

DETECTING FINANCIAL CONTAGION BUBBLES IN FUTURES MARKETS: AN EMPIRICAL EVIDENCE FROM RIGHT-TAILED UNIT ROOT TEST APPROACH¹



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ABSTRACT | The objective of this study is to identify the presence of bubbles and to seek the contributions of the Covid-19 pandemic to bubble formation in futures markets. To assess the impact of financial contagion, daily data for the period between December 1, 2019 and December 11, 2020 were used. The empirical estimation strategy was used based on the GSADF test to investigate whether there are bubbles in futures markets. According to the estimation results, GSADF test statistics for selected 7 futures market indices were found to be statistically significant for the study. The results show that COVID -19 pandemic has contagion effects on futures markets and causes bubble formation for 7 futures market indices. As a result, important insights were obtained regarding the development and spread of the COVID -19 contagion to financial markets.

Keywords: Future markets, COVID-19, financial contagion, bubbles, right-tailed unit root test, GSADF

Jel Codes:: D53, F3, G01

Scope: Economics

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¹ Compliance with the ethical rules of the relevant study has been declared.

VADELİ İŞLEM PİYASALARINDA FİNANSAL BULAŞICILIK BALONLARININ TEŞPİTİ: SAĞ KUYRUKLU BİRİM KÖK TESTİ YAKLAŞIMINDAN AMPİRİK KANITLAR



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ÖZ | Bu çalışma, vadeli işlem piyasalarında balonların varlığını ve Covid-19 salgınının vadeli işlem piyasalarında balon oluşumuna olası etkisini incelemektedir. Çalışmada balonların varlığını ve finansal bulaşmanın etkilerini değerlendirmek için, 1 Aralık 2019 ile 11 Aralık 2020 dönemi arasındaki günlük veriler kullanılmıştır. Çalışmada Genelleştirilmiş SADF (GSADF) testine dayanılarak vadeli işlem piyasalarında balonların olup olmadığı tespit edilmiştir. Elde edilen tahmin sonuçlarına göre GSADF test istatistikleri, çalışma için seçilen 7 vadeli işlem piyasası endeksi için istatistiksel olarak anlamlı bulunmuştur. Bu sonuç, Covid-19 salgınının vadeli işlem piyasalarında bulaşıcı etkilere sahip olduğunu ve 7 vadeli işlem piyasası endeksi için balon oluşumuna neden olduğuna ilişkin ampirik kanıtlar ortaya koymaktadır. Sonuçlar, Covid-19 salgınının finansal piyasalara bulaşmasının gelişimine ve yayılmasına ilişkin önemli bilgiler sunmaktadır.

Anahtar Kelimeler: Vadeli işlem piyasaları, COVID-19, finansal bulaşma, balonlar, sağ kuyruklu birim kök testi, GSADF.

JEL Kodu: D53, F3, G01

Alan: İktisat
Türü: Araştırma

1. INTRODUCTION

One of the most important factors influencing changes in the financial sector at the end of the twentieth century is financial globalization. The globalization of financial markets is an inevitable and ongoing dynamic process that leads to more capital resources to support companies and individuals, more investment products and diversity, more opportunities, and greater complexity of risk and risk management issues (Račickas & Vasiliauskaitė, 2011, p. 1174). The most striking aspect of the recent financial globalization wave is that it leads to variable and cyclical capital flows (Broner & Ventura, 2016). The liberalization of financial systems and the globalization of capital markets have expanded financial services and improved the allocation of resources. At the same time, this has expanded the scope of significant financial cycles. These cycles paved the way for dramatic swings in financial asset prices, amplified the business cycle and financial contagion, and even led to the peak of instability in financial markets. Financial contagion is often used to describe the spread of market disturbances from one country to another. In its broadest sense, financial contagion is about the propagation of adverse shocks that have the potential to trigger financial instability (Moser, 2003; Pereira, 2018, p. 5).

In the case of systemic shocks in financial markets, the systemic risks created by these shocks show the negative effect of financial contagion by triggering a domino effect on other parts of the financial system (Murphy, 2012, p.2). For example, due to the problems in the housing market during the 2008 global crisis, banks that originate mortgage loans got into trouble. The fact that banks that lent mortgage loans financed the necessary funds with the funds they received from investment banks inevitably led to serious difficulties for investment banks and damage to financial markets (Demir et al., 2008, p.8). These losses also grew by spreading from one financial institution to another like a domino effect, and the institutions that are the cornerstones of the financial system began to go bankrupt (Alantar, 2008, p. 2). Another example is that a systemic shock in one part of the financial system disrupts the functioning of payment systems through financial contagion. Contagious losses, panic selling due to uncertainty in one market or institution lead to losses in other markets and institutions. As a typical example, the prices of derivatives, which were far above their actual values, suddenly fell due to the default on subprime mortgages, panic selling in financial markets and the negative impact of these developments on commodity markets (Eraslan, 2016, p.86).

The increasing linkage of financial markets with the globalization process made it more likely that excessive volatility in one financial market would infect other markets. For example, the pandemic of COVID -19 caused the

collapse of all world stock markets in March 2020. As the pandemic spread to financial markets, the Dow Jones Index fell 2977 points in one day on March 16, 2020, the largest decline ever. The pandemic of COVID-19 created an environment of uncertainty for investors. This uncertainty led to huge losses in the stock markets. For example, while there was a 37% drop in the UK stock market, a 33% drop was observed in the German stock market. While there was a 48% decline in the Brazilian stock market, it was 38% in the Polish stock market. In Turkey, the stock market recorded a decline of 15% at the same time.

Increasing the probability of financial contagion causes bubbles to form in financial markets by moving away from the fundamental values of financial asset prices. As stated in the studies on the formation of bubbles in the literature, the explosion of bubbles in the financial markets always shows that there is severe disruption in the financial markets. While in the case of positive bubbles in financial markets there is excessive demand formation, in the case of negative bubbles there is disproportionate sale of financial assets. In case of explosion of bubbles, there is a sudden fall in prices (Malkiel, 2010, p. 14). Considered in this context, the rise and collapse of financial markets has negative effects, as shown by recent global crisis experiences. These effects not only affect financial markets but also the real economy. When asset price bubbles burst, severe adversity can be reflected throughout the real economy in the form of insolvencies and loan defaults. For this reason, both market players and policy makers are concerned about when asset price bubbles occur and what measures need to be taken to prevent them. (Grover & Grover, 2014, p.209). The reason for this concern is that crises often follow the bursting of financial bubbles, and the resulting financial instability sets many developed or emerging market economies back decades (Afşar et al., 2019).

In particular, recent economic developments and outcomes have shown that the COVID-19 pandemic has been significantly but also highly negatively correlated with financial markets and hence the financial system. The research question of this study is to determine whether there is the impact of financial contagion on the future markets that emerged in the COVID -19 pandemic. To assess the impact of financial contagion, the daily data for the period between December 1, 2019 and December 11, 2020 is used and the data was obtained from the Yahoo Finance database. The empirical estimation strategy is based on the Generalized Supremum Augmented Dickey-Fuller (GSADF) test.

One of the features that distinguishes the study from other studies is that it will determine the presence of the contagion effect of the COVID -19 pandemic in future markets. A second novelty of the study is that it will determine when the contagion effect will occur in financial markets and hence the occurrence of

financial bubbles. Another difference is that, unlike the indirect methods used in the literature, the GSADF test used in the study, thanks to its dynamic structure, allows predicting financial contagion in advance and provides more reliable and accurate results. Moreover, given the intense debates on the impact of the COVID-19 pandemic on global financial markets, the study also makes an empirical contribution to these discussions. It is expected that the findings obtained in this study will contribute to the literature both in terms of scope and methodology.

In Part 2, the relevant literature has been presented, in which the findings of previous studies related to the subject matter of this research have been presented. In the following section (namely Part 3), the data set and empirical method were summarized in detail. In Part 4, the empirical findings were presented using a predetermined empirical strategy. In Part 5, a concluding remark was presented.

2. LITERATURE REVIEW

There are few studies in the literature on the impact on financial markets of the COVID-19 pandemic that occurred towards the end of 2019 and affected the whole world. The short time span between the occurrence of the pandemic and its impact on financial markets and economic factors represents the limitations of research in this area. At this point, this study aims to fill this gap in the literature.

First, some recent studies in the literature are important to see the initial impact of the Covid-19 pandemic on futures markets. In these studies, Mao et al. (2020) examined the bubble formation in two of China's major agricultural commodity markets (corn and soybeans) using the right-tailed unit root test. The results of the study suggest that market liquidity and speculation have negative effects on corn and soybean markets and lead to bubble formation.

Shirinov et al (2020) investigated bubbles in oil markets using the SADF test (Supremum Augmented Dickey-Fuller). In this framework, weekly data of WTI and futures prices of Brent oil were used, covering the period from April 1995 to April 2020. According to the results of the SADF test, the bubbles were defined as a few distinct historical episodes. The prices of WTI futures seem to have fewer bubble periods compared to Brent Oil futures. Finally, Chiu and Chou (2020), investigated the presence of bubbles in Soft Commodities the New York futures market. In the study, the period of analysis was chosen from April 26, 1991 to March 27, 2020. According to the results, it was found that bubbles were formed in the New York Soft Commodity Futures Market during the study period.

Among the studies on the impact of Covid 19 pandemic in the literature, Gharib et al. (2020) examine the causal relationship between crude oil and spot gold prices to assess how they are affected by the economic impact of COVID -

19. The study also attempted to identify the bubble formation in gold and oil markets during Covid-19. According to the findings of the study, bubbles formed in the oil and gold markets during the pandemic of COVID -19 which had a bilateral contagion effect.

Cheng (2020) in his study of VIX futures market prices found that futures market prices increased slowly during the COVID-19 pandemic. However, the author found that term market premium prices turned negative by mid-April as the pandemic spread and a sharp decline was observed.

On the other hand, Ji et al. (2020) investigated the role of safe haven of assets traded in financial markets during the Covid 19 pandemic, which is different from the issues discussed in the literature. According to the results of the study, they concluded that gold and soybean futures provided a strong safe haven in the face of the Covid 19 pandemic.

Wang et al (2020) examined the cross-correlation between crude oil prices and agricultural futures prices during the Covid-19 pandemic. According to the authors' findings, there is a strong cross-correlation between crude oil and agricultural futures market transactions. Moreover, the cross-correlation increased after the Covid-19 outbreak in all agricultural futures markets except the orange juice futures market.

Huang and Zheng (2020) examined the relationship between crude oil futures market prices and investor sentiment after the Covid-19 pandemic, and the authors concluded that there was a structural change between futures markets and investor sentiment during the Covid-19 pandemic.

Zeren and Hızarcı (2020) examined the impact of the COVID -19 pandemic on stock markets for six countries. The countries used in the study are China, South Korea, Italy, France, Germany and Spain. As a result of the study, it was found that the overall mortality rate and all stock market indices move together. It was also found that the total cases have cointegration relationship with SSE, KOSPI and IBEX35 and no cointegration with FTSE, MIB, CAC40 and DAX30.

Gursoy (2020) studied the impact of Covid19 on financial markets. The results of the study showed that the SP500 index of the US stock market influenced the SSEC index of the Chinese stock market before December 2019 with a significance level of 5%, while it was found that the Chinese market was more independently influenced by its own dynamics after December 2019. On the other hand, there was no statistically significant causality relationship between Chinese stock market and South Korean stock markets before December 2019, while it was observed that SSEC index influenced South Korean stock market KOSPI50 index unilaterally after December 2019. Similarly, Gursoy et al (2020) investigated the causality relationship between Covid-19 pandemic and

financial indicators. The results show that there is a causality relationship at the 5% significance level between the SSEC index and gold and VIX. While unidirectional causality was found from SSEC index to gold, bilateral causality relationship was found with VIX.

Finally, Ali et al. (2020) examined the impact of the COVID -19 crisis on financial market volatility. In this context, the daily prices and returns of MSCI indices of the first nine countries affected by the COVID -19 pandemic, namely China, USA, England, Italy, Spain, France, Germany, Switzerland and South Korea were examined. The study covers the period between January 1, 2020 and March 20, 2020. In the time period given in the study, it provides evidence that COVID -19 increases the level of uncertainty, which leads to high volatility in stock market returns and that markets gradually deteriorate.

3. DATA AND EMPRICAL METHODOLOGY

3.1. Data

The objective of this study is to determine whether the impact of financial contagion during the COVID -19 pandemic on future markets is statistically significant. To this end, we use a daily dataset of 14 futures market indices. These indices cover a large measure of capitalization levels based on the volume of total futures exchanges in the world and belong to indices that were critically affected by the pandemic. One of the most important features of this study that distinguishes it from the others is that it establishes the presence of the contagion effect of the COVID -19 pandemic in the futures markets. It also determines a precise time period and its side effects when contagion may occur in futures markets consistent with an ongoing emergence of potential financial instability. In addition to these macro-based results, which are discussed in the empirical section, the applied GSADF procedure recognises the dynamic structure of financial contagion by examining instability migration across different futures market indices.

We consider the futures market indices for the core classification. This classification took into account the type of sector in which the corresponding indices are located. In this context, the sample futures market indices selected in the study can be expressed as follows:

1. Energy Markets: CRUDE OIL MARKET, HEATING OIL MARKET, NATURAL GAS MARKET;

2. Metal Markets: GOLD, MARKET; PALLADIUM MARKET, PLATINUM MARKET, SILVER MARKET

3. Agricultural Markets: COCOA MARKET, COFFEE MARKET, CORN MARKET, COTTON MARKET, SOYBEAN MARKET, SUGAR MARKET, WHEAT MARKET

Table 1 presents selected descriptive statistics for 14 major future market indices.

Table 1: Descriptive Statistics

	Mean	Median	Max.	Min.	Std. Dev.	Skewness	Kurtosis	J-B	Obs.
COCOA	2513	2469	3054	2160	207	0.57	2.48	17.23	259
COFFEE	111	110	135	93	10	0.36	2.46	8.75	259
CORN	360	364	426	302	34	0.19	1.81	16.74	259
COTTON	63.69	63.93	72.26	48.41	5.59	-0.49	2.54	12.97	259
CRUDE OIL	40.46	40.67	63.27	-37.6	12.37	-1.07	8.27	350.7	259
GOLD	1745	1736	2051	1459	156	-0.16	1.86	15.13	259
HEATING OIL	1.29	1.21	2.06	0.61	0.33	0.78	2.92	26.70	259
NATURAL GAS	2.11	1.93	3.35	1.48	0.42	0.77	2.58	27.90	259
PALLADIUM	2145	2191	2744	1449	231	-0.31	2.79	4.81	259
PLATINUM	885	890	1071	595	86	-0.67	3.41	21.30	259
SILVER	20.11	18.05	29.24	11.73	4.29	0.34	1.82	20.09	259
SOYBEAN	934	896	1191	821	96	1.20	3.35	64.00	259
SUGAR	12.80	12.78	15.78	9.21	1.61	-0.14	1.96	12.47	259
WHEAT	477	472	579	411	41.26	0.71	2.62	23.64	259

The time period considered in the study covers the period from December 1, 2019 to December 11, 2020. We use the GSADF testing method for the full samples. Following the literature on COVID -19/asset pricing, we describe the empirical results in terms of the start date announced by the World Health Organization (WHO) as early as possible. The main reason for not adopting this date for the start of the empirical investigation is that, for a given report in Wuhan, the stated start date was only an official statement, but the cases no longer depended on it. In other words, there are several unofficial cases and their effects on different economic units that were assumed to have been started far from the official reports. Therefore, we describe empirical results as of December 1, 2019. The following subsection explains the basics of the empirical methods-namely, the GSADF-that were examined in the analysis.

3.2. Empirical Methodology

Much of the research on financial instability and financial bubble detection, in particular, is based on the use of cointegration and standard unit root test methods, which are adopted as indirect methods in the first place. However, the limitations of these indirect methods should also be mentioned in order to conduct further analysis in relation to countries with disparate financial structures and stock market fundamentals. Therefore, the current methodology used in the empirical analysis also considers the counter-arguments and theoretical criticisms based on indirect methods to detect whether bubbles occur in stock markets by introducing a new type of econometric procedure called the generalised

supremum augmented Dickey-Fuller (GSADF) test. Phillips et al. (2015) use the iterative flexible estimation of the regression from which the standard ADF test is obtained, while the GSADF unit root test is computed and allows for nonlinear structures and structural breaks that extend over a long period of time. In this regard, the GSADF test performs better than unit root tests such as SADF and standard ADF as it provides more consistent and accurate results when encountering multiple bubbles (Phillips et al., 2015). Although the GSADF test depends on the recursive operation of the ADF test in subsamples, it is expressed as the largest ADF test because it is much broader than other right-tailed unit root tests. To compute the GSADF test statistic, we first estimate the regression equation 1. Here, r_1 and r_2 are included in the equation to represent the initial and final points of the subsample, respectively, to make repeated regression estimates:

$$\Delta y_t = \tilde{\alpha}_{r_1, r_2} + \tilde{\beta}_{r_1, r_2} y_{t-1} + \sum_{i=1}^p \tilde{\psi}_{r_1, r_2}^i \Delta y_{t-i} + \tilde{\epsilon}_t \quad (1)$$

In the GSADF test, Equation 1 is predicted over and over again for multiple subsamples by using subsamples with a future date and creating subsamples where the starting points at r_1 change dynamically and deviate from zero. From this point of view, the GADF test is calculated using the formula given in Equation 2 (Phillips et al., 2015, p. 1049).

$$GSADF(r_0) = \sup_{r_2 \in [r_1, r_1 + 1]} \{ADF_{r_1}^2\} \quad (2)$$

The next subsection summarizes the empirical results based on the GSADF unit root test method, which determines financial contagion whether it is statistically significant throughout the emergence of COVID -19 across futures markets.

4. EMPIRICAL FINDINGS

This study aims to uncover the presence of bubbles in futures markets using 14 futures market indices. Thus, it will be possible to determine the contagion effects of the Covid-19 pandemic in the financial markets. For this purpose, the GSADF test is used to test whether there are bubbles in the futures markets. The findings obtained in the study are presented in Table 2. The graphs related to the GSADF test are presented by the sector groups in which they are located in Figure 1, Figure 2 and Figure 3. It should be emphasized that the figures for the indices in which the presence of bubbles is found are included in the corresponding figures.

Table 2: The GSADF Test Statistics

	GSADF Test Statistic
COCOA	1.396 (0.02)**
COFFEE	1.092 (0.07)*
CORN	0.312 (0.52)
COTTON	0.283 (0.55)
CRUDE OIL	1.940 (0.00)***
GOLD	0.888 (0.14)
HEATING OIL	0.423 (0.43)
NATURAL GAS	0.631 (0.29)
PALLADIUM	3.376 (0.00)***
PLATINUM	1.764 (0.00)***
SILVER	2.768 (0.00)***
SOYBEAN	0.940 (0.12)
SUGAR	1.901 (0.00)***
WHEAT	0.555 (0.33)

*Note: () refers to the probability values of the test statistics. Critical values for GSADF statistics are 1.008, 1.199, and 1.652 for 10%, 5%, and 1% significance levels, respectively. In addition, the significance levels * 0.10, ** 0.05, and *** 0.01 are given. These critical values were obtained by Monte Carlo simulation with 2,000 replicates*

The GSADF test statistics reported in Table 2 were found to be statistically significant for 7 futures market indices. These indices can be referred to as cocoa, coffee, crude oil, palladium, platinum, silver and sugar. In other words, this result shows empirical evidence that bubbles form in futures market prices. Thus, it was found that the concerns caused by the Covid 19 pandemic that started in China and quickly spread around the world were transferred to these indices. On the other hand, the GSADF test statistics reported in Table 2 were found to be statistically insignificant for the indices of corn, cotton, gold, fuel oil, natural gas, soybeans, and wheat. This result shows that these indices do not form bubbles. In this context, it can be evaluated that the Covid-19 has no financial contagion effect on these indices.

When the results of the study are evaluated in the context of industry groups, it appears that the bubble collapses in financial markets caused by Covid-19 affect all industry groups, i.e., the explosions cause severe disruptions in financial markets. However, the magnitude of this contagion effect varies on a sectoral basis. Indeed, the sector most affected by Covid-19, as the results show, is the metals market. In this market, a bubble has formed in all indices except gold. In the agricultural sector, bubble formation was observed only in cocoa,

coffee and sugar indices. On the other hand, in the energy sector, bubble formation was observed only in crude oil prices according to the results. It can be said that the energy market is the futures market where the Covid-19 has the least financial contagion effect.

Figure 1 shows the impact of the COVID -19 pandemic on futures markets and the formation of bubbles in the Energy Sector group. According to this figure, there was a negative bubble formation in the prices of crude oil indices between the end of February and the end of March. In other words, the financial instability caused by the Covid 19 pandemic peaked during this period, and the prices of these indices collapsed. This negative bubble can be explained by falling oil prices, supply and demand problems, and uncertainty in the global economy and financial markets during the Covid 19 pandemic. In addition, a second negative bubble emerged in April, when oil prices in global oil markets fell below zero for the first time.

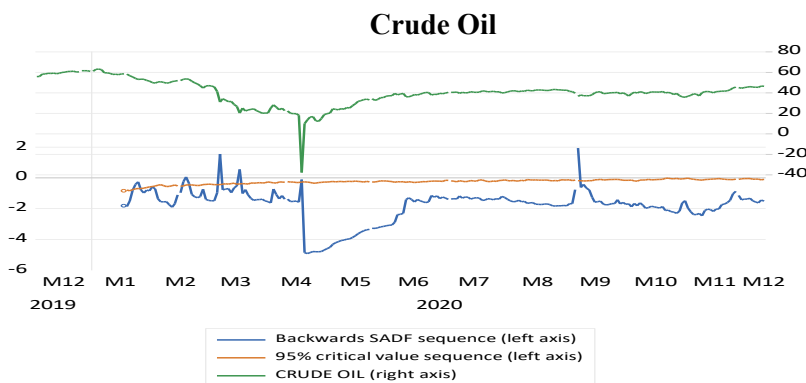


Figure 1: The GSADF Test Results for Energy Sector

The GSADF diagram presented in Figure 2 shows the test results of the future markets included in Metal Sector. According to the figure, it can be observed that COVID -19 has caused a negative bubble in all metal market indices. The uncertainty in the financial markets, especially due to the announcement of the global pandemic on March 11, 2020, was effective for the formation of this bubble. As a result of the contagion effect of the sharp declines observed in all world financial markets in mid-March 2020, financial instability peaked in the period from March 18 to March 25, 2020. In other words, the contagion effect of the COVID -19 pandemic reached its highest level during this period. However, as the global economy and financial

markets entered a recovery process, a positive bubble formed in the platinum and silver indices in late July 2020 and early August.



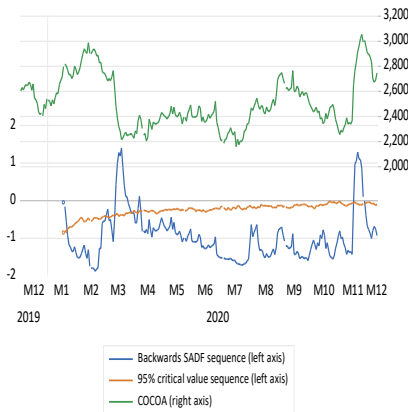
Palladium

Platinum

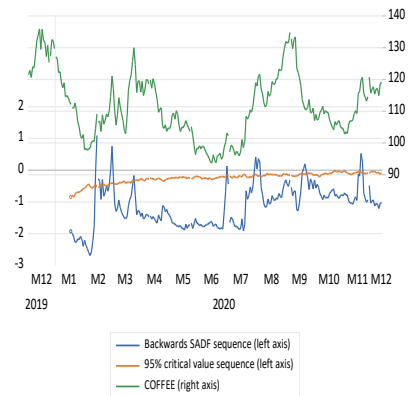
Silver

Figure 2: The GSADF Test Results for Metal Sector

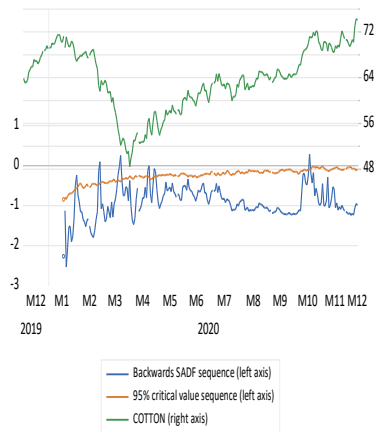
Finally, the bubble formed in the agricultural sector indices after the Covid-19 pandemic negatively affected all world markets. Therefore, the period between mid-February and early April was determined as the period when financial contagion peaked in the futures markets of the agricultural sector. On the other hand, a positive bubble formed in the cocoa indices in late November. Similarly, a positive bubble formed in the coffee futures market indices in late September and in late November and early August. A positive bubble formed in the cotton indices at the end of October. Finally, there was a positive bubble in sugar prices in early May. It can be said that the reasons for these positive bubbles in these markets are due to the recovery process of the financial markets as well as problems arising from speculation and information asymmetry.



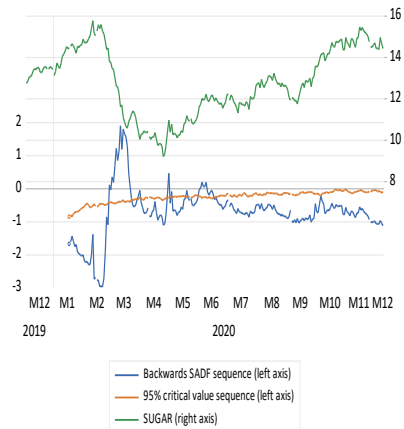
Cocoa



Coffee



Cotton



Sugar

5. CONCLUDING REMARKS

The liberalization of financial systems and the globalization of capital markets have encouraged the emergence of cycles in financial markets. Unusual price movements in financial markets as a result of these cycles made it important to develop new methods for understanding this market. In this study, the objective was to investigate the presence and duration of bubbles in 14 futures market indices with the highest trading volumes during the Covid-19 pandemic. In this way, the contagious influences of the Covid-19 pandemic on financial markets

should be determined. The second objective of the study is to provide information to financial professionals considering investing in these markets and to researchers studying these markets. The study used daily data for the period December 1, 2019 and December 11, 2020 to determine the impact of Covid-19 on futures markets using the GSADF test.

According to the results, GSADF test statistics for selected 7 future market indices were found to be statistically significant. This result shows empirical evidence that the COVID-19 has contagion effects on financial markets and causes bubble formation for 7 futures market indices. Therefore, the results have revealed important insights into the development and spread of the contagion of the COVID-19 in financial markets. In other words, financial contagion and instability caused bubble formation. However, it was found that the metals sector was the sector with the highest financial contagion during the Covid-19 in the period under consideration, while the futures market indices of the energy sector were the market with the lowest financial contagion.

Thus, the interdependence between international markets shows that the Covid-19 increases the risk of destabilizing the futures market. The main reason for this is the uncertain and speculative environment created by the Covid-19 pandemic. However, the results of the study imply that the response of the sectors traded in the futures market during Covid-19 to external shocks was different. Considering the negative impact of Covid-19, future policies in the futures markets and other financial markets should be to avoid the formation of bubbles. Moreover, it is of great importance that financial markets aim for a stable, sustainable recovery process by learning lessons from Covid-19. Future studies will rely on the analysis to examine whether the Covid-19 epidemic caused bubble formation in other financial markets.

6. CONFLICT OF INTEREST STATEMENT

There is no conflict of interest between the authors. (Single Author)

7. AUTHOR CONTRIBUTIONS

ED: The idea;

ED: Design;

ED: Collection and / or processing of resources;

ED: Empirical Analysis and / or interpretation;

ED: Literature search;

ED: Writer.

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9. ETHICS COMMITTEE STATEMENT AND INTELLECTUAL PROPERTY COPYRIGHTS

Ethics committee principles were complied with in the study and necessary permissions were obtained in accordance with the intellectual property and copyright principles.

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