (SADF) methods. The results found price bubbles for XRP 2014-2015 and 2017-2018, ETH 2013-2016 and 2017-2018, and BTC specifically for 2013-2014, 2017-2018-2019.

In the study of Kayral (2021), the SADF test was applied to detect price bubbles in 10 cryptocurrencies during the pandemic period.

According to this test, price bubbles were detected in eight cryptocurrencies. The biggest price bubble was seen in Binance Coin with 84 trading days before Covid-19. The highest price bubble at the time of the COVID-19 outbreak was seen in Theta, with 230 days. Bubbles were detected for Chainlink 183 days, Bitcoin 140, Ethereum 104, Cordano 94, Binance Coin 66 and Litecoin 28 trading days. 75% of economic bubbles occurred during the pandemic period. As a result, cryptocurrencies are speculative assets for new investors.

Fry and Cheah, (2016) modeled the relationship between mathematical finance and statistical physics in order to deflate financial bubbles caused by sudden price increases. Negative price bubbles have been detected in Ripple and Bitcoin since 2014. It seems that Ripple has been overpriced, relative to Bitcoin, over that period.

In the literature, those who investigated the existence of financial bubbles in stocks and the stock market are as follows.

According to the study of Yao and Luo, (2009); the researchers observed irrational investment behavior and excessive price volatility in the SSE China Stock Exchange in the period of 2000-05. He noted that in the late 1990s, share prices spiked and the SSE Composite Index rose above 2,200 by 2000, creating the first market bubble. At the end of the year, the SSE index observed that it had dropped to its lowest point at 1.012.

According to the study of Anavatan and Kayacan Y. (2018), the balloon detection program LPPL (log-periodic power law) model was used to measure the existence of bubbles based on the BIST 100 index of the Turkish Stock Exchange for the period of 03.01.1996 to 15.03.2018. Bubble behavior for the period 28.04.2008 - 06.10.2008 has been detected.

Akkaya (2018) determined the existence of financial bubbles in the Turkish stock market between January 2002 and March 2017 and the variables in their formation. By using the Cointegration and Logistic Regression test for bubble analysis, a relationship was determined between the Borsa Istanbul Return Index and the economic bubbles in the Stock Portfolio of Non-Residents.

Kilic (2020) applied the GSADF test for multi-balloon analysis with the data set consisting of monthly closing prices for the period between December 1994 - March 2020 for the China Stock Exchange. According to the results, the existence of economic bubbles in the Chinese Stock Exchange was detected in three different periods.

Gülcan (2020) investigated the existence of financial bubbles in foreign exchange markets. He used the Generalized Dickey-Fuller (SADF) and Generalized SADF (GSADF) tests to detect bubbles in exchange rates for the currencies with the highest volume, including the Euro, Chinese Yuan, US Dollar and British Pound between 03.01.2005-20.11.2019. For the Japanese Yen, the daily price data for the period between 28.08.2013-20.11.2019 are used. As a result of

the study, the price bubbles caused by overpricing in the Turkish foreign exchange market were examined.

In the study of Remzi, (2021) they examine the explosive behavior of the USD/TRY's 5 domestic stock market indices, bonds, CDS, gold and exchange rate, with weekly observations between 2005 and 2021. During non-crisis periods, such as the COVID-19 epidemic, bubble formations were observed in the bond, gold and foreign exchange markets.

Some of the largest cases of financial price bubbles in history have also occurred in the housing market. Studies examining the economic bubbles caused by the sensational price increase in housing purchases and sales are given below.

Freese (2015) used the Statistical Process Control (SPC) test method to find financial bubbles in house prices in 17 major US cities from 1990 to 2010. According to the EWMA control chart, the regional price observed the presence of bubbles at the initial stage. As a result, the existence of an economic bubble in house prices was determined in all 17 cities. What is interesting to the researcher is that the last bubble formed is not homogeneous, since the regional starting points changed between 1996 and 2002.

Zeren and Ergüzel (2015) examined the existence of bubbles in Turkish housing markets. He stated that there is no real estate price bubble in the data set of Izmir (TR31), Istanbul (TR10) and Ankara (TR51). It confirms that the Turkish housing market has suffered less from the 2008 Mortgage crisis than other countries. As a result of the analysis, real pricing policy was applied in the Turkish housing market after the crisis.

Aizenman et al. (2019) explored the link between the housing sector and economic development. It has been shown that the housing prices of OECD member and non-OECD countries are in a positive direction with economic growth in the 40-year period. It has been determined that the relationship between depreciation in housing valuation and economic growth is not linear, depending on the different criteria of the countries. In the absence of a crisis, the decrease in housing demand moves in a positive direction with economic growth.

Korkmaz, (2019) examined the inflation pressure on the housing price index in 26 regions of Turkey. It used monthly CPI and HPI data for the 2010-2019 period in 26 regions. The causality relationship between the data was analyzed with the Konya Causality (2006) test. Inflation pressures were found in some regions where HPI was analyzed in the variables dated 2010:01 and 2019:01.

In a study done by Akkuş (2019), researchers examined the economic bubbles and their times in the housing sector. In the data set, a 126-month housing price index was used between 2010:01 and 2020:06 periods in Turkey and the TR22 (Çanakkale-Balıkesir) Region. According to the SADF and GSADF test results, which are frequently used in the detection of economic bubbles, the presence of economic price bubbles has been determined in the housing indexes of Turkey and the TR22 Region. As a result of the implementation of the Logit Model

test, increases in CPI, M2 monetary policy and real interest rates in the housing sector increase the presence of price bubbles in the housing sector. As a result, measures should be taken to maintain price stability in the housing index in Turkey.

Brunnermeier (2016) stated that there are few models that can explain why and when the economic bubbles that occur from an increase in the price of an investment instrument that are higher than its normal value begin. According to Brunermeier's analysis, contrary to the period specified by some researchers as a result of various statistical tests, from the beginning of the economic bubbles to the time they burst, detailed analysis has shown that the deflating period of the price bubbles can take a few weeks or a month.

Devenow and Welch (1996) state that there is a distinct belief among experts who do research in the field of finance that people who decide to invest in financial instruments are influenced by those who are at the stage of investing in other financial instruments. Investment decisions made by all populations with a "bandwagon effect" will lead to erroneous results. Decisions made in this direction have revealed different economic reactions, such as non-innovative indecisive changes, flawed expectations, bubbles and madness.

The Phillips and Jun, (2011) research methods evaluate periodic evidence against price bubble alternatives with sequential tests based on unit root analysis. For the bubble asset, the data set is based on crude oil, housing price index and bond price series. All of these series have statistically significant financial bubble characteristics. Statistical estimates from the start time of financial bubbles to the date of the collapse of the bubble show that there is a tidal system among the financial asset units used.

All in all, according to the review of the literature, this thesis can fill an important gap, since there is no study that examines the altcoins bubble in the pre- and post-pandemic period.

3. DATA SET

The data set consists of 1461 observations, covering the period for Dogecoin (DOGE) between 01.01.2018-31.12.2021, 1086 observations covering the period of Crypto.com (CRO) between 11.01.2019-31.12.2021, and 1461 observations covering the period of Binance Coin (BNB) between 01.01.2018-31.12.2021. It consists of 919 observations covering the date of Polygon (MATIC) between 27.06.2019-31.12.2021. The price data of cryptocurrencies benefited from the Investing.com site.

In the study, the Supremum Augmented Dickey-Fuller test, as advanced by Philips and Si-Yu (2011), was utilized. With the SADF model, haphazard and plosive formed bubbles can be successfully separated and speculative attacks can be determined. An E-views12 package program was used in the analysis.

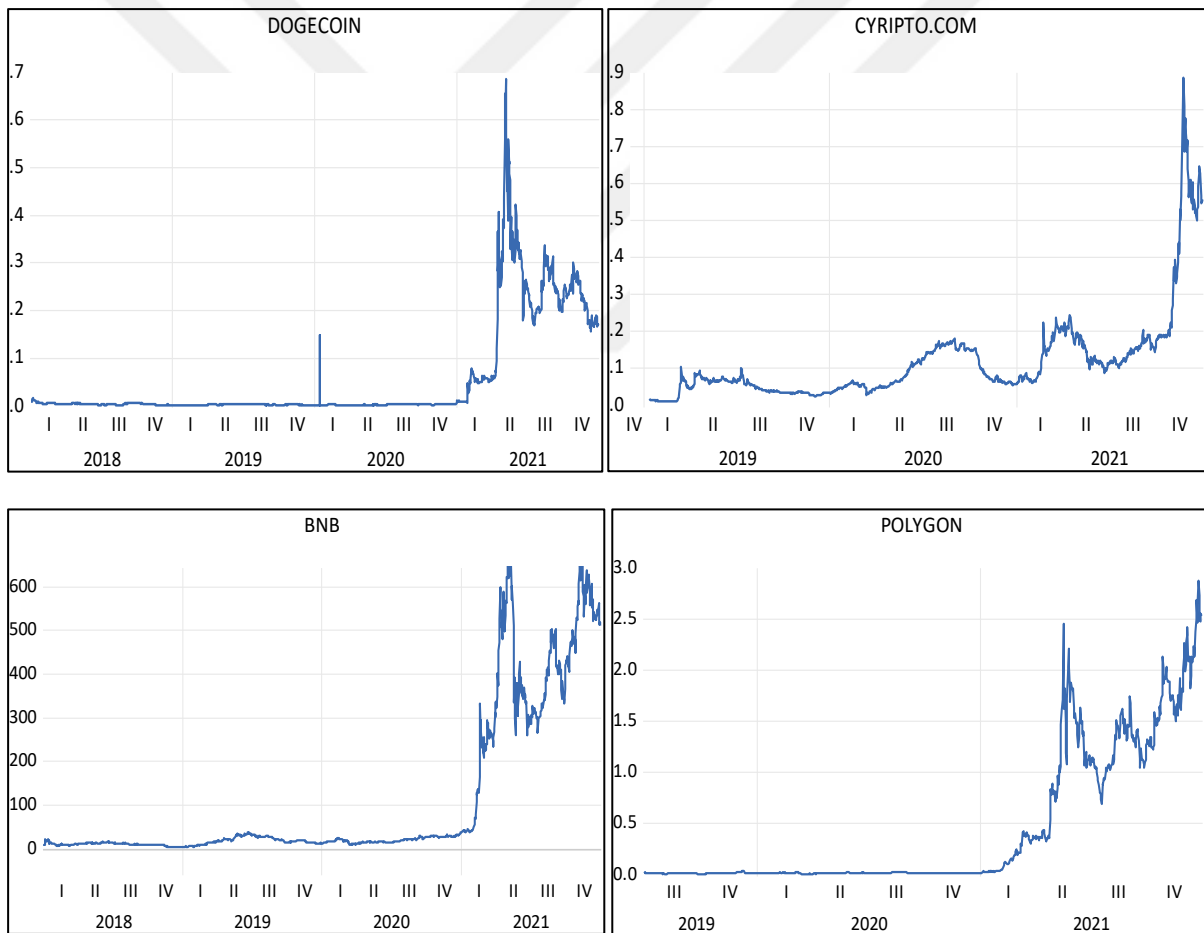


Figure 3.1. The movements of the closing prices for the analysis period of the four altcoins in the study. Source: The author estimates are based on the Investing.com (2022) database. Graphics of price data made Eviews program.

When Figure 3.1 is examined, it is clear that while the prices of Dogecoin, BNB and Polygon were stable at the beginning of the analysis period, they reached the highest prices after the 4th

quarter of 2020. Crypto.com has been showing price fluctuations since 2019, showing a sudden price increase at the end of 2021.

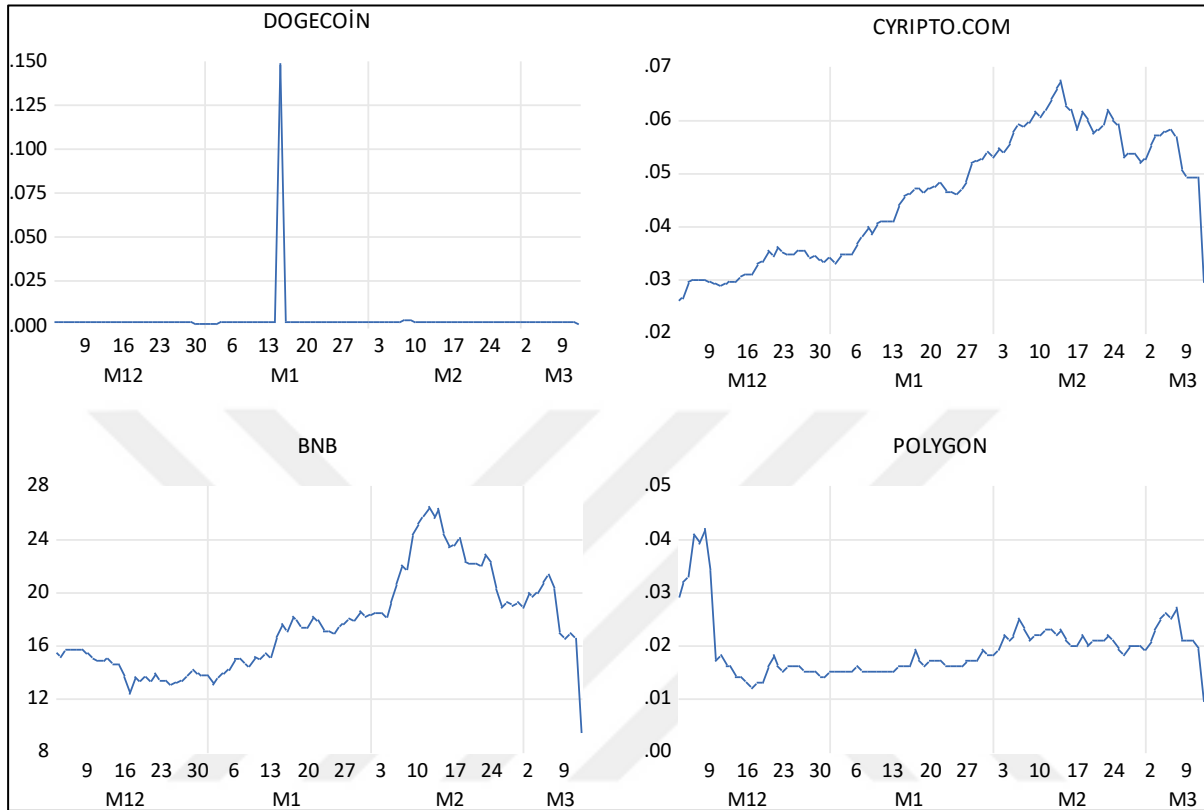


Figure 3.2. Covid-19 Effect on the Cryptocurrency Prices

Source: The author estimates are based on the Investing.com (2022) database. Graphics of price data made Eviews program.

Between 03.12.2019 and 03.12.2020, with the onset of Covid-19, sensational price increases, as seen in the figure 3.2, bubble formation was observed in Dogecoin, Crypto.com, and BNB. In addition, the sudden price increase in the Polygon currency from December 2019 to February 2020 shows the formation of a bubble.

Table 3.1. Descriptive Stats

	DOGECOIN	CYRIPTOCOM	BNB	POLYGON
Mean	0.082777	0.129931	163.1706	0.437490
Median	0.003227	0.096800	28.59000	0.021000
Maximum	0.686880	0.886000	676.5600	2.874000
Minimum	0.001585	0.025900	9.250000	0.008000
Std. Dev.	0.126519	0.129339	204.6717	0.681465
Skewness	1.524146	2.951650	1.021567	1.402276
Kurtosis	4.836512	12.87280	2.488109	3.669579

According to Table 3.1, the cryptocurrency with the highest deviation across the cryptocurrencies that were studied in the present study is BNB, while the lowest Crypto.com

and Dogecoin. This risk ranking is a situation that investors should pay attention to in financial markets and portfolio management

3.2. Medhodology

Philips et al. (2011) suggested a self-repetitive test to validate the null hypothesis of unit root versus the alternative hypothesis of explosive price attitude. He described the SADF test based on the functional:

$$Y_t = \mu + \phi Y_{t-1} + \sum_{j=1}^J \psi_j \Delta Y_{t-j} + \varepsilon_t, \varepsilon_t \sim N(0, \sigma^2) \quad (1)$$

Y_t is asset price. μ , ϕ and ψ are forecast common least squares. J is the utmost delayed number selected according to the model defined criteria. When $\phi > 1$, the price gradually increases. The Supremum Augmented Dickey-Fuller test formula, is used to test the empty hypothesis of unit root ($H_0: \phi = 1$) towards the existence of a bubble ($H_1: \phi > 1$). It is computed by the running regression of Equation (1) growing from r_0 to r_2 :

$$SADF(r_0) = \sup_{r_2 \in (r_0, 1)} ADF_0^{r_2} \quad (2)$$

This is r_0 a dedicated section of the total sample;

If the SADF value overruns the right significant value corresponding to the detonation level, the hypothesis that no explosive action occurred is rejected. This test does not contain any information about time when the balloon started and at the point of bursting. To this end, the end point of each occurrence is fixed with r_2 and the starting point changes as $0 \rightarrow r_2 - r_0$ with a highly backwards supremum augmented Dickey-Fuller (BSADF) methodology.

$$BSADF_{r_2}(r_0) = \sup_{r_1 \in (0, r_2 - r_0)} ADF_{r_1}^{r_2} \quad (3)$$

The beginning and end of the explosive behavior are determined by:

$$\hat{r}_s = \inf_{r_2 \in (r_0, 1)} \{ r_2 : BSADF_{r_2}(r_0) > cv_{r_2}^a \} \quad (4)$$

$$\hat{r}_s = \inf_{r_2 \in (\hat{r}_s + \delta, 1)} \{ r_2 : BSADF_{r_2}(r_0) < cv_{r_2}^a \} \quad (5)$$

$cv_{r_2}^a$ Existence; α is the crucial value of the Supremum Augmented Dickey-Fuller experiment at the significance level, and this value is the time limit shown as a fraction of its sample size.

Below this, an explosive behavior is not defined as a bubble. An explosive behavior below this data is not considered a bubble.

The time series of the data was obtained by a Monte Carlo study based on 1000 iteration

4. RESULTS AND DISCUSSIONS

Table 4.1. SADF Test Results

VARIABLES	Critical Values/ Monte Carlo Simulation**					Lag length:SIC, maxlag=12
	OBSERVATIONS	SADF TEST	99%	95%	90%	Right-Tailed Test*
DOGECOIN	1461	10,86	2,01	1,52	1,30	0,00
CRYPTO.COM	1086	4,79	1,97	1,53	1,30	0,00
BNB	1461	8,02	2,01	1,52	1,30	0,00
POLYGON	919	13.29	1,91	1,47	1,22	0,00

According to the results of the Supremum Augmented Dickey-Fuller test, the estimated test statistics for 4 currencies were found to be larger than the critical values. The H_0 hypothesis is refused. The presence of a speculative bubble formation was determined for the analyzed periods. After detecting the existence of balloons, the second stage started to determine the periods when bubbles were formed.

It represents significance at the 5% importance grade.

If the P value is <0.05 , there is a price bubble.

If the P-value is >0.05 , there is no price bubble.

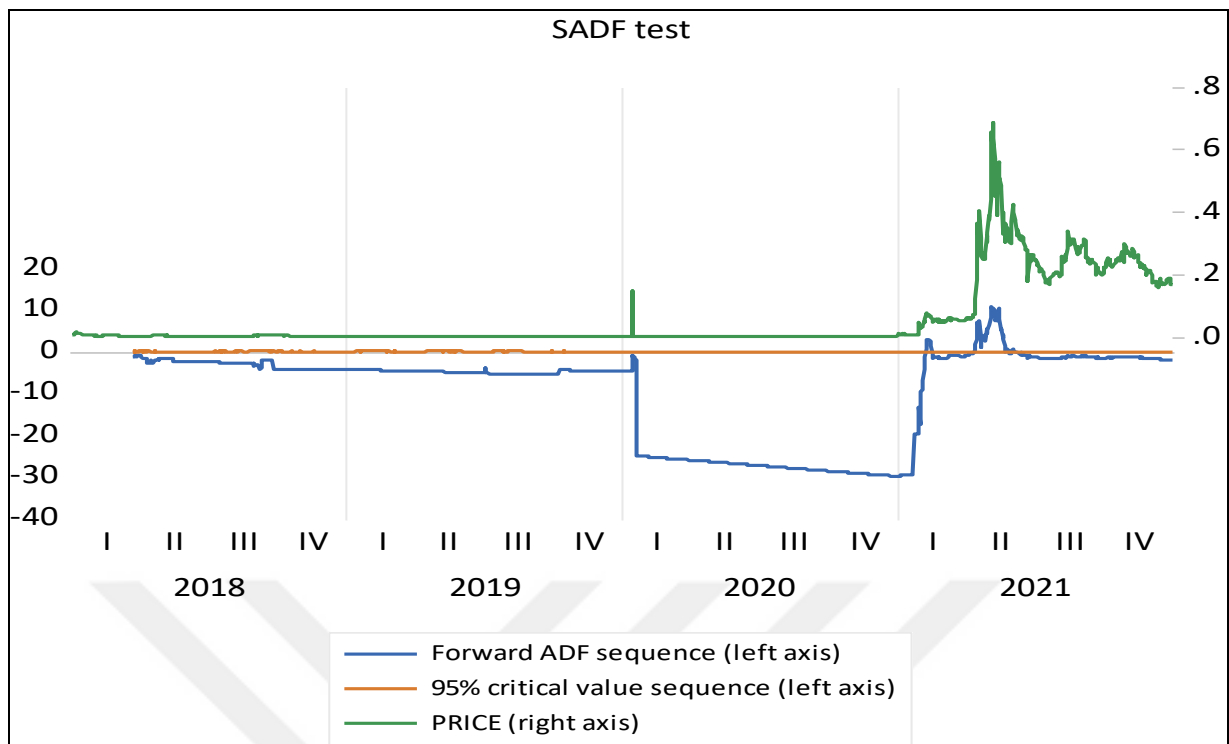


Figure 4.1. Dogecoin SADF Test

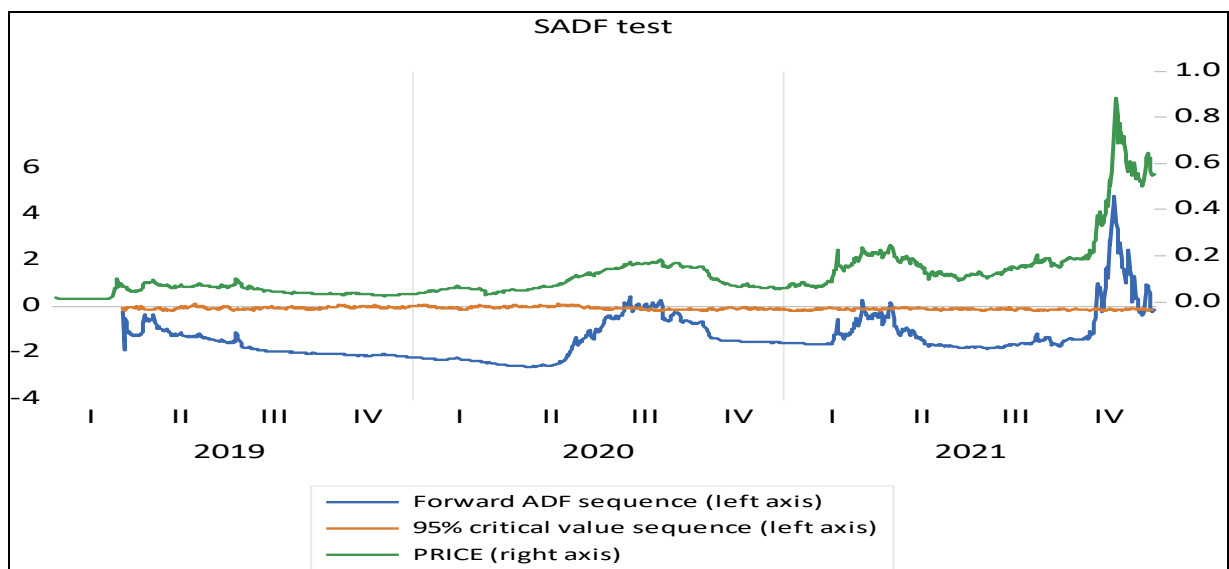


Figure 4.2. Crypto.Com SADF Test

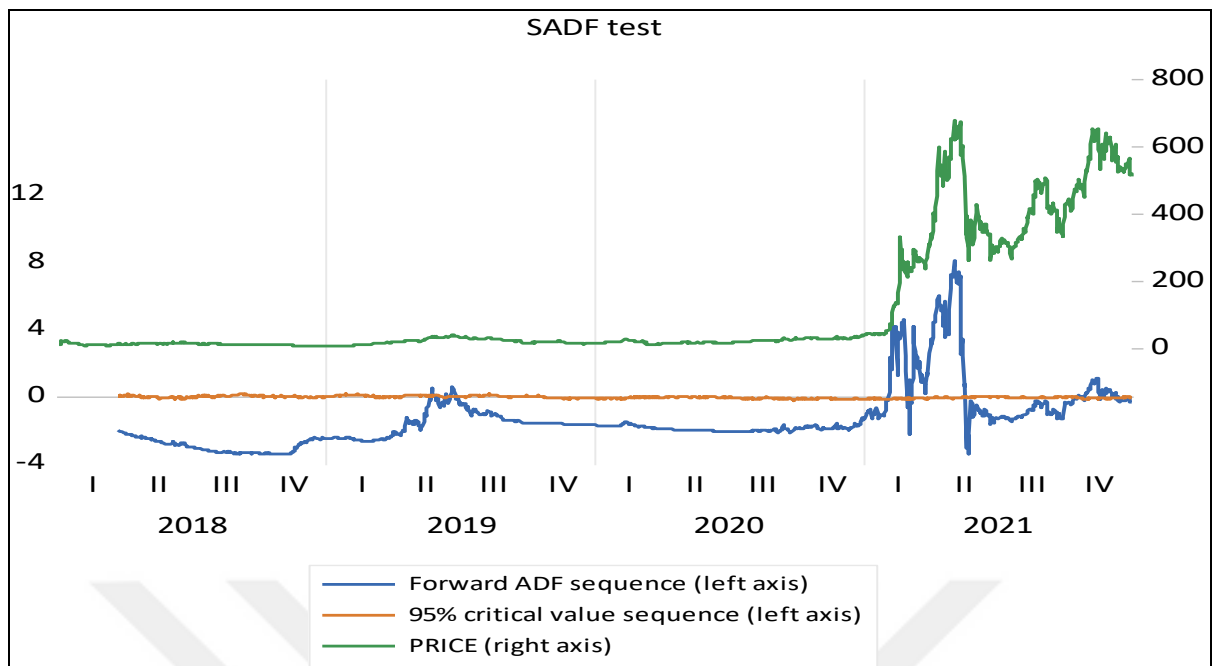


Figure 4.3. Binance Coin SADF Test

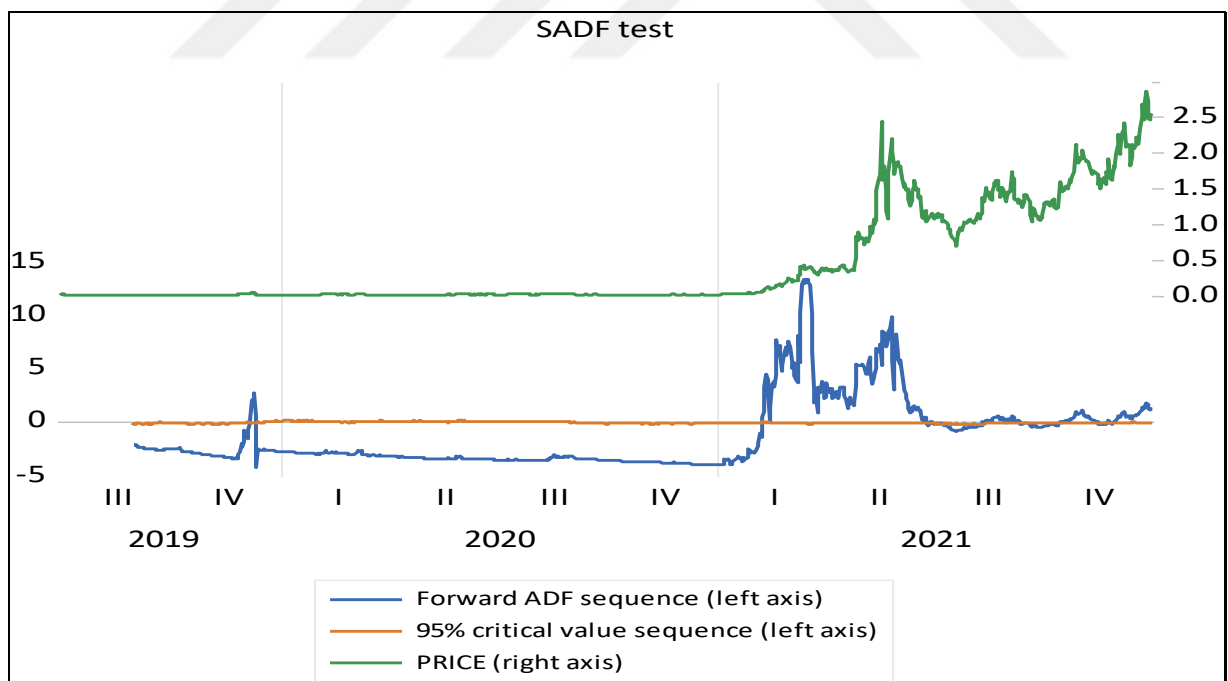


Figure 4.4. Polygon SADF Test

Table 4.2. The start date of bubbles for Altcoins according to our findings

CURRENCY	BUBBLE START	BUBBLE EXPLOSION	
DOGE	1) 14.01.2020-15.01.2020	16.01.2020	2Day
	2) 31.12.2020-12.01.2021	01.13.2021	13Day
	3) 27.01.2021-07.02.2021	17.02.2021	28Day
	4) 19.07.2021-17.08.2021	28.09.2021	70Day
CRO	1) 14.03.2020-30.08.2020	15.11.2020	257day
	2) 01.02.2021-14.04.2021	18.06.2021	118Day
	3) 22.10.2021-23.11.2021	20.12.2021	58Day
BNB	1) 27.01.2021-19.02.2021	25.03.2021	59Day
	2) 26.03.2021-03.05.2021	23.05.2021	56Day
	3) 20.07.2021-05.09.2021	28.09.2021	68Day
	4) 27.10.2021-14.11.2021	18.11.2021	21Day
	5) 20.11.2021-25.11.2021	29.12.2021	40Day
MATIC	1) 04.02.2021-18.05.2021	20.07.2021	168Day
	2) 21.07.2021-28.10.2021	18.11.2021	117Day

Source: The author's findings were calculated based on the SADF Test results data in Figure 4.1, 4.2, 4.3, 4.4.

In Table 4.2, the period in which the bubble effect in the prices is the longest is the daily period (257 days) between 14.03.2020-30.08.2020 belonging to Crypto.com. This period is between 04.02.2021-18.05.2021 (168 days) belonging to MATIC, respectively, MATIC's 21.07.2021-28.10.2021 (117 days), DOGE's 19.07.2021-17.08.2021 (70 days).

In accordance with the conclusion of the Supremum Augmented Dickey-Fuller test implemented in this study, the presence of bubbles was detected for DOGECOIN, CRYPTO.COM, BNB and POLYGON during the researched periods. In particular, the periods of bubble formation for all cryptocurrencies intensified in the last quarter of 2020-2021. Because of the study, whether the Supremum Augmented Dickey-Fuller test conclusions are considered the basis of cryptocurrencies or just a factor that runs the system, the occurrence of speculative bubbles in the prices can be associated with the news at that time, social media posts of famous people, and the effect of events such as Covid-19. The news spread in the second quarter of 2020 attracted the attention of both individual and institutional investors and created a bubble in the prices of cryptocurrencies, and the bubble effect died out in the last quarter.

5. CONCLUSIONS

The aim of this study is to examine price bubbles in 4 of the 20 most popular cryptocurrencies on the market during the period of 2018-2021. In accordance with the Supremum Augmented Dickey-Fuller test results applied in this study, the existence of bubbles was detected for Dogecoin, BNB, Crypto.com and Polygon during the researched periods.

Especially Dogecoin and Crypto.com were chosen in the study. This election, social media posts and advertisements of the phenomena attracted the attention of individual and institutional investors and caused a bubble in altcoin prices. With the technological superiority offered by the blockchain system, even though there was a bubble in prices, it allowed cryptocurrencies to continue their existence. When examining the periods in which the economic bubbles were detected, we found that the bubbles were likely driven by news-based manipulations and Covid-19 fear. The altcoin markets were affected by a series of events during these periods, including the release of positive news about the altcoins, the increased media attention on the cryptocurrency market, and the increased demand for alternative assets, due to the economic uncertainty caused by the pandemic.

When we examine the graphics, crypto money investors have made stable investments in the market until the Covid-19 vaccines were released. When vaccines were released at the end of 2020, decisions made for manipulation caused a price bubble in altcoins. Overall, our results provide new insights into the existence of economic bubbles in the altcoin markets in the post-pandemic period. The findings of this study suggest that bubbles in altcoin markets may be driven by a combination of market fundamentals and external factors, such as news-based manipulations and economic uncertainty.

Therefore, it is a suggestion to the interested readers to show that altcoin money investors can manage their portfolios more healthier way and that investment instruments with higher prices than their value can cause serious losses. In future studies, it will be useful to examine the connection between spot market and the future markets in determining the price bubbles in the future market of altcoins. Further studies can also test the effect of tweets or social media on altcoins. For instance, four hours after Elon Musk posted a picture of Dogecoin on January 28, the price of Dogecoin had quadrupled. It has been determined that the rise in the density of tweets about BTC increases the short-term BTC liquidity, volume, trade and returns (Choi, 2021); (Philippas et al., 2019; Shen et al., 2019. The role of social media in the bubbles of altcoins can be tested in future studies.

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