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Research Article

Testing and Analyzing the Price Bubbles in Turkish EDAM

Türk Gün Öncesi Elektrik Piyasasında Fiyat Balonu Testi ve Analizi

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Abstract

Asset prices exhibit tremendous boost and bust periods, that are often not justified by economic fundamentals. The explosive behavior in asset price series may imply bubbles. Bubbles create erratic price spike periods. These periods of high price volatility are possible to observe in day-ahead electricity markets (EDAMs). The extreme price fluctuations in electricity prices can be considered as deviations from the fundamental values or bubbles. High electricity prices can significantly affect the consumer behavior to make consumers opt for other energy sources that are cheaper. They also have an important impact on key macroeconomic variables such as consumer price index and economic growth. In this paper, we test and analyze the existence of price bubbles in Turkish EDAM by applying the right-tailed ADF unit root tests: RADF, SADF, and GSADF tests, using monthly supply-adjusted prices between December 2011 and April 2021. Empirical results reveal two bubble periods in 2015 and 2018.

Keywords: *Rational Bubbles, bubbles in electricity prices, Right-tailed ADF tests, RADF test, SADF test, GSADF test.*

JEL Classification*: F2; J6; H5*

Öz

Varlık fiyatları ekonomik temeller tarafından gerekçelendirilemeyen muazzam yükseliş ve düşüş dönemleri sergileyebilmektedir. Varlık fiyat serisindeki bu patlayıcı davranışlar, balon oluşumuna işaret etmektedir. Balonlar, istikrarsız fiyat artış dönemleri yaratır. Fiyatlardaki bu yüksek oynaklık dönemlerini gün öncesi elektrik piyasalarında da gözlemlemek mümkündür. Elektrik fiyatlarındaki aşırılıklar da, piyasa fiyatını belirleyen temel değerlerden sapmalar olan balonlar olarak değerlendirilebilir. Yüksek elektrik fiyatlarının gözlemlenmesi, tüketicilerin daha ucuz olan diğer enerji kaynaklarını tercih etmelerini sağlayarak tüketici davranışını etkileyebilmektedir. Yüksek elektrik fiyatları, tüketici fiyat endeksi ve ekonomik büyüme gibi temel makroekonomik değişkenler üzerinde de önemli bir etkiye sahiptir. Bu çalışmada, Türk gün öncesi elektrik piyasasında rasyonel balonların varlığı sağ kuyruklu ADF birim kök testleri: RADF, SADF ve GSADF testleri ile araştırılıp analiz edilmiştir. 2011 Aralık ile 2021 Nisan dönemi için arza gore düzeltilmiş aylık elektrik fiyatları kullanılmıştır. Ampirik bulgulara göre, kullandığımız verilerde 2015 ve 2018 yıllarında olmak üzere iki balon tespit edilmiştir.

Anahtar Kelimeler*: Rasyonel balonlar, elektrik fiyatlarındaki balonlar, Sağ kuyruklu ADF testleri, RADF testi, SADF testi, GSADF testi.*

JEL Sınıflandırma*: F2; J6; H5*

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1. Introduction and Background

Asset price bubbles are important for financial markets since assets are supposed to be priced at their fundamental (intrinsic) values. Sometimes asset prices fluctuate and experience run-ups and rapid declines, resulting in severe deviations from their fundamentals, which are called bubbles. When a typical rational bubble is observed, we see run-ups in the price with explosive behavior (Brunnermeier and Oehmke, 2012). These deviations from fundamentals are significant and might last for a prolonged period (Evanoff, 2012). Throughout history, price boosts in asset prices which could not be explained by fundamentals (bubbles) have given investors tremendous opportunities to increase their wealth. However, sometimes these extreme price increases in form of bubbles might have come with a cost to investors. Subsequent crashes in asset prices after bubble formations might also lead to extreme losses in wealth.

In a typical bubble, rapid price boosts in asset prices generally attract investors. They purchase the asset with the expectation of selling at a higher price, sometimes resulting in a phenomenon called market exuberance or irrational exuberance which might burst and lead to market panic. The price bubbles often lead to misallocations in the economy by distorting the investment decisions in the society (Brunnermeier and Oehmke, 2012).[7]

Price bubbles or deviations from fundamentals are possible to observe in energy markets. Liu and Lee (2018) interpret the bubble behavior in energy prices as evidence for failure of the efficient market hypothesis in the form that Fama (1970) specifies. In their study, they show that oil, gas, and coal market prices systemically deviate from fundamental values and fluctuate beyond "normal", verifying the fact that prices fail to reflect market information efficiently. When energy prices experience surges, it can distort consumer behavior affecting the national income.

Electricity market is different from other energy markets because it is not possible to store electrical energy and it must be consumed immediately. Electricity is an important resource for numerous activities in the society and its demand has been growing. The erratic behavior of electricity prices if exists can significantly affect consumer behavior, consumer efficiency-management techniques: making them look for other energy sources that are cheaper and less cost-volatile (Gupta and Inglesi-Lotz, 2016). The changes in electricity prices are also reflected in production costs, influencing the economic activities and the household cost of living.[8]

Mount (2001) refers to price volatility in electric power markets as being an undesirable feature because customers and new generators considering entry into the industry would find less price volatility beneficial compared to more volatility. Erratic price behavior benefits the existing generators, making life harder for the new entrants. The degree of competitiveness in the market is crucial when reduced competition can lead to higher prices for consumers and lower output. Detecting the existence of electricity price bubbles is important for developing countries where it could benefit the consumers if the government switches to renewable energy sources for electricity production and try to reduce electricity prices.[9]

In this paper, we aim to investigate the evidence of possible bubbles and to date-stamp the price bubble periods in Turkey, a developing country with a recently liberalized day-ahead electricity market (EDAM). We perform the sup augmented Dickey-Fuller (SADF test) proposed by Phillips et al. (2011) and generalized sup augmented Dickey-Fuller (GSADF test) proposed by Phillips et al. (2015) to data. These techniques have been applied in many markets like stocks, commodity markets, and even crypto currency markets. These techniques can be used as a real-time detection mechanism for mildly explosive behavior in prices. Section 2 presents a review of the literature. Section 3 details out the methodology and data while giving out an overview of the Turkish EDAM. Section 4 presents empirical findings with

[7] See Gürkaynak (2008) to review a list of bubbles in the literature.
[8] See Akkemik (2011) and the references therein.
[9] Gürel and Irmak (2017) have a detailed report of renewable energy and energy forming strategies in Turkey.

a discussion. Section 5 concludes and discusses the limitations of the analysis by proposing suggestions for possible future research.

2. Literature Review

In this section we start by a brief literature on the right-tailed ADF tests then we discuss their usage in energy markets.

The standard left-tailed ADF unit root testing strategy has been applied in an early study by Diba and Grossman (1988) to stock prices. Diba and Grossman (1988) explore the rational bubble phenomenon by investigating the co-integration between stock prices and dividends using the monthly S&P's Composite Stock Price Index between 1871 and 1986. Their results indicate no bubble. Evans (1991) criticizes the standard unit root tests and co-integration tests for having low power while detecting bubbles. Phillips et al. (2011) follow the idea of Diba and Grossman (1988) to propose a recursive right-tailed augmented Dickey-Fuller unit root test called the sup augmented Dickey-Fuller test (SADF test) to improve on the Diba and Grossman (1988) procedure. They show that SADF successfully distinguishes between periodically collapsing bubbles and a pure unit root process. SADF test is commonly used in testing and date stamping explosive behavior in prices. Phillips et al. (2011) apply their test to monthly NASDAQ real price and dividend data between 1973 and 2005 and detect a single bubble between 1995 and 2000.

Although the SADF test can successfully detect one bubble in data, its discriminatory power diminishes when there are periodically collapsing multiple bubbles. Phillips et al. (2015) propose a generalized version of the SADF (GSADF) test for detection of multiple bubbles. Phillips et al. (2015) apply their strategy to monthly S&P 500 stock market data from 1871 to 2010 and identify the multiple exuberance and collapse periods.

Bubble formation in energy price data is an important phenomenon explored many times on various markets. Bohl et al. (2013), for example, apply the SADF test to test the existence of multiple bubbles in German renewal energy stocks using the inflation-adjusted daily and weekly, and monthly price index data over the years 2004 and 2011 and compare the results with Markov regime-switching ADF test. They conclude that while SADF detects short bubbles, the Markov regime-switching ADF test detects prolonged speculative bubbles in German renewable energy stocks. Montasser et al. (2015) study the existence of bubbles in ethanol prices using the ethanol-gasoline price ratio in Brazil. Considering gasoline is a substitute for ethanol, and hence, its impact on ethanol prices, they apply ADF, SADF and GSADF tests on the monthly ethanol prices relative to gasoline over the years 2000 and 2012. They detect multiple bubbles in the ethanol prices. Herrera and Tourinho (2019) apply the SADF and GSADF tests to test the existence of bubbles using weekly WTI crude oil spot price and Brent crude oil spot price data deflated by the consumer price index between January 12, 1990, and March 29, 2019. They obtain evidence of multiple bubbles on both series and GSADF test detects more explosive behavior than the SADF test does. Cretía and Joëtsb (2017) investigate the existence of bubbles in carbon prices in the European Union Emission Trading Scheme. They perform SADF and GSADF tests using the monthly contract price data over the years 2005 to 2014. They complement the test with a wild bootstrap procedure to control for the heteroscedasticity of carbon price data detecting multiple bubbles in carbon price data. Li et al. (2020) analyze three regional key natural gas markets US, European and Asian, and perform a GSADF test using monthly data from January 1996 to June 2017. Their results show two price bubbles in Europe, six in Asia, and five in the US data.

The right-tailed unit root tests have been used in applications for Turkey many times for finding bubbles in housing prices and stock prices.[10] Focusing on the energy market prices, the study of Ganioğlu (2017) applies the GSADF test to Turkish data, investigating the rational bubbles in the processed food and energy prices in Turkey and analyzing the explosive deviations of the price series from core inflation levels. Study uses monthly data between January 2003 and March 2017. Her analysis detects three bubbles and suggests that the bubble formations can be monitored by designing policies to anchor inflation expectations.

[10] Please refer to Iskenderoglu and Akdag (2020) for housing prices and Citak (2019) for stock prices and the references therein.

Empirical applications of SADF and GSADF tests specifically on electricity markets are limited. One study that focuses on bubble formation in electricity markets is by Gupta and Inglesi-Lotz (2016). They test for multiple bubbles and date-stamp bubble periods in South African electricity prices. They perform bubble tests using the supply-adjusted (taking supply levels as the fundamental levels for electricity prices) nominal annual price data in natural logarithm form between 1965 and 2013. The tests indicate two bubble periods. The first bubble originates in 1971 and collapses in 1998, main cause of which is mentioned to be due to the existence of a monopolistic unregulated market. The second bubble originates in 2008 and collapses in 2009, which is attributed to a major supply crisis in the country.

We undertake the same approach of Gupta and Inglesi-Lotz (2016) and apply SADF and GSADF tests to investigate explosive behavior in day-ahead electricity prices in Turkey. In our study, we make use of a higher frequency for our data than theirs to lengthen the sample size for the technical analysis, since unit root testing procedures have better power with longer span data (Afriyie et al., 2020). Also due to conveniency of estimation and date-stamping purposes, considering monthly data is preferred as the procedures require a vast number of simulations.

We do not take price indices to reflect the market fundamentals/ intrinsic value/ real value unlike many studies in literature because price indices themselves have components that might include bubble periods especially for a developing country like Turkey (Ganioğlu, 2017).[11] As will be mentioned in the text in Section 3.1, problems might arise with the type of unit root tests we employ when the dividend series/ market fundamentals contain bubble components themselves.

Here, we follow Gupta and Inglesi-Lotz (2016) and supply-adjust our nominal electricity price series and take supply series as the market fundamentals. In their study that analyzes the bubbles in official cash prices and 3-month futures prices of six major non-ferrous metals of the London Metal Exchange, Figuerola-Ferretti et al. (2015) also use the consumption-supply (CSR) ratio as an analogy to the dividends in asset markets to take care of the market fundamentals.

3. Methodology

3.1 Right-tailed ADF Tests

SADF test divides the whole sample into subsets and applies a right-tailed ADF test repeatedly over the subsets of the entire sample. However, the subsample size is increased by one observation at each subtest. A supremum value of test statistics of unit root tests is computed and compared to the critical values calculated using Monte Carlo simulations. GSADF improves the SADF test in several dimensions. It provides much more extensive subsamples and flexible window widths in the double recursive regressions, leading to cover more subsamples and provide greater window flexibility compared to SADF. It uses a recursive backward regression technique to detect a real-time date-stamping (finding the start and end dates of bubbles in data).

Phillips et al. (2011) start with the following asset price model:

$$P_t = \sum_{i=0}^{\infty} \left(\frac{1}{1+r_f}\right)^i E_t(D_{t+i} + U_{t+i}) + B_t \qquad (1)$$

P_t is the after-dividend (present value) price of asset, D_t is the dividend series, r_f is the risk-free interest rate, U_t unobservable fundamentals, B_t is the bubble component. First part reflects the fundamentals or intrinsic value whereas the second part, B_t is the bubble component in the price of an asset. The explosive behavior in asset prices is not due to fundamentals but the bubble component of asset pricing. So, $P_t - B_t$ is determined by market fundamentals and explosive behavior is determined by B_t that satisfies the following property:

$$E_t(B_{t+1}) = (1 + r_f)B_t \qquad (2)$$

If there is no bubble ($B_t = 0$), then the non-stationarity of price is controlled by D_t and U_t series and the price will be utmost I(1). If there is a bubble in price series i.e., $B_t \neq 0$, then asset price will show explosive

[11] See also Ayan and Eken (2021). They show that there is a high correlation between the housing price index (which has been shown many times to contain bubbles) and CPI in Turkey.

behavior. If the *fundamental component is non-explosive*, the explosive behavior arises through the presence of bubbles in prices.

Right-tailed ADF tests detect the bubbles in a time series such as y_t by applying ADF unit root test with an explosive alternative hypothesis rather than the usual stationarity alternative. The idea is that y_t series is composed of two components:

$$y_t = F_t + B_t \qquad (3)$$

In Equation (3), F_t is the fundamental value and B_t is the bubble component in the data. Right-tailed ADF tests aim to detect whether B_t component is zero or not, and to date stamp the bubble periods if there is any.

Following ADF regression model can be generated for y_t series after taking care of the fundamental component:

$$\Delta y_t = \alpha_{r1.r2} + \beta_{r1,r2} y_{t-1} + \sum_{i=1}^{k} \psi_{r1,r2}^{i} \Delta y_{t-i} + \mathcal{E}_t \qquad (4)$$

where y_t is the series of interest, α is the intercept, k is the maximum number of lags, ψs are the coefficients for the differenced terms and ε_t is the error term. Tests calculate the ADF statistics recursively and regression samples involve rolling windows. Regression starts with r_1^{th} fraction of the total sample size and ends with r_2^{th} fraction. Unlike regular left-tailed unit root tests where the null hypothesis (H_0: $\beta_{r1,r2}$=0) is tested against the alternative (H_1: $\beta_{r1,r2}$<0), the bubble (explosive behavior) in the right-tailed ADF test is tested with the following hypothesis,

H_o: $\beta_{r1,r2} = 0$ (unit root)

H_1: $\beta_{r1,r2} > 0$ bubble (explosive behavior)

This type of hypothesis test tries to distinguish between a random walk model and an explosive regime.

As can be seen in Figures 1 and 2, the regressions are repeated in forward recursive manner over the sample sequence incremented by one observation each time and r_w is the window size, $r_2 = r_1 + r_w$. The window size r_w runs from r_0 to 1. The initial window size is set to be $r_0 = 0.01 + 1.8/\sqrt{T}$.

There are three versions of the test. The very first version is the rolling window ADF test (RADF test). RADF calculates ADF statistics repeatedly over a rolling window of *fixed* size $r_w = r_0$ for all subsamples as shown in Figure 1. Each regression run produces an ADF statistics called ADF_{r1}^{r2}. RADF statistic is the supremum ADF_{r1}^{r2} statistics among all possible subsets.

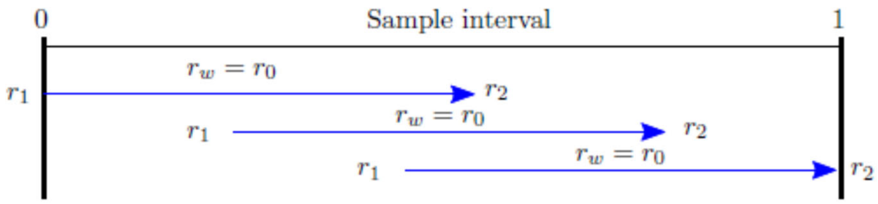

Figure 1. window widths and sample sizes in RADF test. Source: Itamar (2017: Figure 2).

The second version of the test is called the sup augmented Dickey-Fuller (SADF) test. In this test, the regressions start at a fixed point, $r_1 = 0$, however, window sizes increase at each run as shown in Figure 2 (a). Each regression computes an ADF statistics for all subsamples called ADF_0^{r2}. Then SADF statistics is obtained by getting the supremum value of all the ADF statistics among all possible subsamples based on the forward recursive regression and defined as,

$$SADF\ (r_0) = supADF_0^{r2} \qquad (5)$$

In Equation (5), $r_2 \epsilon [r_0, 1]$. If the SADF statistic is greater than the critical values, the SADF test detects bubbles (explosive behavior) in the data.

GSADF test runs the SADF test in a forward recursive manner by changing the starting point of the SADF test. Instead of taking r_1 as 0, it searches for the highest ADF test statistics over all possible starting points and window lengths as shown in Figure 2 (b). The smallest window size is given by $r_0 = 0.01 + 1.8/\sqrt{T}$. GSADF test statistics is taken as the largest ADF statistic over all possible ranges.

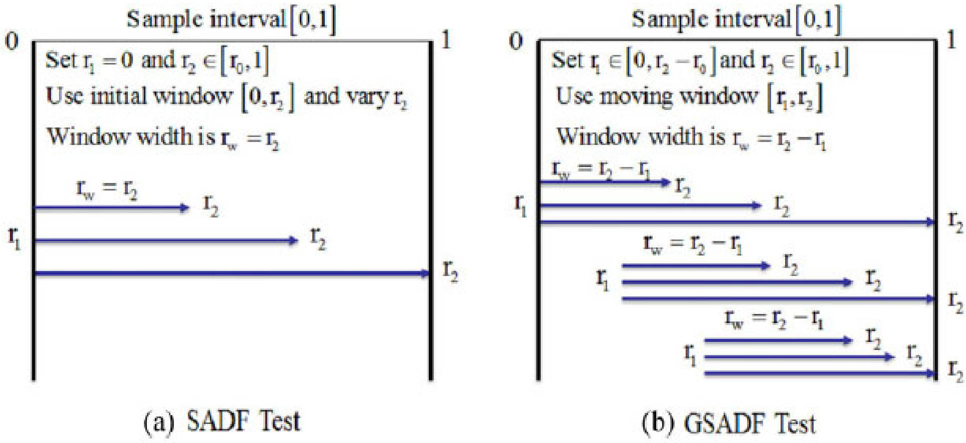

Figure 2. Window widths and sample sizes in SADF and GSADF test. Source: Phillips et al. (2015: Figure 1).

GSADF statistic is given as,

$$GSADF\ (r_0) = supADF_{r_1}^{r_2} \qquad (6)$$

$$r_2 \epsilon [r_0, 1]$$

$$r_1 \epsilon [0, r_2 - r_0]$$

The null hypothesis assumes no bubbles in the data. If the test statistics are greater than the critical values which are computed using Monte Carlo simulations, then these tests suggest that there is at least one bubble in the series. To detect the origination and termination date of a bubble, Phillips et al. (2015) propose a backward sup ADF (BSADF) test. In the tests, the direction of the test reverses. The origination and termination date of a bubble can be determined based on the BSADF statistic.[12]

3.2 Market and Data

Turkish Electricity Market has gone through numerous structural transformations in the 2000s. Electricity Market Law No. 4628 (after modified to be Law No. 6446) aimed to transform the electricity market from a single buyer-single seller model into a more liberal, market-based, competitive model with competitive values. On 1 July 2006, a 3-periods-monthly financial settlement system initiated this process. On 1 December 2009, the current day-ahead market system has been established. In this system, day-ahead market transactions are performed daily on an hourly basis. Prices and volumes for clearing of day-ahead market are determined for each hour. Supply and demand orders are effectively cleared. The demand and consumption for electricity are balanced based on price levels. This new market structure provides the demand side of the settlements with the opportunity of adjusting its consumption based on price levels. These market-clearing prices in spot markets are taken as a reference in other trading platforms such as the forward market. Turkish day-ahead electricity market, the intra-day market, and settlements are operated by EPİAŞ (Energy Exchange Istanbul). Recently, 50.01% of electricity consumption in Turkey is traded in the day-ahead market and volume on this day-ahead electricity market is 149.39 TWh.[13]

The hourly market clearing price data (P) are obtained from EPİAŞ website (https:\\www.seffaflik.epias.com.tr). Data span the period from December 2011 to April 2021. The

[12] See Phillips et al. (2015) on the details of the BSADF statistic.
[13] The reader is referred to the EPİAŞ (https:\\www.epias.com.tr) website for details.

prices are given in TL per MWH (mega Watt hour). Hourly data is converted into monthly frequency. The hourly total injection quantity of electricity series (S) data are obtained from EPİAŞ website (https:\\www.seffaflik.epias.com.tr) and also span the period between December 2011 and April 2021. The total supply of electricity is computed as a summation from all types of electricity generation stations: natural gas, dammed hydro, lignite river, import coal, wind, fuel oil, geothermal, asphaltite coal, black coal, biomass, naphtha, lng.

Since explosive behavior may stem from price deviations from fundamentals, the day-ahead electricity price series is divided by supply series as an analogy to dividends (fundamental values) in stock prices. We use the log of this supply-adjusted price ratio (PSR) to test the existence of mildly explosive behavior in data.

$$\log(PSR) = \log\left(\frac{P}{S}\right) \qquad (7)$$

The data series includes 113 observations. Visual representation of data is given in Figure 4.

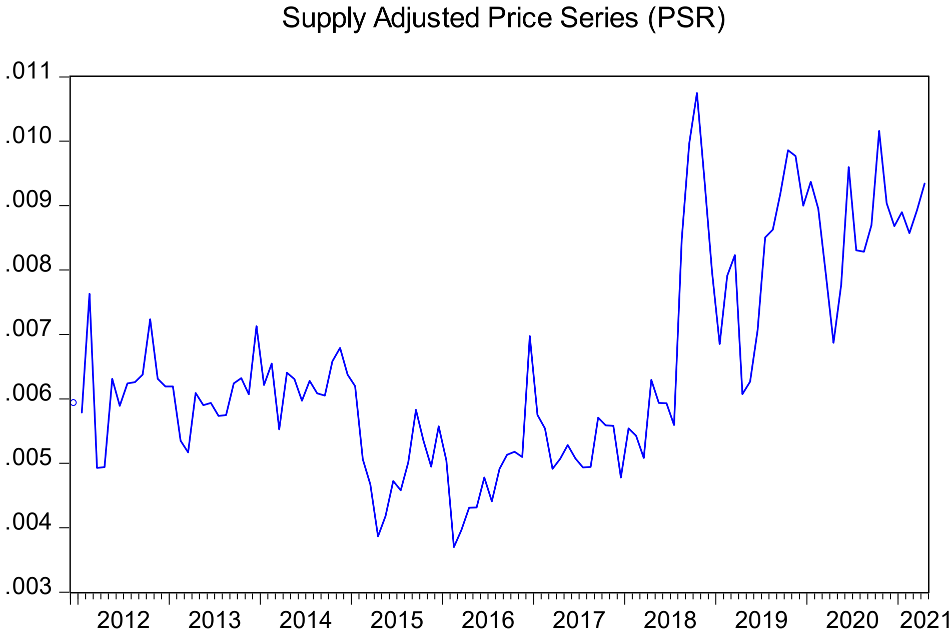

Figure 4. Supply-adjusted Turkish Electricity Prices. Source: https://seffaflik.epias.com.tr.

4. Empirical Results and Discussions

We apply three forms of the right-tailed tests (RADF, SADF and GSADF). The critical values are obtained using Monte Carlo simulations with 1,000 replications. The smallest window size is taken as 20, based on the rule given in Phillips et al. (2015), $r_0 = 0.01 + 1.8/\sqrt{T}$. The maximum lag length, k is chosen to be 6 to avoid size distortions as recommended by the authors. Table 1 provides the results of the right-tailed ADF tests.

Table 1. Results of the right-tailed ADF tests.

Test	**t-Statistic**	**Prob.**	**Test critical values**		
			99% level	95% level	90% level
RADF	1.416***	0.103	0.751	0.0469	-0.329
SADF	-0.545	0.767	2.056	1.400	0.999
GADF	2.285***	0.027	2.759	2.059	1.71

Note: Null hypothesis is that the logarithm of supply adjusted price series has a unit root against the alternative of an explosive behavior. The sample spans from 2011:M1 to 2021:M4, resulting in 113 observations. Critical values are found through Monte Carlo simulations (run with EViews) with 1,000 replications. Window size is 20. Lag length or k = 6. (*) Significant at 10%; (**) Significant at 5%; (***) Significant at 1% level.

The results of the maximum rolling window ADF test (RADF Test) are given in Table 1. Results reveal that test statistic is calculated to be 1.416 and it is greater than the 99% critical value. Thus, at the 1% significance level, we reject the null hypothesis in favor of the alternative. So, the results of RADF test reveal the existence of speculative bubbles in day-ahead electricity prices during the sample period.

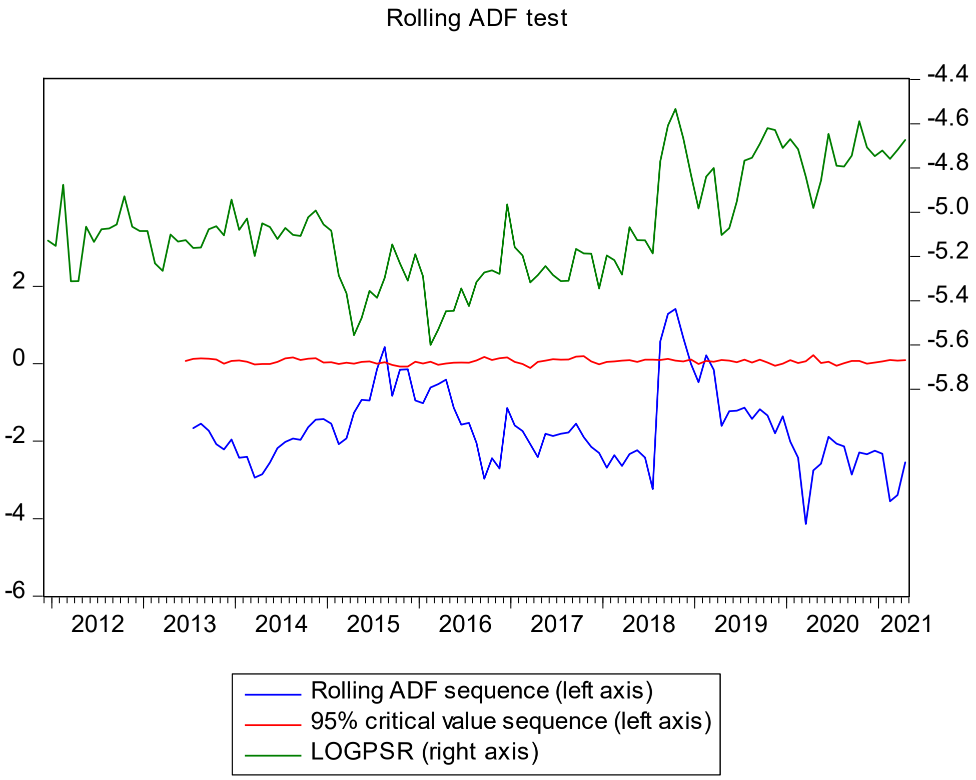

Figure 5. The plot of date stamping bubble periods in the supply-adjusted day-ahead electricity prices using the RADF test.

A visual representation of RADF test results is provided in Figure 5. The graph includes the PSR series in log form (in green), the sequence of the supremum ADF_{r1}^{r2} statistics (in blue) and the corresponding 95% critical values sequence (in red). Test statistics sequence obviously exceeds the 95% critical values between 2018:M8-2018:M12, revealing the origination and end dates of the bubble. Also, in around August and September of 2015, RADF test detects another short-lived bubble.

The results of the SADF test in Table 1 show us that the SADF test statistics has been found to be -0.545 and it's less than the 90% critical value. Thus, we cannot reject the null hypothesis of no explosive behavior. So, the results of the SADF test did not detect any existence of rational bubbles in day-ahead electricity prices during the sample period. This result is confirmed by the graph in Fig. 6. The simulated critical values are always greater than the forward ADF sequence.

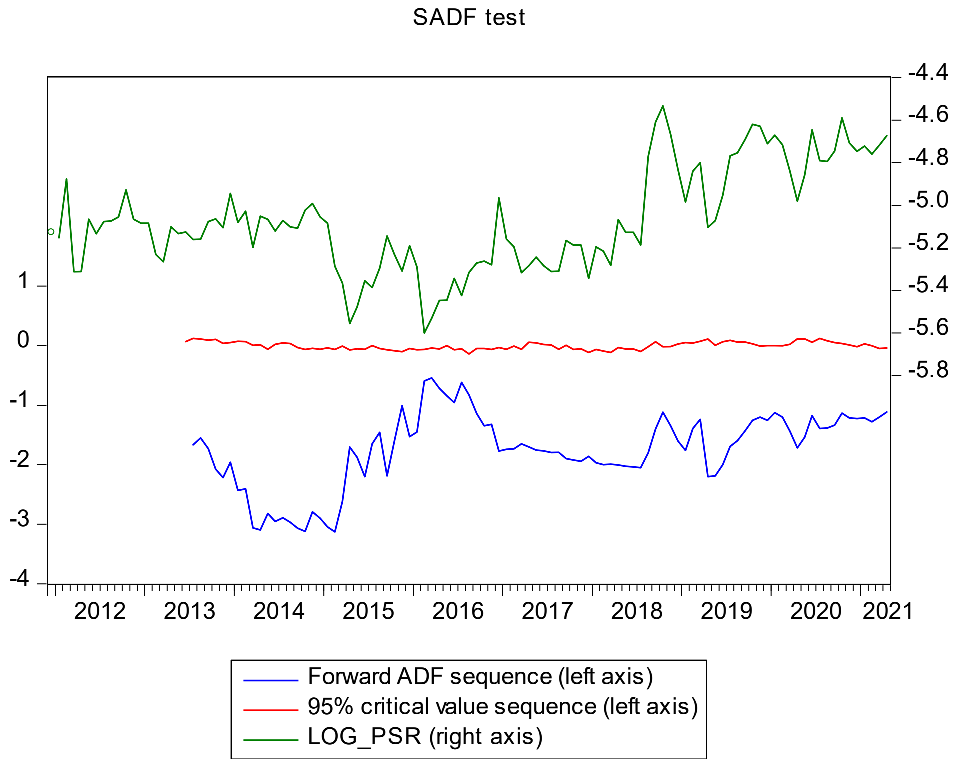

Figure 6. The plot of date stamping bubble periods in the supply-adjusted day-ahead electricity prices using the SADF test.

The results of the GSADF test are given in Table 1 as well. GSADF test statistic is calculated to be 2.285 and it is over the 99% critical value. Thus, at the 1% significance level, we reject the null hypothesis of no explosiveness. So, the results of GSADF test reveal the existence of speculative bubbles in day-ahead electricity prices during our sample period.

A visual representation of GSADF test results is provided in Figure 7. The graph includes the PSR series in log form (in green), the sequence of backward GSADF statistics (in blue) and the corresponding 95% critical values sequence (in red). A visual inspection of this graph demonstrates that there is evidence of one speculative bubble in day-ahead electricity prices: 2018:M8-2018:M12. At the start of the bubble period, test statistic exceeds the critical value, rejecting the null hypothesis of no explosiveness. Once the bubble collapses, test statistic falls below the critical value.

As a summary, out of RADF, SADF and GSDAF tests, RADF and GSADF tests both detect explosive behavior in Turkish EDAM for the period between August 2018 and December 2018. RADF test detects another one in August and September of 2015. The explosive price periods indicate the significant deviations of price series from the fundamental values.

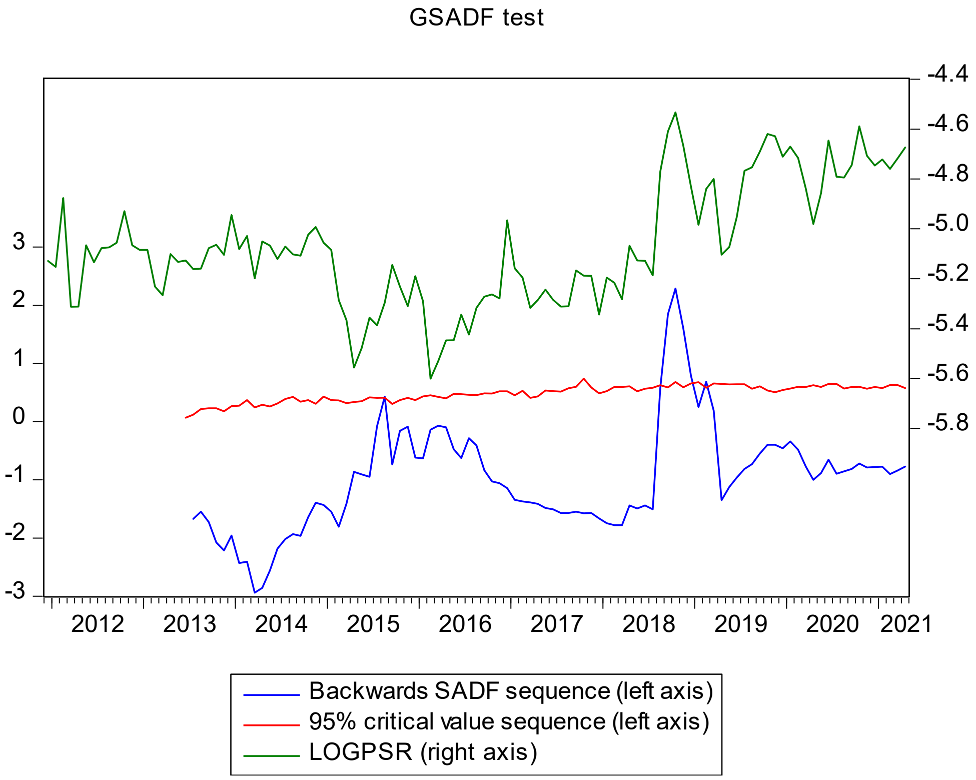

Figure 7. The plot of date stamping bubble periods in the supply adjusted day-ahead electricity prices using the GSADF test.

There are possible explanations of the occurrence of these bubbles in the Turkish EDAM for the year 2018, that are based on the USD/TRY exchange rate. Turkish electricity prices are heavily influenced by imported natural gas prices and imported coal prices. The electricity in Turkey is generated mainly through natural gas-LNG power stations and coal power stations: shares are 30.88% and 21.31% respectively (EPİAŞ, 2018).14 Turkey imports natural gas from different countries mainly from Russia and Iran.15 Hence, the electricity market is heavily influenced by the USD/TRY exchange rate. Furthermore, to diversify the energy generation resources, the Turkish government has provided price guarantee-subsidies to wind, solar, and other renewable energy power generating plants which contribute to the electricity supply. These government price guarantees have been provided in terms of the USD during the period of our analysis. The guaranteed prices that are applied to the facilities within the scope of the Renewable Energy Resources Support Mechanism (YEKDEM) are determined by the Renewable Energy Resources (YEK) Law No. 5346 (Turkish Official Gazette, 2011). These prices are 7.3 USD cents/kWh for hydroelectric and wind power generation facilities, 10.5 USD cent/kWh for geothermal power generation facilities, and 13.3 USD cent/kWh for biomass and solar power generation facilities. All these factors increase the sensitivity of electricity prices to exchange rate volatility. In fact, the bubble period starts following the rapid depreciation periods of Turkish Lira against the US dollar in 2018 as can be seen in the Figure 8.[16] As natural gas prices also fluctuate and contain surge periods, the heavy dependence on imported natural gas & coal of electricity generation in Turkey creates high sensitivity to the USD/TRY exchange rate, that might result in bubbles as our study indicates.

[14]The remaining 49.2% share is lignite 14.91%, dams 13.60%, wind 6.6%, hydraulic stream 6.27%, solar 2.49%, geothermal 2.3%, hard coal-asphalt 1.61%, hard biomass 1.07% and fuel oil %0.48. Also, the usage of renewables in energy generation in Turkey have been increasing (IEA, 2021).

[15] Natural gas prices also occur to have bubble periods (Li et al., 2020).

[16] Beginning of August 2018 and in the earlier months, Turkish lira has sharply depreciated against the US dollar. By September and November, it has gradually appreciated. However, the consequences of the depreciation have obviously affected the electricity prices (also see Figure 4).

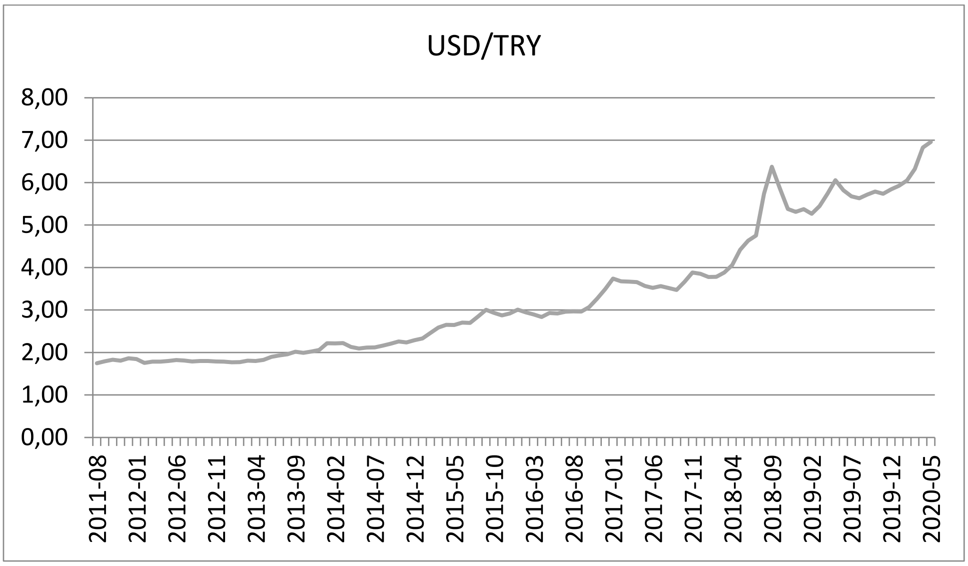

Figure 8. Monthly USD/TRY exchange rates series between August 2011 and May 2020 (Source: www.evds2.tcmb.gov.tr).

In addition to the year 2018, RADF test has detected a bubble in 2015, possibly due to the higher than European average natural gas prices that Russia has been imposing on Turkey (Coşkun, 2015).[17] In mid-2015, Turkish energy company BOTAŞ, has announced that they could take Gazprom into an international arbitration process, while Gazprom has failed to agree on a price discount after becoming involved in a dispute with private companies over gas deliveries to Turkey (Winrow, 2017).[18]

The existence of bubble periods in Turkish EDAM by using supply-adjusted prices also arises the question whether the day-ahead electricity market is liberal or competitive enough. The liberalization of the Turkish electricity market has started with establishment of the regulatory agency, Energy Market Regulatory Authority (EMRA) in 2001. Since then the steps taken by the authorities aimed at creating a liberal and competitive market while setting consumer protection as priority (Akkemik, 2011). The recently formed day-ahead market might not be functioning as competitively to produce price bubbles which are found from prices that are a ratio of the supply quantities. Since the prices realised at EDAM are used as references in other trading platforms such as the forward market, any distortion that might occur in the EDAM might also affect the others in a negative way. Since the Turkish EDAM is a recently developed young market, it might take some time for the market to become deeper, more liberal and competitive. Hence, more steps can be taken to further liberalize the Turkish EDAM.

5. Conclusion

This paper investigates the existence of mildly explosive behavior or bubbles in Turkish EDAM (day-ahead electricity market) prices using monthly data between December 2011 and April 2021. We employ the recently developed right-tailed tests: RADF test, the SADF test proposed by Phillips et al. all (2011) and the GSADF test proposed by Phillips et al. (2015). Two out of three tests (RADF and GSADF) we employ show the existence bubbles in Turkish supply-adjusted electricity prices between August 2018 and December 2018. RADF test also detects a bubble period in 2015.

In recent years, there have been concerns among various stakeholders, policymakers, and researchers on the increasing electricity prices in Turkey. Furthermore, surge periods in electricity prices may drive up the cost of goods and services, resulting in costs to the overall economy. Therefore, investigating the

[17] Turkey has bought around 55% of her natural gas from Russia in 2015 (Ellyatt, 2015).

[18] BOTAŞ is the state-owned crude oil and natural gas pipelines and trading company which dominates the gas imports in Turkey.

possible price bubbles or explosive behavior in electricity market is important for consumers, and policymakers like the Ministry of Energy, Turkish Electricity Transmission Company, and EPİAŞ.

As Gupta and Inglesi-Lotz (2016) mention, bubbles in electricity prices may also indicate uncompetitive market conditions. Since creating a competitive nature for the Turkish EDAM has been the primary goal of the authorities from the beginning, existence of explosive erratic price periods (with supply as the market fundamentals) in the market raises some concern, suggesting further improvements on the liberalization of the Turkish EDAM. Other factors such as input prices are also important possible causes of electricity price bubbles in Turkey.

The share of electricity generation from imported natural gas-LNG power stations and import coal power stations are high: 31% and 21% respectively, in Turkey. This heavy reliance of electricity generation on natural gas and coal imports makes market-clearing prices sensitive to USD/TRY exchange rate volatility. In addition, the Turkish government's dollar price guarantee subsidies for wind, solar, and other renewable energy power plants (based on the law no 5348) intensifies the effect of exchange rate volatility on electricity prices. The data show that the electicity price bubble period has occurred following the rapid and sudden depreciation of Turkish Lira against the US Dollar in August 2018 and lasted until the end of the year. Another bubble has seemed to occur in August and September of 2015, when the Turkish energy company BOTAŞ has had a price dispute with Gazprom about the high import prices of natural gas to Turkey. High input costs are found to have a strong influence to form price bubbles in Turkish EDAM.

In summary, our study finds mildly explosive bubbles for Turkish EDAM using supply-adjusted market prices, suggesting there could be several possible causes. One cause is due to the structure of the day-ahead market: if it is not functioning competitive enough bubbles might occur. Turkish EDAM is a recently formed and relatively young market which aims to create liberal and competitive market conditions. However, this might take time and further steps might be taken by the policymakers on the liberalization and the deepening of the market. Another important cause is the heavy reliance on the imported natural gas and coal as inputs in power generation (creates exchange rate sensitivity) and the newly announced dollar price guarantee subsidies for wind, solar, and other renewable energy power plants. Government policies are needed to mitigate the increasing input cost effects and thus increasing USD/TRY exchange rate effects on the electricity prices.

Another line of research on electricity markets focuses on detecting any strategic behavior in the markets through game theoretical approaches and new simulation models (Hortaçsu et al., 2017; Aliabadi, 2016). Recently the structure of electricity markets have been transforming worlwide, becoming more liberal and competitive to achieve lower prices on average. Strategic behavior might lead to inefficiency and lack of competition may cause high and volatile prices (Mount, 1999). Collusive behavior among power generators in electricity markets might occur since electricity market structures are oligopolistic.[19] One limitation of our study is that: within the context of this data analysis, one can detect and analyze the bubble component in prices but detecting any collusive and/or manipulative behavior in the market is not viable. Finding out more about how these strategic interactions may take place and linking real life price fluctuations with game theoretical studies and simulation experiments could be an interesting next step of this research in understanding the way that electricity markets operate.

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[19] Tacit collusion for example is a strategic behavior in which firms tacitly agree to maintain higher prices.

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Araştırma Makalesi

Testing and Analyzing the Price Bubbles in Turkish EDAM

Türk Gün Öncesi Elektrik Piyasasında Fiyat Balonu Testi ve Analizi

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Genişletilmiş Özet

Giriş

Varlık fiyatları, temel analiz tarafından haklı gösterilmeyen muazzam ani yükseliş ve düşüşler yaşayabilmektedir. Fiyattaki bu patlayıcı davranışlar balon anlamına gelmektedir. Bu balon oluşumları emtia piyasaları da dâhil olmak üzere birçok piyasada görülebilmektedir. 1637 lale balonu, 1720 güney deniz balonu, 2000 yılı Dot Com balonları örnek olarak zikredilebilir. Fiyatlardaki ani ve patlayıcı artışlar, servetlerini hızlıca artırmak isteyen yatırımcıları tarih boyunca cezbetmiştir. Daha yüksek fiyattan satmak niyetiyle oluşan talep, fiyatları daha da yukarı seviyelere yükseltmekte, ancak belli bir seviyeden sonra sürdürülemez noktaya gelen varlık fiyatlarında ani ve sert düşüşler yaşanmaktadır. Balon oluşumunun varlık fiyatlarında aşırı volatiliteye neden olmasının yanında, iktisadi ajanların yatırım kararlarını bozarak tasarrufların optimum dağılmasının da önüne geçmektedir. Tüm bu hususlar, varlık fiyat balonlarının doğası, nedenleri, tespiti ve benzeri yönlerle ekonomik araştırmaların ilgisini çekmiştir.

Yöntem

Bu makalede yakın zamanda Phillips ve diğerleri tarafından geliştirilen sağ kuyruklu öz yinelemeli ADF birim kök testleri RADF, SADF ve GSADF testleri uygulanarak, Türk Gün Öncesi Elektrik Piyasasındaki rasyonel balon oluşumu incelenmiştir (Phillips ve diğerleri, 2011; Phillips ve diğerleri, 2015). Bu testler son zamanlarda oldukça popüler olmuş, hem hisse piyasasında, hem de petrol, kömür, doğal gaz, kriptopara gibi diğer piyasalarda uygulanma alanı bulmuştur.

Bu testler, Diba and Grossman (1988) tarafından geliştirilen sol kuyruklu birim kök test yöntemini takip etmektedir. Ancak, Evans (1991)'ın standart birim kök testleri ile eşbütünleşme testlerinin dönemsel olarak sönen balon oluşumlarını tespit etmede yeterli olmadığı yönündeki eleştirileri üzerine, Phillips ve diğerleri (2011) fiyatlardaki patlayıcılığı tespit etmek üzere sol kuyruklu yerine sağ kuyruklu ve öz yinelemeli ADF birim kök testlerini önermiştir. SADF testi adı verine bu yöntemde, bütün veri alt verilere bölünmekte, her defasında gözlem sayısı bir arttırılarak test öz yinelemeli olarak gerçekleştirilmekte, test istatistiğinin supremum (eküs) değeri, Monte Carlo simülasyonlarıyla elde edilen kritik değeri ile karşılaştırılmaktadır. Philips ve diğerleri (2011) bu testi 1973 ila 2005 dönemindeki aylık reel NASDAQ serisine uygulamış ve 1995 ile 2000 yılı arasındaki balonu başarılı bir şekilde tespit etmiştir.

Tek balon formasyonunda iyi performans gösteren SADF testinin çoklu sönen balon içeren verilerde balon tespit gücü azalmaktadır. Bu sebeple, Phillips ve diğerleri (2015) SADF testinin genelleştirmiş versiyonunu geliştirmişlerdir. GSADF testi adı verilen bu test, hem altörneklemleri hem de pencere aralıklarını değiştirmekte böylece çift yönlü özyineleme sağlamaktadır. Yazarlar, GSADF testini 1871

ila 2010 yılları arasındaki aylık S&P 500 serisine uygulamışlar ve bilinen balon oluşumlarını başarılı bir şekilde tespit etmişlerdir.

Bu testler, son dönemde balon tespiti amacıyla başta hisse piyasaları olmak üzere birçok piyasada oldukça popüler olarak uygulanmaktadır. Enerji fiyatlarında balon tespiti son zamanlarda hız kazanmıştır. Elektrik piyasalarında balon araştırmaları henüz kısıtlı olarak uygulanmaktadır. Bu alanda tarafımızca tespit edilen Gupta ve Inglesi-Lotz (2016) çalışması, Güney Afrika elektrik piyasası için 1965 ila 2013 yılları verisi ile arz (çıktı) ayarlı fiyatlarını kullanarak balon tespiti yapmıştır. GSADF ve SADF testleri ile, bahse konu dönemde 1971-1998 ile 2008-2009 dönemlerini kapsayan iki balon tespiti yapılmıştır. Çalışmamızda, Gupta ve Inglezi-Lotz (2016) yöntemini takip ederek Türkiye elektrik piyasası için daha yüksek frekanslı ve daha geniş bir veri seti kullanarak balon analizi yapmış bulunmaktayız. Elektrik fiyatlarının çıktı ayarlı olması demek her bir takas fiyatının çıktı değerine bölünmesi anlamı taşımaktadır.

Veri Seti

Bu çalışmada, Aralık 2011-Nisan 2020 tarihleri arasındaki arz (çıktı) ayarlı aylık piyasa elektrik takas fiyatları kullanılmıştır. Toplam 113 gözlem bulunmaktadır. EPİAŞ internet sayfasından saatlik olarak elde edilen fiyat (TLM / WH) ve arz (çıktı) serileri, hesaplamaları kolaylaştırmak amacıyla aylık serilere dönüştürülmüştür. Elektrik arz miktarı hesaplanırken, ithal kömür, doğal gaz, hidroelektrik, doğal gaz gibi tüm kaynaklardan elde edilen miktarlar (MWH cinsinden) toplanarak toplam arz miktarı bulumuş, fiyat arz miktarına bölünmüştür. Tüm analizler veriler logaritmik forma dönüştürülerek yapılmıştır. Gupta ve Inglezi-Lotz (2016) makalesinde arz değeri elektrik piyasasının esas (fundamental) değeri olarak ele alınmıştır. Dolayısıyla, tespit edilen balonlar fiyatın esas değerinden sapması olarak da yorumlanacaktır.

Bulgular

Analizler pencere genişliği 20, maksimum gecikme sayısı 6, Monte Carlo simülasyon sayısı 1000 kullanılarak yapılmıştır. RADF testi ve GSADF testi bulguları, Türk Gün Öncesi Elektrik Piyasasında 2018 yılında bir balon oluştuğunu, balonun Ağustos ayında ortaya çıktığını ve Aralık ayında ise söndüğünü göstermektedir.RADF testi de ayrıca 2015 Ağustos-Eylül ayları gibi bir balon tespit etmiştir.Çalışmamızda elektrik fiyatlarının esas değerinden (arz) önemli derecede yukarı yönlü sapmaları olup olmadığı araştırılmıştır.

Sonuç ve Tartışma

Son dönemde elektrik fiyatlarında yükselişler kamuoyunda yaygın olarak tartışılmakta, uzun dönemli fiyat dalgalanmaları mal ve hizmet maliyetlerini arttırmaktadır. Elektrik fiyatlarındaki artışlar tüketici davranışlarını değiştirerek, fiyat endeksi ve ekonomik büyüme değerleri gibi anahtar ekonomik değişkenleri etkilemektedir. Bu sebeple, elektrik piyasasında olan bir balonun tespiti, meydana geliş ve sönüm tarihleri, muhtemel sebepleri, hem tüketiciler hem de politika yapıcılar açısında önemli olabilmektedir.

Fiyatlardaki ani patlamalar tesadüfi olabileceği gibi rekabetçi olmayan bir piyasada tedarikçilerin manipülatif davranışlarını da yansıtabilmektedir. Henüz yeni bir piyasa olan Türk gün öncesi elektrik piyasasının rekabetçi olarak tasarlanan yapısı dikkate alındığında, balon periyotlarının görülüyor olması düşündürücüdür. Ayrıca, fiyatlarda ortaya çıkan balonun önemli sebepleri için girdi fiyatları üzerine yoğunlaşmak da ülkemiz açısından önem taşımaktadır.

2018 yılındaki balonun ortaya çıktığı ve söndüğü dönemlerin, Türk lirasının 2018'deki hızla değer kaybettiği dönemlere denk geldiği görülmektedir. Zira elektrik üretiminde, ithal girdilerin (ithal kömür ile doğal gazın) toplam %52 payı olduğu, ve yenilenebilir güneş, rüzgâr gibi enerji üretimine ABD doları cinsinden alım garantisi teşviği verildiği dikkate alındığında, balon dönemi ile TL'deki değer kaybı anlam kazanmaktadır. Elektrik üretiminin ithal girdilere dayanması ve yinelenebilir enerji alım garantilerinin ABD Dolarına endekslenmesi, elektrik fiyatlarının USD-TL döviz kurlarında yaşanacak dalgalanmalara bağımlılığını arttırmıştır.

RADF testinin 2015 yılındaki saptadığı balon da yine elektrik üretiminde önemli bir kaynak olan doğalgazın Avrupa ortalamasından yüksek ithalat fiyatı ile ilgili BOTAŞ' ın Gazprom' u uluslararası tahkime götürmek üzere anlaşmazlık yaşadığı dönemlere denk gelmektedir.

Bulgulardan da anlaşılacağı üzere Türkiye' de elektrik piyasası Amerikan Doları döviz kuruna bağımlı olarak hareketlenmektedir. Elektrik üretimi girdi fiyatlarının yapısı önem taşımakta; ithal girdiler ve Amerikan Doları bazlı alım garantileri elektrik fiyatlarındaki balon oluşumlarında önemli rol oynamaktadır.

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Etik Kurul İzni: Bu çalışma halka açık arz edilen veriler kullanılarak tamamlanmıştır. Kullanılan veriler herhangi bir etik kurul iznine tabi değildir.