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Testing bubbles formation at real-time commodity prices

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Price bubbles, which play an important role in financial crises, can be observed in various assets. Regardless of the type of asset or assets, the resulting price bubble can distort the balance in financial markets. In this case, it may turn into an economic crisis that potential leap into the real sector and the financial sector. Therefore, it is an important step to test in which assets the price bubbles occur and how long they are exposed to price bubbles. Previous experience indicates that the price bubbles that may occur in commodities that are important especially for the global companies producing and the households consuming the goods subject to production is an important process for the economy. In this study, 16 different real-time commodity prices that are indexed in US Dollars and which contain metal, plant, meat and energy groups, are used to examine the existence of the price bubble in selected commodities. For commodity prices, 2015–2019 daily closing prices were used and sup augmented Dickey–Fuller test was applied. Consequently, the result of the findings affirms the existence of a price bubble for beef cattle and timber, while the price bubble for the other 14 commodities could not be ascertained. This shows that in the majority of real-time commodities, price movements are driven by core values and are in line with the efficient market hypothesis.

JEL CLASSIFICATION
C22; G12; G17; R31

1 | INTRODUCTION

Price bubbles are the major cause of possible financial crises. When the resulting price bubbles explode, they carry over to the real and financial sectors, thus leading to associated financial or economic crisis. Therefore, the existence of empirical studies on price bubbles is important in terms of measures to be taken against the crises that may occur in financial markets. When the crises in the financial markets are analyzed, statistical evidence implies that the price bubble caused by the sharp rise in tulip bulb prices in 1937 is responsible for the crisis experienced at the period. Likewise, Missisipi bubble which caused the biggest financial crisis in 18th century 46 Europe has caused the financial system in France to collapse. The effect of the crisis also led to the formulization of the popular good marketing method. The present occurrences support the evidence that the global crisis that occurred in 2008 is due to the explosion of the bubble and the bubble in housing prices.

Among the financial crises caused by the mentioned price balloons, the most recent 2008 is the Global Crisis. With the increase in the abundance of liquidity before the 2008 Financial Crisis, there was an increase in the supply of housing loans and the loan conditions improved. When FED's interest policy changes are added to this situation, there was an increase in demand. The rising demand has not been reflected in housing prices late, and housing prices have risen dramatically (Yıldız, 2011, p. 63). The main reason of the crisis is the excessive financial values and the formation of a bubble. With the swelling balloon replaced by a deflated balloon, the rapid and sharp decreases in prices and the negative air blowing in the financial sector are the leading causes of the crisis.

Even though price bubbles are the main cause of the financial crisis that has occurred since the tulip crisis, it is still not seen as an important factor by individual investors. Prices formed in the market are priced according to the basic needs that are purchased and sold. However, when speculative purchases and sales come into play, the prices in the market gradually become swollen, which may lead to the formation of a price bubble. The buyer makes the purchase decision with the thought that the price will rise, and the seller makes the sales

decision with the thought that the price will fall. Buyers and sellers who make forecasts for the future cannot make exact estimates. This is because the prices of the goods and services in question may fall or rise, thus indicating high volatility in the prices of these good and services (Akdag, İskenderoglu, & Alola, 2020; Alola, 2020; Alola, Cop, & Alola, 2019). Buyers, hoping that prices will rise continuously, can buy more than they need to make a profit, and when they make enough profit, they can sell again. At this point, there is a perception in the market with the increase in sales and everyone tries to dispose of the goods they have bought with the thought that the prices will fall. In this way, the resulting bubble during the purchase process explodes and turns into a financial crisis. While describing price bubbles as unexplained price movements, Brunnermeier (2008) and Garber (2000) argued that prices exceed the basic value and that the reason is that they are expected to sell at higher prices in the future. In the literature, empirical studies on price bubbles that may occur in various investment instruments have been demonstrated. Housing prices, crypto moneys and the price bubbles evaluated in terms of the securities market and the stock market are among the common research topics in the literature.

In the study of Ceylan, Ekinci, Tüzün, and Kahyaoğlu (2018), they tested bubble formations on Bitcoin and Ethereum. Findings obtained as a result of the applied GSADF test have reached many price bubble formations for both cryptocurrencies. Çağlı and Mandacı (2017) tested the existence of balloons in Borsa Istanbul by applying the GSADF test. Findings indicate that there are speculative balloons for all sectors except financial sector index. In the study of Akkaya (2018), the existence of balloons formed in the stock exchange Istanbul return index was tested. Findings show that there were many balloon formations in 2002–2017 period.

There are many methods used in studies on price bubbles. These methods are variance tests, stationarity tests, unit root and cointegration tests and sup augmented Dickey–Fuller (SADF) and generalized sup augmented Dickey–Fuller (GSADF) tests. For instance, LeRoy and Porter (1981) and Shiller (1981) studies, variance tests for price bubbles, in the Diba and Grossman (1988) and Hamilton and Whiteman (1985) studies, stationarity tests were recommended, while in Campbell and Shiller (1987) unit root and cointegration studies were recommended. Tests are recommended (Fabozzi, Kynigakis, Panopoulou, & Tunaru, 2019, p. 2) Phillips, Shi, and Yu's (2015) study, which became widespread, SADF and GSADF tests are widely used in the literature for the detection of price bubble. In the present study, the existence of price bubbles for 16 different commodities included in real-time commodity prices, which is thought to contribute to the literature, was tested. Daily price movements were analyzed using SADF test.

By using the applied econometric models, many studies have provided evaluation on the price bubbles of commodity prices. Until now, far-reaching studies such as Diba and Grossman (1988), Khalifa, Miao, and Ramchander (2011), Liu and Tang (2010) and Shi and Arora (2012) have provided information on the subject of price bubbles. Other similar studies such as Akdağ and Koçbulut (2019), Areal, Balcombe, and Rapsomanikis (2016) and Pan (2018) are important and current literature on the subject. The common denominator of these studies is the evaluation of price bubbles in terms of precious metals. Even though they focus on different commodities, the aim is to test the existence of price bubbles that can occur in precious metals. However, the study of Diba and Grossman (1988) could not reach a conclusion on the price bubbles of gold prices, while other studies shows evidence of the effectiveness of price bubbles on precious metals.

As a result of the aforementioned studies and findings for the existence of one price bubble for beef cattle and timber, the price bubble for other 14 commodities are not significant. This situation shows that in the vast majority of real-time commodities, price formations move within the framework of core values which in line with the efficient markets hypothesis. Meanwhile, the remaining part of the current study is arranged as follows: the next section, Section 2 presents the literature review of previous studies. The data description and the adopted methodology are illustrated in Section 3 while the findings and discussion of the results are the content of Section 4. Lastly, the study is summarized in Section 5 and as well incorporating the policy direction for the study.

2 | LITERATURE REVIEW

In this section, different studies investigating the existence of bubbles for commodity prices are and the existence of price bubbles for the housing market, securities market and stocks and crypto coins, which are the most frequently encountered in the literature, are also included in different titles.

2.1 | The real estate market

Case and Shiller (2003) tested the existence of housing prices for the 1985–2002 period for 41 states of the United States by using a survey method. As a result of the findings, the housing price bubble was reached in most of the states. In the study of Kranz and Hon (2006), the existence of a price bubble for the period 1996–2000 belonging for 50 different settlements of Spain was tested. From the investigation, the result of the findings implies that the statistical evidence of price bubbles in Spain was affirmed. In the study of Escobari and Jafarinejad (2016), real estate investment trust data for the period 1980–2013 was used for the United States in general by applying the GSADF test method. As a result of the findings, significant evidence of price bubbles in the said index was presented.

Shi (2017) tested the existence of a price bubble in the housing market for the entire United States and 21 states. In the study, while data period of 1978–2015 were used, comet root tests and vector autoregressive model were applied. From the result of the findings, there is a statistical evidence of a bubble in the USA and in the middle of the 2000s in the mid-2000s. The study also found a significant evidence of a price bubble in the regional sense in the late 1980s. Afşar and Doğan (2018) carried the study that shows the presence of housing price bubble for Turkey by using the SADF and GSADF test

TABLE 1 Commodity subgroups and period range

Plant group	Price period	Metal group	Price period
Coffee	March 2, 2015–January 10, 2019	Gold	March 2, 2015–January 10, 2019
Cocoa	March 2, 2015–January 10, 2019	Copper	March 4, 2015–January 10, 2019
Candy	March 2, 2015–January 10, 2019	Palladium	March 2, 2015–January 10, 2019
Timber	March 2, 2015–January 10, 2019	Platinum	February 26, 2015–January 10, 2019
Cotton	March 2, 2015–January 10, 2019		
Orange juice	March 2, 2015–January 10, 2019		
Meat group	**Price period**	**Energy group**	**Price period**
Beef cattle	March 4, 2015–January 10, 2019	Crude oil	March 2, 2015–January 10, 2019
Live cattle	March 4, 2015–January 10, 2019	Natural gas	March 2, 2015–January 10, 2019
Lean pork	March 4, 2015–January 10, 2019	Heating fuel	March 2, 2015–January 10, 2019

method. Similarly, the study also found that there is a bubble in housing prices for the period of 2010–2017 in Turkey.

Also, Fabozzi and Xiao (2018) employed the Dickey–Fuller test method to examine the existence of the United States house prices for the period 1991–2015. As a result of the findings, the existence of the bubble in housing prices was reached before the 2008 mortgage crisis. In the Hu and Oxley (2018) study, the GSADF test method was used to test the presence of the housing price bubble in Japan. The findings obtained in the study indicate that there was a price bubble for the estimated data of 1970–1999. Similarly, Iskenderoglu and Akdag (2019) examined the housing price bubble over the period 2010–2018 period some of the cities in Turkey: Ankara, Izmir and Istanbul. The study applied the SADF and GSADF estimation methods and found a significant evidence of price bubbles for Istanbul and an inconclusive evidence of price bubble for cities such as Izmir. Additionally, the study found that bubble was formed in the housing prices for Ankara especially through the SADF test method but not in the application of the GSADF test method.

2.2 | The securities and stocks market

In the study of Altay (2008), the existence of price bubbles for Borsa İstanbul was tested for the period 1998–2006. As a result of the linear and nonlinear unit root tests applied, the existence of price bubbles in the subindices was detected. In Yanık and Aytürk (2011) study, the presence of Turkey's market share for the period 2002–2010 was tested for price bubble. The findings obtained as a result of time dependence test were not found in the BIST100 index.

In Bozoklu and Zeren's (2013) study, the existence of price bubbles in the securities market was tested by using the cointegration tests. The findings indicate that there is no rational bubble in the stock markets for the period 1998–2013. But, the study of Rotermann and Wilfling (2014) found that there is effect of the bubbles formed by the Bayesian Monte Carlo method on stock prices. The findings indicate that there was an increase in stock price volatility after the bubbles were formed, and the price volatility was the highest as a result of the bursting of the bubbles.

Also, the study of Nartea, Cheema, and Szulczyk (2018), the existence of price bubbles for the Indonesian and Singapore stock exchanges was tested. As a result of the explosion tests applied to the closing prices of 1970–2013 period, the existence of price bubbles in the stock exchange index of both countries was detected.

2.3 | The crypto coins market

Cheung, Roca, and Su (2015) tested the existence of a price bubble for crypto coins. From the result of the GSADF test obtained for the experimented period of 2010–2014, there are three large price bubbles for crypto currencies. In the study of Kristoufek (2015), the existence of a Bitcoin price bubble was tested with wavelet consistency analysis. The findings show that there are bubbles in Bitcoin prices for 2011–2014 period.

In the Bartos (2015) study, it was tested whether or not a bubble exists in Bitcoin prices. As a result of the results obtained from the least squares regression analysis found the existence of Bubble in Bitcoin prices. Similarly, the Landgraf (2016) study, the existence of price bubbles in the NIKKEI 225 stock market index and Bitcoin prices was tested. The results obtained from the GSADF test were the presence of bubbles for both variables.

2.4 | Bubble of commodity price

One of the first studies on the existence of price bubbles for gold which is considered as a safe investment instrument for investors is Diba and Grossman (1988). The study applied frequency analysis and found the presence of bubbles in gold prices. In a similar study, Liu and Tang (2010) examined the presence of price bubbles and found the evidence of price bubbles in the precious metals. Khalifa et al. (2011) also found the existence of price bubbles in precious metals such as gold, copper and silver was tested by applying the GARCH model. In a similar study, Shi and Arora (2012) found the presence of price bubbles in commodity prices.

TABLE 2 SADF test results

	Critical values			
Variables	**1%**	**2%**	**3%**	**Test statistics**
Gold	2.469418	1.655317	1.208355	−1.212237
Copper	2.016531	1.427016	1.138593	−0.160274
Beef cattle	**2.341096**	**1.461637**	**1.075116**	**2.085026***
Live cattle	0.117903	2.499898	1.947550	0.117903
Natural gas	2.511652	1.199286	0.902417	−0.161496
Crude oil	2.511669	1.344818	0.976247	0.227266
Coffee	2.240628	1.466231	1.090743	−0.729316
Cocoa	2.240628	1.466231	1.090743	0.364728
Heating fuel	2.240628	1.466231	1.090743	0.590424
Timber	**2.240628**	**1.466231**	**1.090743**	**2.064990***
Palladium	2.240628	1.466231	1.090743	0.390416
Cotton	2.240628	1.466231	1.090743	−0.143794
Platinum	2.240628	1.466231	1.090743	−0.105072
Orange juice	2.240628	1.466231	1.090743	0.761347
Candy	2.652192	1.540257	1.177148	0.892128
Lean pork	2.240628	1.466231	1.090743	−0.414228

Note: *1, Critical values were determined as initial widow size 0.10 (111) from 100 replica Monte Carlo simulations.
Abbreviation: SADF, sup augmented Dickey–Fuller. The *indicates the statistical significant at 1% especially for the bold commodities

Lucey and O'Connor (2013) examined the existence of price bubbles in gold prices in a similar fashion and found a significant evidence of price bubbles. Diba and Grossman (1988) used the ADF test applied and found that there is a presence of price bubble in the gold prices. In the study of De Meo (2013), the existence of bubble that could occur in commodity prices was tested. As a result of the findings, the presence of price bubble was established. In the study of Gutierrez (2013) which is a similar to the previous ones, it was found that the bubbles in wheat, corn and coarse rice prices were deflated.

However, 12 agricultural products showed a price boom which is similar to the study of Etienne, Irwin, and Garcia (2013) for the soybean market. In the study of Ahmed, Rosser, and Uppal (2014), price bubble formations were tested for commodities that belong to the metal group. The findings obtained as a result of the applied regime switching and BDS are in the direction of the price bubble for the tested metals. Figuerola-Ferretti, Gilbert, and McCrorie (2015) have reached the price bubble for Copper, Zinc, Tin, Lead, Nickel and the absence of a price bubble for aluminum by applying GSADF test.

In a recent study, Areal et al. (2016) found the existence of a price bubble for a total of 28 items of commodity included in the agricultural commodity over the estimated period of 1980–2012. The findings are that there are bubbles in six different commodity prices. In Pan (2018) study, bubble formations in gold and silver prices were tested. Hence, the study found that bubbles existed from the result of the SADF and GSADF tests applied. In the study of Akdağ and Koçbulut (2019); gold, silver, platinum and palladium were found to exhibit price bubbles. Moreover, the findings obtained by using GSADF test implied that there is price bubble in precious metals.

3 | DATA AND METHODOLOGY

In this study, real-time commodity price movements form www.investing.com were used and analyzed in E-views program. Commodities indexed by the US Dollar, Metal, Plant, Meat and Energy groups were used and the starting and ending dates may vary for the daily closing prices used. Commodity items and prices related to these commodity groups are listed in Table 1.

The plant, meat, metal and energy groups in the real-time commodity group were subjected to the SADF test known as the right-tailed unit root test and developed by Phillips, Wu, and Yu (2011) presence tested. The analysis was implemented through the E-views program by including the RTADF extension.

Regression Equation (1) is used to reach the unit root calculations of the SADF test applied to test the existence of price bubbles (İskenderoğlu & Akdağ, 2019, p. 1089, quoted from El Montasser, Gupta, Martins, & Wanke, 2015):

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

Since SADF test is used for the equivalence of ADF test, the Equation (2) used in ADF test is shown below.

$$ADF_{r_1 r_2} = \lambda_{r_1 r_2} / se(\lambda_{r_1 r_2}) \quad (2)$$

It can be stated that the following equation should be used to reach SADF test application (Phillips et al., 2015, pp. 1048–1049):

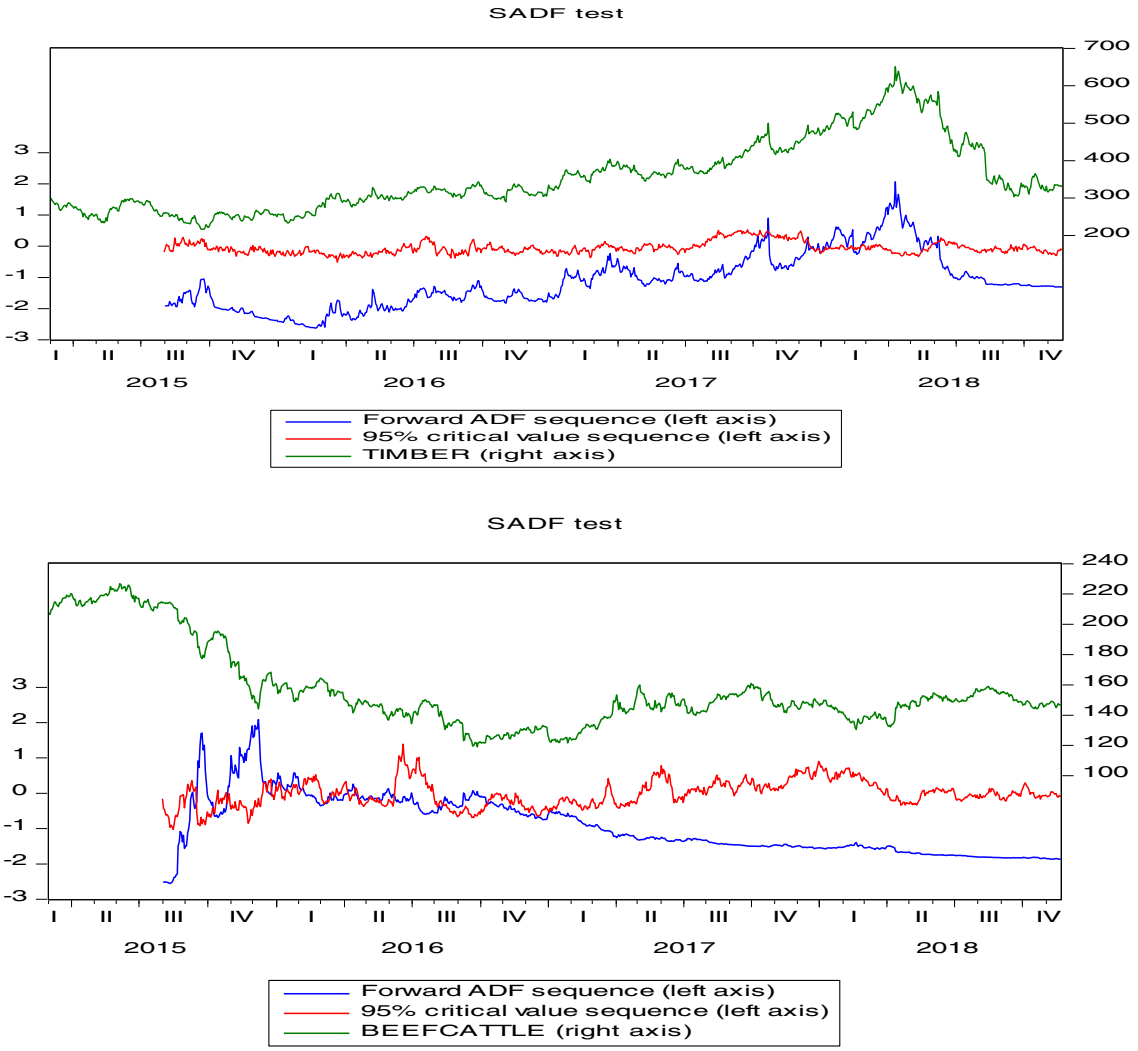

FIGURE 1 Timber and beef cattle prices SADF test result graph. SADF, sup augmented Dickey–Fuller

$$\mathrm{SADF}_{r_2} r(0) = sup_{r_1 \in [0, r_2 - r_0]} \mathrm{ADF}_{r_1}^{r_2} \quad (3)$$

In the SADF unit root test to be applied, the prices of the data included in the application shall be tested for whether a bubble exists and Equations (1)–(3) shall be utilized.

4 | FINDINGS

The results of the SADF test for 16 different commodities indexed to the US Dollar, which are included in real-time commodity prices, are shown in Table 2 and each commodity is evaluated for 1, 5 and 10% statistical significance level.

In Table 2, the existence of price bubbles that may occur in the daily closing prices of the 16 different commodities in real-time commodities over the tested period of 2015–2019 by using the SADF unit root test methods. The findings showed that no price bubble could be found in the prices of the commodities in the energy and metal group, while the price bubble was found in the timber in the plant group and in the beef cattle in the meat group. The starting and ending points for the price bubble in timber and beef cattle are shown in graph 1 below (Figure 1).

Chart 1 shows that in the third quarter of 2017, the price bubble formed in the timber prices, while the bubble formed in the second quarter of 2018 is about to end. When the beef cattle prices are analyzed, it is observed that the price bubble started in the fourth quarter of 2015 and ended in the last quarter of 2016.

A price bubble could not be reached for 14 different commodities such as gold, copper, live cattle, natural gas, crude oil, coffee, cocoa, heating fuel, palladium, cotton, platinum, orange juice, sugar and lean pork. The relevant SADF test graphs are given in Appendix as Figure A1. Findings show that most of the 16 different commodities do not have a price bubble. Thus, contrary to the studies such as Areal et al. (2016), De Meo (2013), Etienne et al. (2013), Gutierrez (2013), Liu and Tang (2010) and Shi and Arora (2012), the current study found that the price bubbles were not intense. In this case, it shows that commodity prices are priced in line with the effective markets hypothesis.

5 | CONCLUSION

The major economic crises such as the Mississippi bubble, the Great Depression, the Japanese Real Estate Bubble, the 2001 Crisis and the 2008 Crisis, which have been the major crises caused by price bubbles to date, have affected both developing and developed countries, thus responsible for serious damage to the global and related economies. Price bubbles that may occur as a result of speculative transactions explode as a result of sudden decreases, thus causing economic crises.

In this study, the existence of price bubbles for 16 different commodities indexed to the whole world was tested. Commodities such as gold, copper, live cattle, natural gas, crude oil, coffee, cocoa, heating oil, palladium, cotton, platinum, orange juice, sugar, lean pork, timber and beef cattle, both in terms of production in the real sector and consumption of households in terms of importance were examined. While gold, natural gas, coffee, heating oil, sugar and beef cattle are important for household consumption, 16 different commodities, particularly crude oil, are closely related to global companies that produce in the same way and provide great support to the economy in terms of development. Therefore, since the evidence of potential price bubbles in these commodity items and the determination of these bubbles are an important process for global markets, SADF test was applied to the daily closing price movements of over the period of 2015–2019. As a result of the findings, the study found existence of a price bubble for beef cattle and timber, while the price bubble for the other 14 commodities could not be reached. This shows that the majority of real-time commodities, price movements are driven by core values and are in line with the hypothesis of efficient markets.

5.1 | Policy implication and future study direction

In this case, investors should not be perceived that prices will rise forever and should not make large purchases because the price bubbles may occur with time. Otherwise, it will be unlikely that they will suffer great losses since it will be inevitable to be adversely affected by sharp declines in prices.

In the future, new studies that will test the presence of bubbles in commodity prices may contribute greatly to the literature. Such study could be conducted by using commodity indices or British Pound indexed real-time commodity data rather than using closing data of real-time commodity prices indexed to the US dollar.

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CONFLICT OF INTEREST

The authors declare no conflicts of interest.

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APPENDIX A.

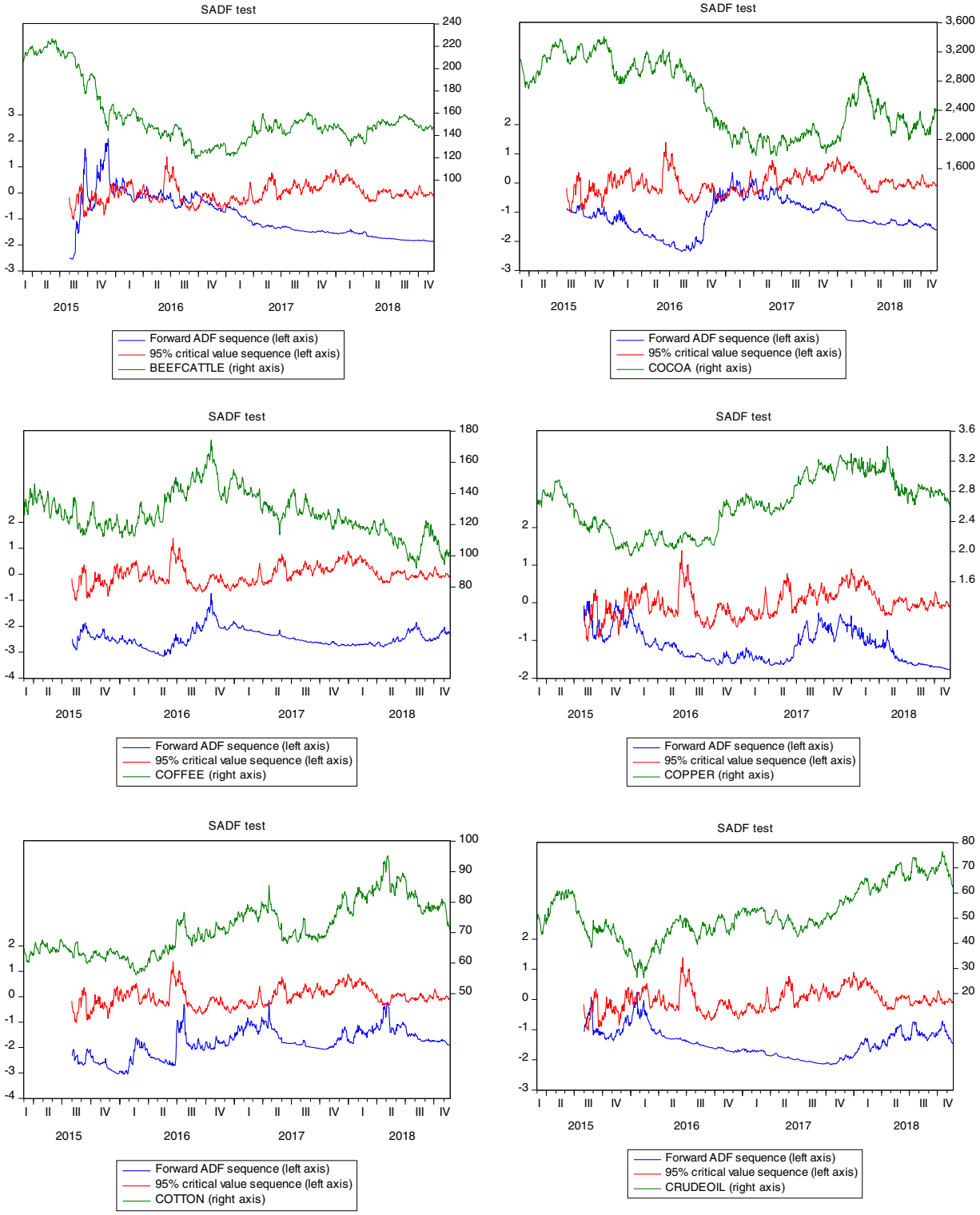

FIGURE A1 Commodity prices SADF test result chart. SADF, sup augmented Dickey–Fuller

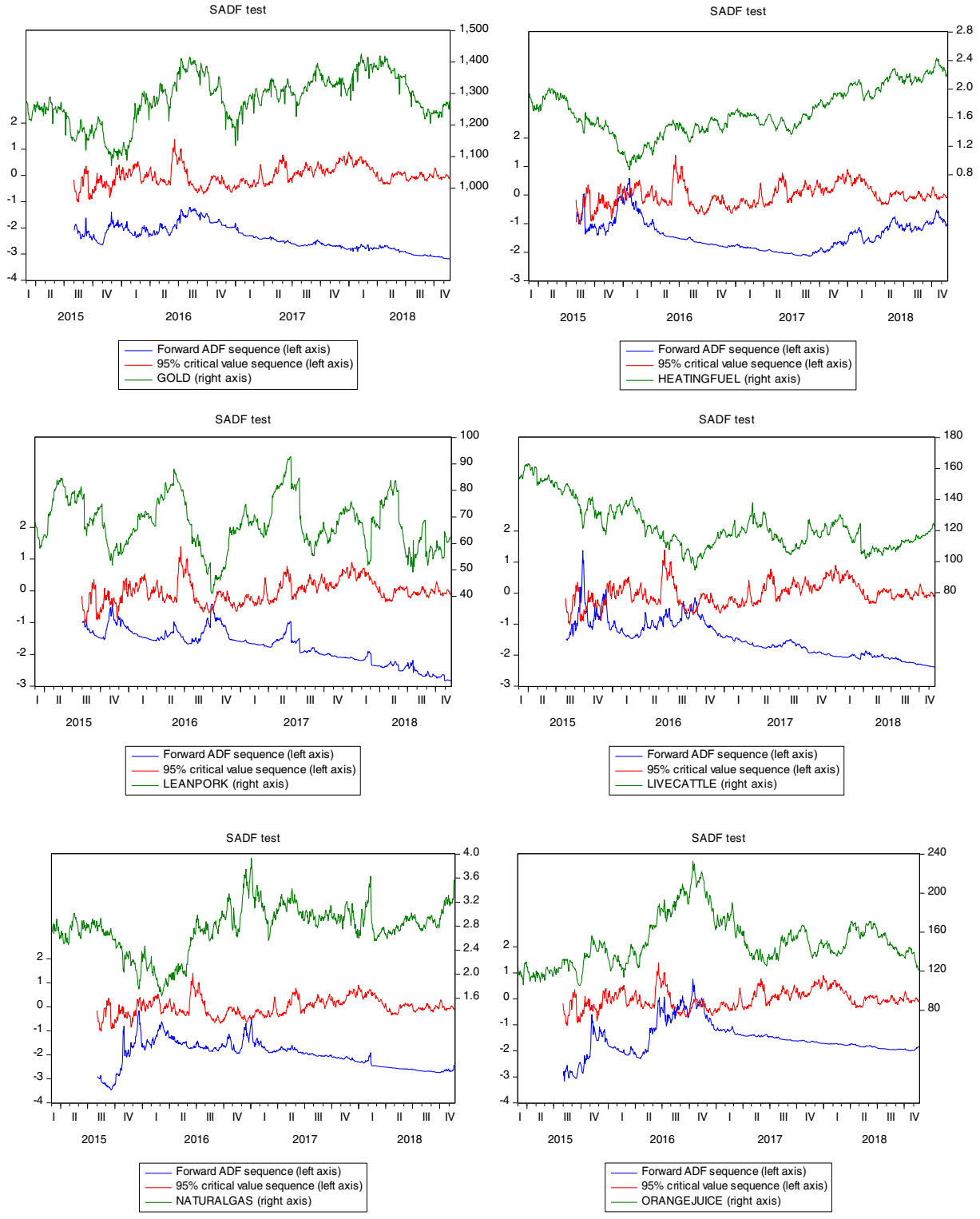

FIGURE A1 (Continued)

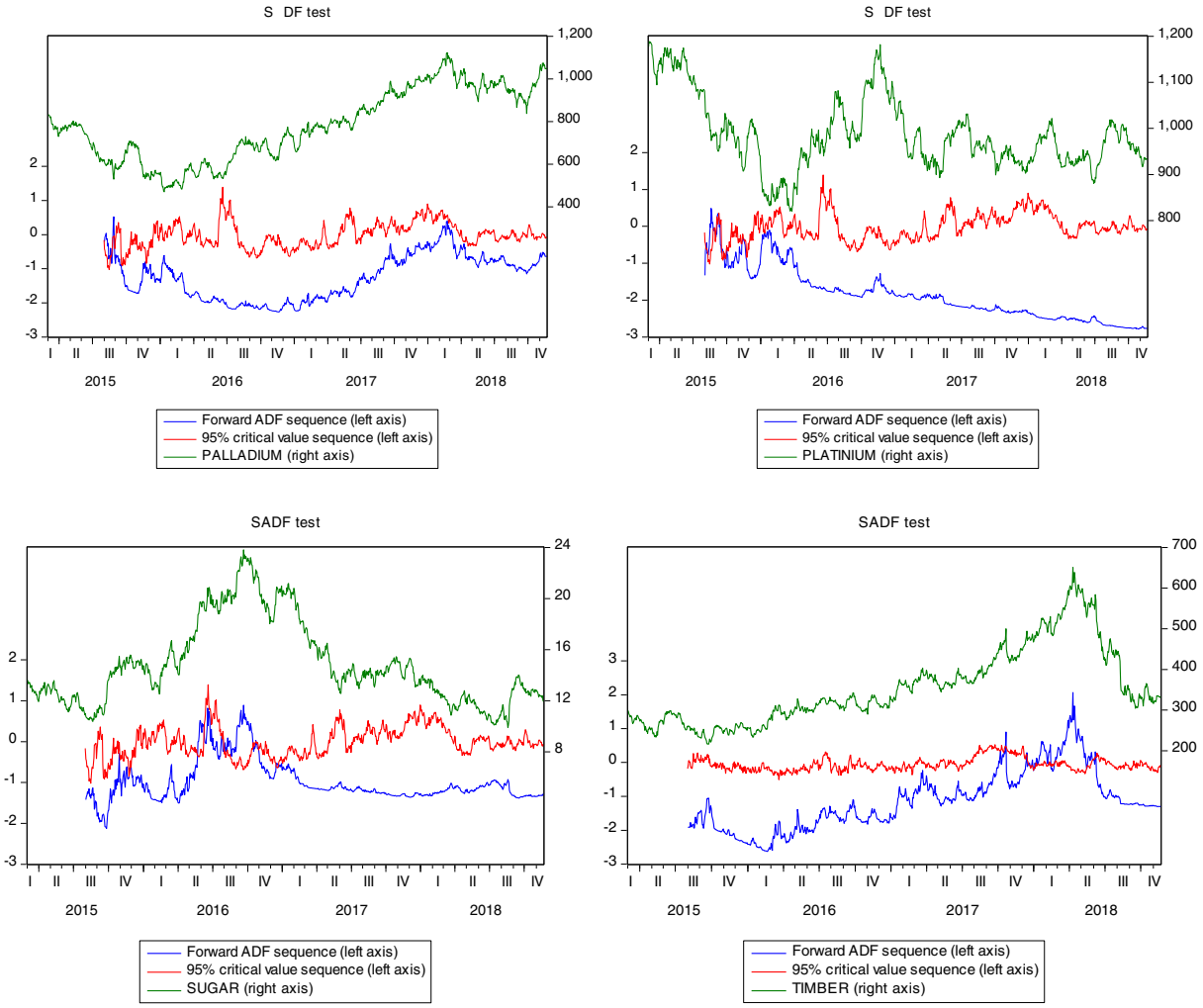

FIGURE A1 (Continued)