Quality & Quantity (2022) 56:769–777
https://doi.org/10.1007/s11135-021-01153-3

VIX or ınvestors scare?

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Accepted: 16 April 2021 / Published online: 27 April 2021

Abstract
The behavior of the VIX index became significantly volatile during the 2007–2009 Global Financial Crisis (GFC) period, which is an important period when the 2008 financial crisis was triggered. In this context, the reality of the fear index that occurred during this period is a matter of concern as reflected by the financial markets literature. Therefore, the study employed the daily VIX index data for the period of 03.01.2007 to 31.12.2009. Thus, the Sup-Augmented Dickey Fuller (SADF) and Generalized Sup-Augmented Dickey Fuller (GSADF) test were used to examine the presence of bubble in the fear index for the pre-crisis, crisis period and post-crisis. As a result of the SADF test results, the presence of price bubbles is statistically significant at 5% statistical level for the period under consideration, while the findings of the applied GSADF test are significant at 1% statistical level. In addition, the VIX index movements were exposed to bubble formation in two different periods and that the bubbles in those periods were deflated. This confirms that there may be speculative movements in VIX index. Thus, reflecting the significant presence of fear associated with the occurences of the pre-, during, and post-crisis period of the GFC.

Keywords Price bubble · VIX Index · SADF and GSADF tests · Global Financial Crisis

1 Introduction

Globalization is one of the most important phenomena that includes and shapes lifestyles, phenomenon production, consumption behavior, international relations and politics (Akova and Kantar 2020: 6). Globalization also plays an important role in the economy and financial markets. As a result of the technological developments, it has become very easy to get information about different geographies and developments. This situation also allows the financial crisis in a country to be felt rapidly in a different geography. This situation indicates that the financial crises experienced in the 2000s were a more important research subject.

When the financial crises that were experienced throughout the history are analyzed, significant evidence revealed that the occurence of the crises have developed as a wave that spreads from developed economies to the economies of developing countries. In this

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case, the Global Financial Crisis (GFC) serves as the biggest proof of financial contagion and that related occurence has existed since the earliest times. Looking at a common point for financial crises, it is seen that the main reasons for the crises are price bubbles, this justifying the evidence of explosive bubbles. Since the tulip madness, the first manipulative movement in history, the biggest reason behind the existence of financial crises is the existence of price bubbles. The formation and extinction of price bubbles may cause stagnation or crises when they occur in an undesirable market. On the other hand, the uncertainty caused by price fluctuations in the market can make investors vulnerable. As a result of the reasons responsible for the uncertainty caused by price fluctuations, thus occurence of the creation of volatility indices to become inevitable. The VIX (Volatility) index created by the Chicago Options Exchange in 1993 has become an index that is closely followed by credit rating agencies, investors and governments. VIX index, which has become a global indicator, can be expressed as a numerical value of uncertainty for investors.

In studies such as Friedman (1953), Baumol (1957), Kohn (1978) and Shiller (1981), which were the first set of studies in the field of price bubbles, volatility tests were applied. In some case, the changes in the price of financial assets are higher than the changes in the basic value, thus validating the existence of price bubble. In the study of Brunnermeier (2008), the price bubble exceeding the basic value was expressed as a price bubble. This was the result of the tulip unusual experience between 1934 and 1937 that is known as the Mississippi Bubble in 1720, the Great Depression of 1929, and finally the major cause of the global crisis in 2008, when prices exceeded the core value.

When the literature is examined, many studies related to the price bubble are spread across several related filed. Thus, these fileds which include the Housing prices, exchange rates, stock market indices and the price bubble, which concerns the price movements of many sectors, are just a few of the previous researches. In this study, the existence of bubbles that occur in the VIX index were examined. Compared to the researches conducted in the past, it has been found that price bubbles are not associated with the VIX index.

Addressing the existence of bubbles in the VIX index will make an important contribution to the financial literature. The aim of the study is to test whether there are bubbles in the VIX index, which is an important indicator for investors. In this way, it will be help to examine whether there are speculative movements in VIX index. Therefore, how real or how virtual fear is the VIX index is the main research question in this case and is designed to be answered in the succeeding sections. In specific, the testing or investigation of the research question is restricted to the period 2007–2009 as a significant emphasize for the 2008 Global Crisis period. Thus, this enables the speculative movements in the VIX index to be evaluated as a reference for the 2008 period that affected almost every part of world.

2 Price bubble and VIX fear ındex

2.1 Price bubble

The evidence from financial lietrature revealed the fact that there are dozens of definitions about the price bubble that have relevant or common definition with the concept in the current research question. The concept of price bubble has become diverse with given the works from such as Palgrave (1926), Kindleberger (1996), Kindleberger and Aliber (2005), and Brunnermeier (2008). In this context, the related definitions and concepts similar to the current study are given in Table 1 (Oran 2011).

Table 1 Price bubble definitions

Author	Definitions for Price Bubbles
Palgrave (1926)	Any unfounded initiative with high risk
Kindleberger (1996)	It is a long upward price movement and the inward that follows Collapse
Kindleberger ve Aliber (2005)	It is related to an unsustainable price or cash flow movement …
Brunnermeier (2008)	Striking price increases and the following crashes

By examining the extant literature in detail, different definitions can be reached for price bubbles. For instance, the study of Dezhbakhsh and Demirguc-Kunt (1990) pointed to the existence of a price bubble in the event that prices deviate from its core value.

Case and Shiller (2003) defined price bubbles as an increase in prices due to the expectation of future price increases. In addition, the study of Mayer (2011) show that prices increase more than necessary and decrease more than necessary, thus showing that there is a bubble in asset prices. As can be seen, the definitions related to price bubbles are many and it can be understood that there is no common/consensus definition. However, it may be considered as a common point that they cause financial crisis. Therefore, price bubbles, which are a problem that can be encountered in almost all of the financial values, have been tested for precious metals, exchange rates, indices, stocks, prices of goods and services and assets that can be the subject of many purchases and sales. Therefore, it is useful to examine the studies on financial bubbles that occur on different financial assets that can cause global financial crises.

2.2 VIX (fear) ındex

The VIX index, whose value of purchase and sale prices is close to each other and that exhibit a decrasing value, is an index that is determined by investors and expresses the future 30-day volatility. The increase in the index, also known as the fear index, indicates that the fear in investors has increased (Whaley 2000). When the concept of volatility, which has a significant impact on investors' decisions, rises, it becomes risky for investors and they can stop investing in this direction (Akdağ 2019). Thus, VIX index is one of the indicators that are closely followed by investors and have an important role in investment decisions. By affecting the investor decisions of the VIX index, it actually affects the financial markets in parallel with the reactions of the investors. For the VIX index, which can influence the financial markets, there are local and foreign studies in the literature.

In the study of Sarwar (2012), through the use multiple regression analysis and a daily data between 1993 and 2007, a negative relationship among the stock market indices of countries such as America, Brazil, China, India, and Russia. In a similar study, Huang and Wang (2017) found a negative and significant relationship between the VIX index and the Taiwan stock market index through the regression analysis that was employed for the daily data over the period 2007–2014. On the other hand, in the study of Sarwar and Khan (2017), the relationship between the the VIX and the stock market of the Latin American countries was tested such tha a negative and significant relationship was found between the VIX index and stock market indexes. Additionally, the study of Sadeghzadeh (2018), which is also one of the importantly related studies, the the study revealed the evidence of both Granger causality and Cointegration analysis between BIST100 and VIX index.

The findings revealed that there is causality and cointegration from VIX index to BIST100 index. When Turkey also studies examined by Sahin (2018), which is also related to the studies of İçellioğlu and Öner (2018) Kula and Baykut (2017), the VIX index with different models implemented posited that there is a negative and significant relationship between VIX and BIST100 index. On the other hand, Akkaya (2018) found that TürkEuro bonds were affected by the VIX index when a regression analysis is employed. In a similar study of Güler (2019) that utilized the ARDL boundary test approach, the study found a long-term and negative relationship between VIX and trade investments.

In the study of Akdağ, Kılıç and Yıldırım (2019), which is one of the studies that have used the case of several countries, the relationship between VIX and tourism index was tested for 11 different countries. As a result of the Granger causality and cointegration tests applied, a short-term and negative relationship was found between the tourism indices and the VIX index of all countries except that of the united States and Sri Lanka that revealed a negative relationship in the long term.

Moreover, Yıldırım (2019) established a relationship between VIX index and DAX volatility index, US Dollar index and Crude oil prices. By applying the ARDL limit test to data; It was found that the VIX index has a long-term relationship with the Dollar Index and the US Dollar index. However, it was found that there is no long-term relationship with crude oil prices.

3 Literature review: a synopsis

In the study of Altay (2008) that tested for the evidence of price bubbles in Borsa Istanbul stock price, the market indexes were employed. Given that seven different sub-indices were utilized, the findings obtained revealed a statistical evidence of price bubbles. In a similar study, Koy (2018) considered the case of the developing countries by applying the SADF and GSADF tests for specific price range. The result revealed price bubbles for the case of Brazil, Indonesia, Mexico, Chile, South Korea, India, Russia just as the case of Qatar and Turkey.

Furthermore, the study of Çağlı and Mandacı (2017) revealed the existence of a price bubble when ten years data span was tested for 21 different indices from the Borsa Istanbul. In the study, where the recursive flexible forecasts model was applied, the presence of price bubbles was reached. Another one of the most important and related study about price bubble is the studies on cryptocurrencies. In the study of MacDonell (2014), the behavior of Bitcoin prices was discussed and the findings were obtained from the presence of price bubbles. In a similar study by Ceylan et al. (2015), the existence of a price bubble for cryptocurrencies BTC and ETH was tested. As a result of the findings obtained from the analysis in which the GSADF test was applied, the existence of price bubbles for both cryptocurrencies was established. In addition, the study of Cheung et al. (2015) also examined the existence of the price bubble of cryptocurrencies, which has increasingly become the most popular investment instrument of recent years. Accordingly, the study revealed that there are three different price bubble formations obtained as a result of the applied GSADF test.

Moreover, Kristoufek (2015) observed the price changes of Bitcoin and pointed out that the asset was both a normal financial asset and an asset containing speculative bubbles. In the study of Baek and Elbeck (2015), it was tested whether price bubbles for Bitcoin exist while employing the regression model applied. As a result of the findings obtained in the

econometric model by using macroeconomic indicators, the study affirmed that Bitcoin is a speculative tool. Notwithstanding, the study of Alabi (2017) examined the existence of price bubbles by creating a network theory for Bitcoin. As a result of the network theory modeled which is based on the amount of users, the result validated that the number of users has a determining feature in the price bubbles that may occur in Bitcoin.

4 Study data and method

In this part of the study, information about the data used in the analysis and the applied analysis will be included. In this way, information about the period of the variable included in the analysis will be provided, and the mathematical process related to the analysis applied to determine the price bubbles will be explained.

4.1 Data

The VIX index, known as the Chicago Board Options Exchange (CBOE) Volatility Index, is an indicator that shows the market's 30-day volatility expectation in an annual format. The VIX index is obtained based on the volatility of S&P 500 index buying and selling options (CBOE 2018). Given the dynamic behavior of VIX index, which is an important indicator for investors espcially between 2007 and 2009, which is an important period for the 2008 crisis, the study is aimed at examining whether it is a real or virtual fear during this period. Therefore, daily VIX index data for the period of 03.01.2007 and 31.12.2009 were used in the study. Thus, the presence of the bubble in the fear index was tested for the pre-crisis, crisis process and post-crisis. The said data were obtained from investing.com and analyzed by using the E-views 9 program.

4.2 Methodology

The most popular tests used to test the presence of price bubbles are the SADF and GSADF tests, and both tests were used in the study in question. The reason for applying the SADF test and the GSADF test to detect the occurrences of price bubbles in the study is that the GSADF test gives more advanced results compared to the SADF test. In the study of Phillips et al. (2011), it was suggested that the detection power of the SADF test is limited if there are more than one bubbles and the GSADF test, which has a higher detection ability in multiple bubble formation.

When applying unit root calculations for SADF and GSADF tests, the regression equation in Eq. 1 is applied (El Montasser et al. 2015: 21):

$$Y_t = m + y_{t-1} + \sum_{i=t}^{p} \alpha_i \Delta y_{t-i} + \varepsilon_t, \varepsilon_t \sim N\left(0, \sigma^2\right), t = 1, \ldots, T \tag{1}$$

Since the ADF unit root test equality is used while applying SADF unit root test, the Eq. (2) used in the ADF test application is given below.

$$ADF_{r_1,r_2} = {}^{r_1,r_2}\Big/_{se\left(_{r_1,r_2}\right)} \tag{2}$$

It can be stated that the following equation should be used to reach the SADF test application (Phillips et al. 2011: 1048–1049):

$$SADF_{r_2} r(0) = sup_{r_1 \in [0, r_2 - r_0]} ADF_{r_1}^{r_2} \tag{3}$$

$$GSADF(r_0) = Sup_{r_2 \in [, r_0 - 1]} SADF_{r_2}(r_0) \tag{4}$$

In SADF and GSADF tests where the existence of price balloons are tested, the null hypothesis representing the absence of a price bubble is expressed as H_0: $\lambda = 1$, while H_1: $\lambda > 1$ represents the existence of the price bubble.

4.2.1 Findings

The findings obtained as a result of the SADF (Sup-Augmented Dickey Fuller) and GSADF (Generalized Sup-Augmented Dickey Fuller) test applied for the detection of bubbles that may occur in VIX index movements, which are accepted as fear index across the whole world, are shown in Table 2.

As a result of the SADF test results, the presence of price bubbles is statistically significant at the level of 5% for the period in question, while the findings of the applied GSADF test are significant at the level of 1%. This indicates that the VIX index movements have more virtuality than the real ones.

In other words, it can be said that there are speculative movements in VIX index movements for the period 2007–2009. Speculative movements in the VIX index can be accessed from the Figiure 1 obtained as a result of the SADF and GSADF tests.

When Fig. 1 is examined, VIX index movements are exposed to the formation of bubbles sharply in two different periods and they disappear in the same way. 2007–2009 period in the chart; It consists of three parts: before the crisis, after the crisis and after the crisis. The bubble, which occurred at the end of the second period of 2007, which was before the crisis, faded at the end of the third period of the same year and re-occurred towards the end of the third period during the 2008 crisis and faded at the end of 2008. The beginning of 2008, which is an important period for the crisis process, can be regarded as the period with the highest bubble. This situation can be regarded as the most distant point of real

Table 2 SADF and GSADF test results

Variable: VIX	%	t-statistic
SADF		3.759091[b]
Critical Values	1	2.138495
	5	1.551248
	10	1.264416
GSADF		4.609071[a]
Critical values	1	2.039457
	5	1.918139
	10	1.878513

[a]Significant at 1% significance level

[b]Significant at 5% significance level

The critical values were obtained from 100 replicates of Monte-Carlo simulations and the Initial window size 0.10 (75) was taken

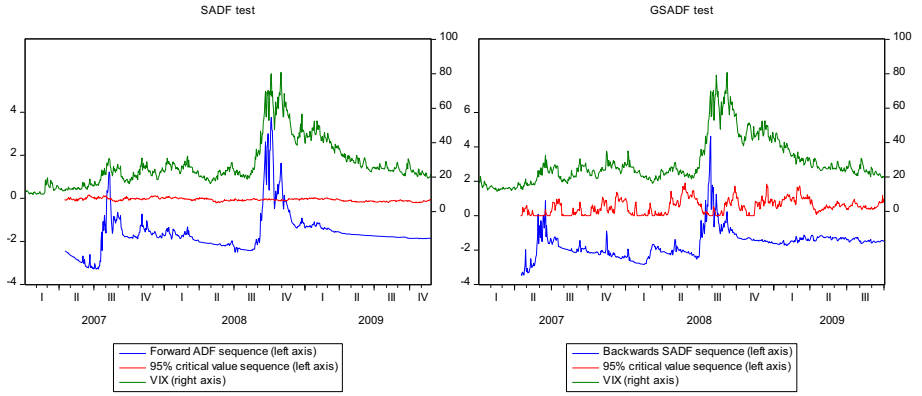

Fig. 1 SADF and GSADF test chart

value of VIX index movements for 2007–2009 period. Looking at the 2009 period, it is understood from Fig. 1 that there is no bubble formation.

5 Conclusion and policy ımplications

The VIX index is an important indicator that illustrates the reaction of the investors and markets. Speculative bubbles formed in the VIX index can mislead investment decisions, thus affecting the pricing in financial markets as it illustrates the market dynamics. Importantly, this study suggests that if the VIX index exceeds 30% levels, investors are afraid of an increased volatile markets. İn addition, if the VIX index drops below 20%, volatility has declined and therefore there is a decrease in the severity of investor concerns. As it turns out, it is obvious that investors fear occurs on the basis of certain levels. Considering the strong correlation between investors' decisions and the reactions of the markets, speculative movements that may occur in the VIX index that directly affect investor decisions can affect the markets on a global basis. The GFC that happened in the examined period is a clear revelation to this assertion. Therefore, the existence of speculative movements in the VIX index, which is an important indicator that can affect the markets and investment decision, may lead to misleading of the markets and investors. In the study in question, the existence of speculative bubbles that could occur in the VIX index was carefully examined and illustrated in a graphical pattern.

As a result of the Sup-Augmented Dickey Fuller and Generalized Sup-Augmented Dickey Fuller tests, three different bubble formations were found between 2007 and 2009. In this case, it can be said that there are speculative bubbles in the VIX index for the period 2007–2009 (specifically during the period of the GFC). When the findings are examined as in the extant literature of Altay (2008), MacDonell (2014), Ceylan et al. (2018), Baek and Elbeck (2015), Çağlı and Mandacı (2017) and Latif et al. (2017), the findings significantly corroborates most of the aforementioned previous studies. The presence of speculative bubbles may disrupt its balance in the global markets by casuing changes in the VIX index, which are carefully monitored by the financial markets of developed and developing economies, thus affecting the global financial indicators and market. Therefore, it is calculated

based on the option prices, which are one week to maturity and depend on the S & P500 index with a maximum of two months.

In regard to policy prediction, a more effective monetary and fiscal policy might be essnetial to mitigate the effect of potential disruption in the financial market as a result of shock on investors fear across the globe. This is because the bubbles that existed in the period 2007–2009, which is a very important period for the 2008 global crisis created a virtual fear for investors, the VIX index indicator may mislead the investors and even cause the financial crisis to become more severe. For this reason, it will be important for the realists of the VIX index to use different indexes, maturities and instruments instead of using two month term options within the S & P500 index used to calculate the VIX index.

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