Analysis of the relationships between Bitcoin and exchange rate, commodities and global indexes by asymmetric causality test

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Abstract

This study investigates the asymmetric causal relations between Bitcoin and gold, Brent oil, US dollar, S&P 500 and BIST 100 Indexes for the weekly data of the period between November 2013 and July 2018 via by Hatemi-J (2012) test. The results indicate only a causal link going from the Bitcoin price to S&P 500 Index. Consequently, a change in Bitcoin prices appears to influence the investors' decisions on the S&P 500 Index. Therefore, it can be said that the investors in S&P 500 Index have closely followed the new macro-financial developments in the market and have been active on the S&P 500 market. However, the presence of a causality relation between Bitcoin price and other variables cannot be determined. Thus, it is supposed that Bitcoin may exist in association with the commodity market and other global indicators in the future, along with the recognition of the Bitcoin currency by countries, its being accepted as a means of exchange and its increased reliability.

Keywords: bitcoin, commodities, exchange rates, global indexes, asymmetric causality test

Introduction

Money is no longer just a means of exchange; but it also functions as a unit of accounts, a store of value, and a standard of deferred payments; and even at present, it serves as a commodity item (Indra, 1992). It is not surprising that money has been influenced by ultimate technological advances and especially by the widespread use of the internet database (European Central Bank, 2012). Accordingly, by observing the evolutionary history of the payment systems in the economy, it is quite obvious that the payment system has evolved over time. Along with the development of science and technology, the form of money continues to change over time

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(Nurhisam, 2017). One of the recent changes is the high traded volume of electronic currencies, i.e. virtual currencies on the markets.

Over the last few years, there has been an explosion of virtual currencies; for instance, Bitcoin, Litecoin and Ripple have emerged to financial markets. Correspondingly, Bitcoin revolutionized the area of digital currencies; and since then, it has been influential in the current life. Thanks to the increased technological opportunities and to the significant number of internet users, Bitcoin has become widespread in international markets. Given these circumstances, it is inevitable that Bitcoin will be affected by the financial markets and the real economy.

Bitcoin is a digital or virtual form of cryptocurrency that is fully distributed; it uses peer-to-peer technology to enable instant electronic payments (Bartos, 2015; Nakatomo, 2008) based on mathematical proof and relies on cryptographic protocols. It is progressed by consensus network, namely open source software (Giungato *et al*., 2017; Nakatomo, 2008). Bitcoin consists of the Bitcoin protocol, the block chain, distributed mining and transaction script (Antonopoulos, 2014). Unlike regular fiat money, a Bitcoin has no physical form, it is not a legal tender, it is not issued by any government bank or organization (Murphy *et al*., 2015), its supply is not manipulated by a government or other central authority (Yermack, 2013), and can be inflated at will (Kurihara and Fukushima, 2017). The points which make Bitcoin superior and the subject of numerous discussions are the use of a different technology than other currencies in use and the chance to conduct point-to-point money transfer without relying on a central body. Additionally, thanks to the present technology, Bitcoin is not controlled by any government or organization. The whole technology is built on a logic called "block chain". The block chain is the major characteristic used to maintain the processes of the Bitcoin system, in that all transactions and transfers are entered into block chain records and double spending is prevented (Bartos, 2015). Hence, a block chain is like a book containing the ledger of all past transactions (Chiu and Koeppl, 2017).

Bitcoin is the first implementation of a cryptocurrency, and it was originally developed in 2008 as a system for electronic transactions without relying on trust, described and implemented by a group of programmers under the pseudonym of Satoshi Nakamoto, published as a proof of concept for a currency (Nakamoto, 2008). However, Bitcoin software was first issued at the beginning of 2009 by an anonymous entity, working under the name "Satoshi Nakamoto" in Japan, after the same entity in 2008 introduced the concept in a study (Rogojanu and Badea, 2014).

Without doubt, Bitcoin is probably the most widely known and used cryptocurrency in the world, being a powerful form of cryptocurrency, and its dynamics and status have been controversial (Katsiampa, 2017). Despite criticisms on currency's technical, safety and legal issues, there is an increasing interest not only from academic researchers, but also from the real world (Bartos, 2015). While it was highly approved in the national economies of countries such as Japan, China, UK, Sweden and Denmark, many national economies deprecated it for being the

most open and insecure payment system (Bhardwaj *et al*., 2017). However, since Bitcoin became the first decentralized cryptocurrency in 2008, a wide variety of cryptocurrencies have been traded around the world. As Bitcoin is the combination of elements forming the basis of the digital currency ecosystem, the currency used in the exchanges between participants seeking to enter the cryptocurrency market should also be Bitcoin (Antonopoulos, 2014). Consequently, it is necessary to analyse both the development process and the possible effects of digital currency since it is likely to take the place of banknotes and coins in the future (Ozturk and Koc, 2006) and to provide many functions of banknotes.

While being among several cryptocurrencies, Bitcoin also stands out among others in terms of building an economic structure as the principal and most popular cryptocurrency with regard to criteria such as market capitalization, number of transactions, trading volume, range of opening and closing prices, and number of users (Vyas and Lunagaria, 2014). To this end, the aim of this paper is to examine the causality relationships between the Bitcoin price and commodity markets, exchange rate and global indexes via Hatemi-J (2012) asymmetric causality test, which is designed to detect the impact of positive and negative shocks separately by eliminating the existence of asymmetric information in financial time series.

Previous papers have exclusively dealt with the financial characteristics of Bitcoin, the price of Bitcoin, the characterizations of Bitcoin as a financial asset. If the previous studies are analysed, it can be clearly observed that no study includes both employing the Hatemi-J (2012) asymmetric causality test and the existence of the relationships between Bitcoin prices and commodity markets, exchange rates and global indexes used for the description of the dynamics of time-varying asset correlations. The current study attempts to fill this research gap. For this purpose, the existence of the relationships between Bitcoin prices and global indexes, exchange rates and commodity markets are analysed by Hatemi-J (2012) asymmetric causality test which can split positive and negative shocks separately, using time series weekly data over the period 24.11.2013 to 08.07.2018.

To the best of our knowledge, it is the first research analysing the relationships between Bitcoin prices and commodity prices, exchange rate and global indexes via Hatemi-J (2012) asymmetric causality test. Furthermore, due to the fact that the price of Bitcoin has been extremely volatile in recent years, it is important to work with current data. Thus, this study is considered to have contributed greatly to the expansion of research in this area.

The rest of this paper is structured as follows: in section 2, the research background is described extensively; in section 3, our methods and data specifications are briefly presented; in section 4, the experimental results are provided; and in the final section, conclusions and recommendations are outlined. Policy recommendations within the framework of the findings will provide the conclusions of this study. The findings and discussions of this study are aimed to be an important source for future empirical, econometric and theoretical researches. In

other respects, this study is considered a dimension regarded not only academically but also in terms of investor behaviour.

1. Literature review

The rapid rise of Bitcoin's popularity and the increase in the number of block chain wallets have attracted a growing interest among economists and have led to many academic articles about Bitcoin.

Based on the three basic functions of money, i.e. a medium of exchange, a store of value, and a unit of account, Yermack (2013) examined whether Bitcoin should be considered as a currency. In his study, the author observes that Bitcoin's volatility is a lot higher than the volatilities of other widely used currencies. He also added that this undermines Bitcoin's usefulness as a medium of exchange and a unit of account. Yermack also observed that there is virtually zero correlation between Bitcoin's daily exchange rate with the U.S. dollar and the dollar's exchange rates against the British pound, Swiss franc, euro, yen and gold.

Van Wijk (2013) investigated the impact of stock markets, exchange rates and oil price on Bitcoin price. The result suggests that the Dow Jones Index, the euro–dollar exchange rate and oil price have a significant impact on the value of Bitcoin in the long run. Glaser *et al*. (2014) investigated whether users consider Bitcoin an asset or a currency. At the end of the study, they came to the conclusion that Bitcoin is not a currency used for purchasing goods and/or services, but rather a speculative financial asset. Chen and Vivek (2014) investigated the Bitcoin's function as a medium of exchange and its usefulness as an investment asset. The study found that Bitcoin as a cryptocurrency may not be suitable as an exchange currency, whereas it can play a substantial role in increasing the efficiency of an investor's portfolio. Brandvold *et al*. (2015) examined Bitcoin exchanges to study Bitcoin's price formation and to find which exchanges react to the new information in the fastest way and are accurate in price formation. They analysed Bitfinex, Bitstamp, Btce, BTC China and Mt. Gox as they had the biggest traded volume at the time of the analysis and Bitcurex and Virtex which had smaller traded volumes. The study revealed that Mt. Gox and Btce were exchanges with the highest traded volume and the prominent price leaders; while smaller exchanges, as expected, did not play a role in the price discovery and they followed the market.

In their study examining Bitcoin as a medium of investment, Briere *et al*. (2015) revealed that its investment offers significant diversification benefits. The results indicate that Bitcoin offers significant benefits for a diversified portfolio due to its high return and volatility, as well as to its low correlation with traditional assets. However, they also added that some risks can occur in the long term.

In their paper, Baek and Elbeck (2014) first compared the volatility of Bitcoin and stock market index; and then, investigated the drivers of Bitcoin returns. Consequently, they found that Bitcoin is 26 times more volatile than the S&P 500

Index. Additionally, they also found in their regression model that the only variable affecting Bitcoin prices is the monthly change on the highest and lowest daily price differences. Atik *et al*. (2015) explored the relationship exists between Bitcoin and the exchange rate in case of Turkey over the period 2009 to 2015. They examined the most trading currencies around the World, in order to influence Bitcoin on other exchange rates. For this purpose, the interaction between Bitcoin daily exchange rates and the most commonly used cross exchange rates in the World was examined by the co-integration analysis. The results of the analysis indicate one-way causality between Bitcoin and the Japanese yen and also, the Japanese yen and Bitcoin had a delaying effect on each other. Dyhrberg (2015) used a daily dataset covering the time period from 2010 to 2015 as a basis to investigate whether Bitcoin is a hedge or safe haven asset against price drivers by employing the asymmetric GARCH. As a result of this research, they concluded that as in gold, Bitcoin holds some of the same hedging features and can hedge against stocks in the FTSE and USD currency in the short term in order to take measures against Bitcoin's market risk. He also revealed that Bitcoin can be contained in the variety of instruments available to market analysts to hedge market specific risk.

In another study, Dwyer (2015) indicated that variance in Bitcoin returns is higher than in gold and foreign exchanges while Bitcoin returns are higher than both investment classes. According to Edwards (2015), collapses like the bankruptcy of Cointerra and a bitcoin-mining hardware company in the US, and problems concerning the cryptocurrency besetting the system, which caused fluctuations in the Bitcoin price and $1,151 peak value of Bitcoin on 4th December 2013, dropped to $200 by mid-February 2015 with the fall in the Mt Gox Bitcoin exchange, stopped the operations of Bitcoin miners.

Bouoiyour and Selmi (2015) explored the association between precious metals, such as gold and silver, and Bitcoin prices with high fluctuations in financial markets by using an optimal-GARCH model. They concluded that gold, silver and Bitcoin as a hedge and safe haven are not constant over time and Bitcoin acts as a weak safe-haven in the short run, and as a hedge in the long run. Another result is on the Bitcoin market, where prices are driven more by negative than by positive shocks. Kristoufek (2015) argues on how Chinese economy reflects Bitcoin applications and its prices, and examines the probable influence of Bitcoin prices in the Chinese market. At the end of the analysis he found that despite being a speculative asset, its suitability for the trade money supply and fundamental economic factors affect the Bitcoin price in the long term. He concluded that Bitcoin is a unique asset both for not possessing the property of a safe investment instrument, and for its speculative nature. Furthermore, the study concluded that there is a positive and significant relationship between the Financial Stress Index and Bitcoin's price. Georgoula *et al*. (2015) applied time series analysis to examine the relationship between Bitcoin prices and major economic variables; researched the technological information, such as Google Trends and Wikipedia. According to their results, the

value of Bitcoins has a negative significant association with the exchange rate of USD and EUR. Their finding reveals that the Bitcoin price has a positive impact on the number of Bitcoins in circulation. They also found that Bitcoin price has a significant negative relationship with S&P 500 Index. Bouoiyour *et al*. (2016) analysed the relationship between electronic commerce transactions and investor attraction. The study suggests that Bitcoin prices have significantly affected electronic commerce transactions. The study also indicates that investor attraction has significantly affected Bitcoin prices. Moreover, their study supports the excessively speculative nature of Bitcoin without overlooking its economic benefits.

In his study, Dyhrberg (2016) used the asymmetric GARCH model which tests the hedging characteristic of Bitcoin. He revealed that Bitcoin may possess a hedging instrument against the US dollar in the short term and stocks in the Financial Stress Index and may be ideal for risk infelicitous investors in anticipation of negative shocks to the market. Ciaian *et al*. (2016) characterized and evaluated the determinants of Bitcoin price by applying time-series analytical mechanism over the 2009 -2015 period. By contrast to the previous studies, they only found a significant impact of global macro and financial development captured by the Dow Jones Index, exchange rate and oil price for the short term; and they did not determine Bitcoin price in the long run.

Bjerg (2016) tested Bitcoin as a typical theory of fiat money. He revealed the analysis under the principle that Bitcoin is commodity money without gold, fiat money without state, and credit money without debt and mentioned that despite the fact that Bitcoin is no gold, state or debt backing. Szetela *et al*. (2016) explained the association between the selected exchange rates and Bitcoin price using ARMA and GARCH models. The results of GARCH models revealed that there is a conditional variance which exists between Bitcoin and US dollar, euro and yuan while ARMA models indicated no dependency existed between the return of Bitcoin to Zloty and all other exchange rates. Kocoglu *et al*. (2016) analysed the efficiency, liquidity and volatility of the Bitcoin markets of firms traded on the eight different stock exchanges. Their studies indicated that it is not a reliable instrument despite its high yield. Besides, the Bitcoin market stood out as still vulnerable to many risks and speculations.

Icellioglu and Ozturk (2017) studied the short and long run causal relationship between Bitcoin and selected exchange such as dollar, euro, pound, yen and yuan investigated in the 2013-2017 period. To analyse the causality relation between Bitcoin and selected exchange, Johansen Test and Granger Causality Test were employed. The results of the test carried out by Johansen and Granger revealed that the existence of long- and short-run relationships between Bitcoin and other exchanges – i.e. dollar, euro, pound, yen and yuan – were not detected.

Poyser (2017) aimed to investigate the relationship between Bitcoin's market price and a measure of micro and macro variables employing a different method, namely the Bayesian Approach. They reported that the Bitcoin price had a negative

association with the investor's attention, gold price and pair of yuan to USD while it had a positive association with the stock market index, pair of USD to euro. Another result of this study suggested that Bitcoin is an asset, since it currently seemed to react as a speculative and secure instrument as well as a potential for a capital flights instrument.

Dirican and Canoz (2017) aimed to reveal whether Bitcoin is a factor affecting investor decisions. By using ARDL boundary test method in their study, they investigated the presence of a co-integration between Bitcoin and selected indices. A co-integration relationship between Bitcoin prices and leading US and Chinese stock market indices was observed. Within this context, it can be stated that investors in these stock markets could be influenced by Bitcoin prices in their long-term investment decision process. No relationship was found with BIST100, FTSE100 and NIKKEI225 indices. Jin and Masih (2017) examined the correlation between Bitcoin return and the stock index which constitute Islamic principles by using the MGARCH-DCC, CWT and MODWT methods and daily data from January 2013 until January 2017. Using diverse methodologies in their study, they found that Malaysia's Sharia's stock market and Bitcoin were low or negatively correlated, which indicates that Bitcoin can be seen as a significant diversification instrument to increase portfolio performance for Islamic stock indexes.

By using ARCH and GARCH methods, Eswara (2017) aimed to investigate the effect of volatility of Indian cryptocurrency along with five global cryptocurrencies as dollar, euro, sterling, yen and yuan using. The analysis of test results was based on the long returns of the time series data of six cryptocurrencies, resulting in 105 observations using EVIEWS statistical software. The results indicated that there was a significant impact on BTC/INR volatility due to other cryptocurrencies. Moreover, the test results showed that BTC/INR was positively correlated to BTC/USD and was the least and negatively correlated to BTC/CNY.

In another study by Kajtazi and Moro (2017), the literature review shows no significant correlation or negative correlations between Bitcoin and traditional assets traded in the western countries in particular, while there are small but statistically significant correlations between Bitcoin and several Chinese assets.

Baur *et al*. (2017) indicated that Bitcoin may be a diversification tool due to its low correlation with traditional instruments, and may reach a certain level in the investment portfolio. The results also suggest that Bitcoin is mostly used as a speculative investment, not as an alternative currency and medium of exchange. Bouri *et al*. (2017) studied to explore how the volatile price of Bitcoin changes denominated in the US dollar. The study used daily returns data over the period 2011 to 2016. Besides, they aimed to research whether Bitcoins can be a hedge, risk aversion or have safe range asset under market uncertainty scenarios. In the short run, they reported that Bitcoin behaved as a hedge, since it reacted positively to great financial movements. Nonetheless, the robustness analyses suggest that there is a negative relation between the volatility index and Bitcoin movements. According to

their studies, it is essential to research the association between Bitcoin's market price and financial measurement, and precious metals prices in a dynamic environment. Sovbetov (2018) studied variables which affect the prices of five of the most traded cryptocurrencies by employing ARDL bound test. The results showed that both in the short and long run, financial variables which are at market risk, trading volume and volatility, determine five cryptocurrencies. The study indicated that S&P 500 Index reacts positive impact on Bitcoin, Ethereum and Litcoin in the long-run, and its sign turns to negative because of losing significance in short-run.

Baur *et al*. (2018) employed similar issue and econometric models to Dyhrberg's (2016). They analysed the relationship between Bitcoin, gold and US dollar by using GARCH volatility analysis. The results of the econometric model revealed that Bitcoin acts differently in terms of returns over time, volatility and correlation features in comparison with other assets such as gold and the US dollar.

By applying Johansen Co-integration and Granger Causality models, Gulec *et al*. (2018) investigated the association between the selected financial indicators and Bitcoin price. The first period ran from the establishment of variables in March 2012 until May 2018. The results indicated that Bitcoin prices have an increasing trend with a high volatility and that the relationship that exists between interest rates and Bitcoin prices is a variable.

2. Data and methodology

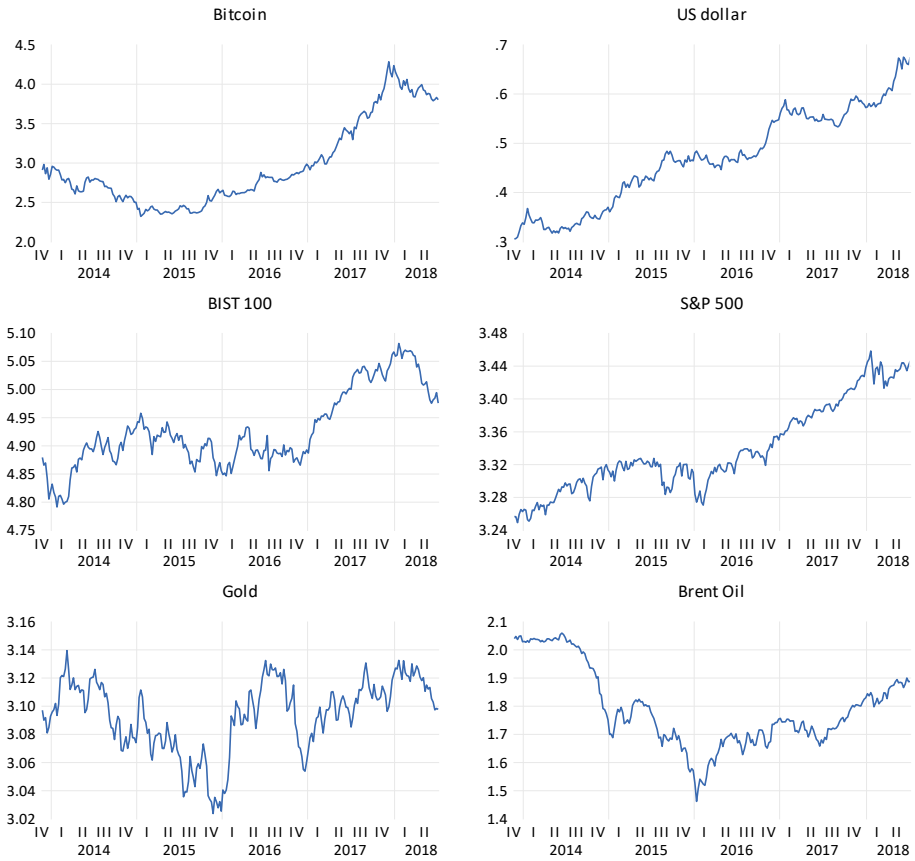
This current paper attempts to examine the impacts of negative and positive shocks occurred in the virtual currency which pioneered other cryptocurrencies called *Bitcoin* on other macroeconomic variables and global indexes. Our analysis focuses on the Bitcoin prices (BTC/USD) due to the fact that the highest share in the cryptocurrency markets belongs to Bitcoin currency. The previous study shows that the relationship between the price of Bitcoin and various stock market indexes was examined. However, commodity prices are ruled out in most of the studies. Based on this finding, this study analyzes gold price (Gold, 1 troy ounce), exchange rate (USD, 1 US dollar), Brent oil price (Brent oil, per barrel) variables as well as the S&P 500 Index which is a market-capitalization-weighted index of the 500 largest U.S. publicly traded companies by market value[1], and the BIST 100 Index which is a capitalization-weighted index composed of the national market firms except investment trusts[2].

Accordingly, the asymmetric causality relations between Bitcoin and exchange rate, commodities and global indexes are examined. The frequency of the dataset is on a weekly basis and covers the 24.11.2013 to 08.07.2018[3]. The natural

[1] Read more on https://www.investopedia.com/terms/s/sp500.asp.
[2] See https://www.bloomberg.com/quote/XU100:IND.
[3] Data where extracted from http://www.investing.com.

logarithm of the data was taken before the analysis. It is aimed to eliminate the scale effect between variables by taking the natural logarithm into account.

Figure 1. Graphical line of variables



*Source: o*wn calculations.

Figure 1 reflects the evolution of Bitcoin, US dollar, gold, Brent oil, S&P 500 index and BIST 100 index between the years 2013 and 2018. As seen in figure 1, the price or value of Bitcoin series has an increasing trend with high volatility and the price of one Bitcoin (BTC/USD) reached a new all-time high in 2017, the US dollar has been frequently uptrend by years but the level of gold is more balanced, and increases and decreases in Brent oil price are felt most heavily during 2013-2018. In general, it can be observed that the line of all variables has monotonically displayed increasing or decreasing trends between 2013 and 2018. The basic descriptive statistics of the variables are presented in Table 1.

Table 1. Descriptive statistics of the variables

Variables	Mean	Median	Minimum	Maximum	Std. Dev.
Bitcoin	2217.193	618.95	209.9	19,187	3486.525
S&P 500 Index	2195.751	2099.165	1775.32	2872.87	279.370
Brent Oil	65.323	56.815	28.94	114.81	22.752
US dollar	3.024	2.929	2.019	4.73	0.674
Gold	1243.067	1252.55	1056.2	1379	71.809
BIST 100 Index	85,756.79	81,701.54	61,858.21	120,701.9	14,007.86

Source: own calculations.

Table 1 reports results of the descriptive statistics of all variables. When Table 1 is analysed, based on 24.11.2013-08.07.2018 periods, it can be observed that the average price of 1 Bitcoin is about $2217, Bitcoin ranges between $209.9 and $19,187. The maximum values of the S&P 500 Index, Brent oil, US dollar, gold and BIST 100 Index are 2872.87, 114.81, 4.73, 1379 and 120,701.9, respectively. Furthermore, the minimum values of the S&P 500 Index, Brent oil, US dollar, gold and BIST 100 Index are 1775.32, 28.94, 2.019, 1056.2 and 61,858.21, respectively. Consequently, we may say that there is a great deal of change in the US dollar. Therefore, this tangible change is thought to affect commodity prices and stock market index directly.

The financial time series includes asymmetric information and a heterogeneous structure of market. Asymmetric causality tests are frequently used in order to eliminate the existence of asymmetric information in financial time series (Zeren and Koc, 2014). With this object, the causality relationships between Bitcoin prices and commodity markets, exchange rates and global indexes are analysed via Hatemi-J (2012) asymmetric causality analysis. This is because market participants are expected to have heterogeneous beliefs. Therefore, each investor can be expected to make different decisions against shocks which occur in the market. Starting from here, investors' diverse reactions towards the positive and negative shocks are not taken into consideration, if the analysis uses Granger causality test. As a result, the magnitude of the positive and negative shocks may lead to other tests thus leading to misleading results. So, the Hatemi-J (2012) test is a convenient method for researches which employ financial time sequences.

We can find numerous studies in literature that reveal causality relationships between variables. Hacker and Hatemi-J (2006) test and Toda-Yamamoto test (1995) are causality tests which analyse correlations between variables by using the bootstrap method. Due to the possibility of non-normal distribution of errors in these tests, the bootstrap technique is used to create new critical values. The deficiency of these models is that they cannot separate the positive and negative shocks. So, a failure in separating shocks in series is a weakness of these tests. It is assumed that the negative and positive shocks have the same impact in the data generating process of the tests. In the Hatemi-J (2012) test, an asymmetric causality test, shocks are

divided into negative and positive by distinguishing their impacts. The main motivation of this study is the direction of the causality relationship between the Bitcoin prices and the abovementioned five variables. For this purpose, Hatemi-J (2012), in which positive and negative shocks may have different causal impacts in the asymmetric causality test, is used.

It is assumed that there are two series as y_{1t} and y_{2t} in order to reveal the asymmetric causality relation between two integrated series:

$$y_{1t} = y_{1t-1} + \varepsilon_{1t} = y_{1,0} + \sum_{i=1}^{t} \varepsilon_{1i} \quad t = 1,2,.....,T \tag{1}$$

$$y_{2t} = y_{2t-1} + \varepsilon_{2t} = y_{2,0} + \sum_{i=1}^{t} \varepsilon_{2i} \quad t = 1,2,.....,T \tag{2}$$

Where, t=1,2,…T; $y_{1,0}$ and $y_{2,0}$ represent initial values. In addition, the error terms ε_{1i} and ε_{2i} are determined as white noise residuals. In this regard, the positive and negative shocks are presented as follows, respectively:

$$\varepsilon_{1i}^{+} = \max(\varepsilon_{1i}, 0),\ \varepsilon_{2i}^{+} = \max(\varepsilon_{2i}, 0),\ \varepsilon_{1i}^{-} = \min(\varepsilon_{1i}, 0),\ \varepsilon_{2i}^{-} = \min(\varepsilon_{2i}, 0) \tag{3}$$

Therefore, residuals can be stated as a sum of the positive and negative shocks as $\varepsilon_{1i} = \varepsilon_{1i}^{+} + \varepsilon_{1i}^{-}$, and $\varepsilon_{2i} = \varepsilon_{2i}^{+} + \varepsilon_{2i}^{-}$. With the information assumption, it is possible to express the equations for a $y_{1,0}$ and $y_{2,0}$ as follows:

$$y_{1t} = y_{1t-1} + \varepsilon_{1t} = y_{1,0} + \sum_{i=1}^{t} \varepsilon_{1i}^{+} + \sum_{i=1}^{t} \varepsilon_{1i}^{-} \tag{4}$$

and similarly;

$$y_{2t} = y_{2t-1} + \varepsilon_{2t} = y_{2,0} + \sum_{i=1}^{t} \varepsilon_{2i}^{+} + \sum_{i=1}^{t} \varepsilon_{2i}^{-} \tag{5}$$

Finally, the positive and negative shocks which take part in each variable can be expressed as an equation in cumulative form as follows:

$$y_{1t}^{+} = \sum_{i=1}^{t} \varepsilon_{1i}^{+}, y_{1t}^{-} = \sum_{i=1}^{t} \varepsilon_{1i}^{-}, y_{2t}^{+} = \sum_{i=1}^{t} \varepsilon_{2i}^{+}, y_{2t}^{-} = \sum_{i=1}^{t} \varepsilon_{2i}^{-} \tag{6}$$

3. Empirical application

Detecting the causes of the ups and downs on the volatility of Bitcoin prices is very important in terms of investors. Thus, the Hatemi-J (2012) approach allowing

the examination of various impacts together is used to investigate the effects of the shocks on the variables. Before applying the Hatemi-J (2012) causality test, the results of the Augmented Dickey-Fuller (ADF, 1979, 1981) unit root test is analysed to reveal the characteristics of the variables. Table 2 reports the results of applying the ADF unit root test.

Table 2. Results of augmented dickey-fuller test

Test	Variables	Intercept	Intercept and Trend
Augmented Dickey-Fuller Test	Bitcoin	0.173	-1.995
	S&P 500 Index	-0.627	-2.664
	Brent Oil	-1.672	-0.804
	US dollar	0.047	-2.280
	Gold	-2.527	-2.637
	BIST 100 Index	-1.428	-2.284

Note: all variables become stationary when they are first differenced.
Source: own calculation.

The above results indicate that all series include unit root both in the intercept model and in the trend and intercept model. While the unit-root hypothesis could not be rejected for all series in levels, the first differences were found to be stationary (Table 2). Once the characteristics of the variables were determined, the focus of the study was shifted to causality analysis. Under these circumstances, the effects of the shocks in the variables were investigated via Hatemi-J (2012) which can separate the positive and negative shocks. Table 3 reflects the results of applying the Hatemi-J (2012) asymmetric causality test.

The causal relationships which show mutual interactions between Bitcoin price and Brent oil price, US dollar, gold price; BIST 100 Index and S&P 500 Index variables are summarized in Table 3. Faced with positive and negative shocks, the reaction at Bitcoin prices were analysed as *Panel A*, *Panel B, Panel C, Panel D* and *Panel E*. The panel results are explained as follows, respectively.

Firstly, in Table 3 *Panel A*, the causality relationship between Bitcoin prices and the S&P 500 stock market index was investigated. According to the results, there was one-way causality for Bitcoin prices towards the S&P 500 Index. A negative trend in Bitcoin prices affects the S&P 500 stock Index both negatively and positively. It was observed that Bitcoin investors do not have a homogeneous structure. Accordingly, S&P 500 investors can get a different position in the face of diminishing Bitcoin prices. It can also be said that investors in the index quoting the largest companies in the world take into consideration the Bitcoin price movements in their investment decisions. In addition to these results, the superiority of the Hatemi-J (2012) causality test compared to the standard causality tests (decomposition of positive and negative shocks) was also observed. Conversely, it

appears that if a positive shock occurs at Bitcoin prices, the S&P 500 Index tends to be adversely affected. It is considered that the increase in the Bitcoin price is negatively priced by the S&P 500 investors. As a result, it was found that the S&P 500 investors adopt a highly sensitive position towards the Bitcoin prices. When the other direction of causality is examined, it is seen that the increases and decreases in the S&P 500 Index do not significantly affect Bitcoin prices. This result is compatible with Georgoula *et al*. (2015) and Sovbetov (2018).

Table 3. Results of Hatemi-J asymmetric causality test (2012)

Null Hypothesis	Test Value	Critical Bootstrap Value			Null Hypothesis	Test Value	Critical Bootstrap Value		
		%1	%5	%10			%1	%5	%10
Panel A									
$Bitcoin^{+} \not\Rightarrow S\&P\ 500^{+}$	0.254	6.892	3.923	2.699	$S\&P\ 500^{+} \not\Rightarrow Bitcoin^{+}$	0.069	6.805	3.805	2.689
$Bitcoin^{+} \not\Rightarrow S\&P\ 500^{-}$	**4.811****	7.947	4.188	2.799	$S\&P\ 500^{-} \not\Rightarrow Bitcoin^{-}$	0.432	6.853	6.853	6.853
$Bitcoin^{+} \not\Rightarrow S\&P\ 500^{-}$	**6.135****	9.667	6.173	4.707	$S\&P\ 500^{+} \not\Rightarrow Bitcoin^{-}$	2.608	7.083	3.788	2.607
$Bitcoin^{-} \not\Rightarrow S\&P\ 500^{+}$	**16.549***	9.643	6.160	4.701	$S\&P\ 500^{-} \not\Rightarrow Bitcoin^{+}$	0.438	7.507	3.790	2.690
Panel B									
$Bitcoin^{+} \not\Rightarrow Brent\ Oil^{+}$	0.275	7.108	3.912	2.692	$Brent\ Oil^{+} \not\Rightarrow Bitcoin^{+}$	0.009	7.320	3.860	2.673
$Bitcoin^{-} \not\Rightarrow Brent\ Oil^{-}$	0.684	7.151	4.021	2.782	$Brent\ Oil^{-} \not\Rightarrow Bitcoin^{-}$	0.324	7.200	3.861	2.667
$Bitcoin^{+} \not\Rightarrow Brent\ Oil^{-}$	0.780	7.272	3.863	2.716	$Brent\ Oil^{+} \not\Rightarrow Bitcoin^{-}$	0.184	6.810	3.844	2.712
$Bitcoin^{-} \not\Rightarrow Brent\ Oil^{+}$	0.561	7.037	3.798	2.646	$Brent\ Oil^{-} \not\Rightarrow Bitcoin^{+}$	0.215	7.111	3.710	2.664
Panel C									
$Bitcoin^{+} \not\Rightarrow$ US dollar^{+}	3.523	9.590	6.150	4.669	US dollar$^{+} \not\Rightarrow Bitcoin^{+}$	0.887	9.346	6.148	4.736
$Bitcoin^{-} \not\Rightarrow$ US dollar^{-}	0.321	7.094	3.904	2.745	US dollar$^{-} \not\Rightarrow Bitcoin^{-}$	0.460	7.280	4.092	2.825
$Bitcoin^{+} \not\Rightarrow$ US dollar^{-}	1.904	6.913	3.919	2.742	US dollar$^{+} \not\Rightarrow Bitcoin^{-}$	0.274	7.080	3.918	2.672
$Bitcoin^{-} \not\Rightarrow$ US dollar^{+}	1.238	7.062	4.032	2.858	US dollar$^{-} \not\Rightarrow Bitcoin^{+}$	0.356	6.811	3.785	2.665
Panel D									
$Bitcoin^{+} \not\Rightarrow Gold^{+}$	0.421	6.887	3.813	2.674	$Gold^{+} \not\Rightarrow Bitcoin^{+}$	0.134	6.915	3.831	2.665
$Bitcoin^{-} \not\Rightarrow Gold^{-}$	1.229	7.189	4.029	2.807	$Gold^{-} \not\Rightarrow Bitcoin^{-}$	0.047	7.045	3.979	2.781
$Bitcoin^{+} \not\Rightarrow Gold^{-}$	0.417	7.520	3.799	2.673	$Gold^{+} \not\Rightarrow Bitcoin^{-}$	0.235	6.776	3.844	2.774
$Bitcoin^{-} \not\Rightarrow Gold^{+}$	0.190	7.113	3.889	2.720	$Gold^{-} \not\Rightarrow Bitcoin^{+}$	0.130	7.109	3.743	2.685
Panel E									
$Bitcoin^{+} \not\Rightarrow BIST\ 100^{+}$	0.004	7.268	3.735	2.614	$BIST\ 100^{+} \not\Rightarrow Bitcoin^{+}$	0.779	6.759	3.758	2.639
$Bitcoin^{-} \not\Rightarrow BIST\ 100^{-}$	0.107	7.174	3.895	2.746	$BIST\ 100^{-} \not\Rightarrow Bitcoin^{-}$	0.208	7.850	3.880	2.706
$Bitcoin^{+} \not\Rightarrow BIST\ 100^{-}$	0.077	6.879	3.841	2.665	$BIST\ 100^{+} \not\Rightarrow Bitcoin^{-}$	0.966	7.190	3.863	2.709
$Bitcoin^{-} \not\Rightarrow BIST\ 100^{+}$	5 0.498	6.775	3.894	2.730	$BIST\ 100^{-} \not\Rightarrow Bitcoin^{+}$	0.001	7.062	3.871	2.666

Note: The denotation A $\not\Rightarrow$ B indicates the null hypothesis that variable A does not cause variable B. For example, Bitcoin$^{+} \not\Rightarrow$ BIST 100^{+} means that a positive shock in Bitcoin does not cause positive shocks in the BIST 100 Index. *, ** and *** values denote significance at the 1% 5% and 10%, respectively. The bootstrap p-values are, in each case, based on 10,000 replications.
Source: own calculations.

Secondly, the results in Table 3 *Panel B* indicate that there is no causality relationship between Bitcoin prices and Brent oil prices. Therefore, the causal relationship is not found from Bitcoin prices to Brent oil prices and the other way around. These results revealed that Bitcoin investors are not affected by the increase and decrease in Brent oil prices. Thus, the positive and negative shocks to Brent oil price do not seem to determine Bitcoin price. These results are consistent with the findings of Ciaian *et al*. (2016).

Thirdly, the results in Table 3 *Panel C* indicate that we did not find any causality relationships between Bitcoin prices and exchange rate (US dollars). Hence, no association was found neither from Bitcoin prices to exchange rate nor

the other way. This means that US dollars fluctuation does not affect Bitcoin investors' decision. The fact that Bitcoin is not affected by the exchange rate as a cryptocurrency can be presented as an important result. Generally, there is a mutual exchange relation among currencies and all currencies, including the US dollar, depreciate. However, it appears that the up and down movements in the US dollar do not significantly affect Bitcoin investors' decision. Thus, it is possible to make some inferences: the US dollar has been a stable or safe-haven currency on international markets; however, Bitcoin is not a currency, but a speculation due to the security gap in the Bitcoin and excessive volatility. Besides, there is no competition as a medium of exchange between US dollar and Bitcoin use in transactions. These results are consistent with the findings of Atik *et al*. (2015) and Gulec *et al*. (2018).

Fourthly, in Table 3 *Panel D,* we obtained that there is no mutual causality relationship between Bitcoin prices and gold prices as an investment instrument. It was observed that Bitcoin investors are not affected by gold price shocks. Due to the investors' caution against Bitcoin, gold stands out among the methods principally preferred by the investors. Gold has been preferred as the currency of choice throughout history. Gold is a commodity while Bitcoin is a more elusive instrument. It is expected that the inverse relationship between Bitcoin and gold as a safe investment instrument has been marked. It is only natural when there is an inverse correlation between the prices of Bitcoin, a relatively new investment instrument, and gold has been identified as a safe haven asset. But such a relationship does not exist in this study. These results are consistent with the findings of Gulec *et al*. (2018).

Finally, in Table 3 *Panel E,* we obtained that there is no causality relationship between Bitcoin prices and BIST 100 Index. This means that the causal relationship is not found from Bitcoin prices to BIST 100 Index and the other way around. Here, the increase or decrease in the Bitcoin price and the recent remarkable increase in the Bitcoin returns do not affect the BIST 100 Index investors' decisions. Therefore, these investors remain unresponsive to the risks and returns of Bitcoin. In a similar vein, investors seeking to enter the Bitcoin market will not find the impacts of the BIST 100 in the Bitcoin market. The nonexistence of a causality relationship between the BIST 100 Index and Bitcoin may stem from the fact that investors in Turkey are not up to date on the issue and cautious against Bitcoin, since cryptocurrencies are not the subject of today's traditional financial sector regulations and pose too much risk; legal gaps and the need for speaking a foreign language to follow foreign markets; the difficulty in investing as cryptocurrencies require a great deal of information for investment purposes; and that a considerable portion of the share investors in Turkey do not have adequate information about these markets. These results are consistent with the findings of Dirican and Canoz (2017) and Gulec *et al*. (2018).

Conclusions

The phenomenon of cryptocurrencies is developing at a high rate from day to day. In direct proportion to its recognition among ever-increasing cryptocurrencies in the financial market and the number of its users, Bitcoin differs from other cryptocurrencies regarding the number of daily transactions and market capitalisation. Bitcoin prices have regularly displayed high volatility and the presence of high volatility is commonly associated with owners of Bitcoin actively taking part in its economy. There is an increasing interest in Bitcoin markets among users and academic research community as well. Hence, Bitcoin is the most widely known and used cryptocurrency in the world and its dynamics have been a controversial topic due to its use, mining, extreme volatility and characteristics as well as to the fact that cryptocurrency increased in popularity and became known to a wider audience.

The original side of this study is that we presume it is the first research analysing the relationships between Bitcoin price and commodity market, exchange rate and global indexes via Hatemi-J (2012) asymmetric causality test. This study attempts to examine the impacts of the virtual currency called Bitcoin on the other commodity prices and global markets with the increase in its use as a decentralized payment instrument and its treatment as an investment instrument. In this regard, the literature contribution of this study resides in revealing the relationship between commodity prices and the global indexes which may affect Bitcoin investors' decisions in international markets.

Hatemi-J (2012) test indicates that there is a causality relationship between Bitcoin prices and S&P 500 Index. The results suggest that a negative shock in Bitcoin leads to negative and positive shocks in the S&P 500 Index and a positive shock in Bitcoin leads to negative shocks in the S&P 500 Index. It can be suggested that a significant part of the investors in the S&P 500 market have sufficient information about the Bitcoin market, follow technological advances closely and that there is a lot of interest in computer applications which attract users' attention. On the contrary, there is no causality relationship between S&P 500 Index and the Bitcoin price. In the end, the result reveals that there is a unidirectional relationship between Bitcoin and S&P 500 Index. However, it is observed that causal relations from negative to positive and positive to negative shocks do not exist between Bitcoin and gold, Brent oil, US dollar and BIST 100 Index. Moreover, Bitcoin currency does not seem to be significantly affected by macro-financial developments. At present, several countries have warned that Bitcoin is insecure, has no legal tender and does not meet the standards of electronic money. Consequently, the use of Bitcoin has been completely or partially banned by some countries. However, it is expected that Bitcoin may have certain relationships with the exchange rates, commodity markets, global indices and other global indicators in the future; along with the identification of Bitcoin as a cryptocurrency, it is accepted as

a digital currency and its use is permitted by countries in the real economy, being regulated by central banks.

When all the results of the study are analysed, it can be observed that Bitcoin investors affect the S&P 500 Index. In addition, the Bitcoin currency is found to be one of the determinants of volatility in the S&P 500 market. Therefore, it is recommended that investors who take an active role in the S&P 500 market should closely follow the Bitcoin prices. As we look into the future, we expect Bitcoin to continue to make strides to become an accepted currency worldwide. Bitcoin and other cryptocurrencies are supposed to have the potential to replace traditional and new payment methods. Because this paper tends to only examine a relation in terms of certain variables, it has several limitations. In this context, future studies should focus on cryptocurrencies' relationships, especially those between Bitcoin and other financial instruments, global indicators and national exchanges, as well as on the relationship between Bitcoin exchanges and Bitcoin's relationships with other currencies.

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