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# Investigation of Interest Rates Applied by Banks in Türkiye to Deposits in Various Maturities by the GSADF Test

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**Abstract**

The decisions taken by banks regarding interest rates have an impact on all actors in the economy, including borrowers, depositors, savings, and consumption expenditures. In this study, we examined asset bubbles in the weighted average interest rates applied by banks in Türkiye for deposits according to various maturities with the "Generalized Supremum Augmented Dickey-Fuller (GSADF)" unit root test. Considering the weekly deposit interest rates for the last 10 years (2014-2024); statistically significant bubbles were found in all 1-month, 3-month, 6-month, and 12-month interest rates at the 0.01 significance level. The background of the relationship between the type of asset and the economic crisis following the bursting of a bubble is relevant to the financing of that asset. We expect that this study will guide banks in updating their reserve amounts by taking into account extraordinary situations in order to avoid liquidity shortages. After investigating the bubble occurrence, we have looked for the important events in Türkiye that coincide with the bubble dates. We have observed bubbles in 1-month, 3-month- 6-month maturities at the same time with the plebiscite in 2017, the presidential and parliamentary elections in 2018 and 2023.

**Keywords**:: GSADF Test, Deposit Interest Rate, Maturity, Bubble Assets, Dates of the Bubbles.

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# Türkiye'de Bankaların Çeşitli Vadelerdeki Mevduata Uyguladığı Faiz Oranlarının GSADF Testi ile İncelenmesi

**Öz**

Bankaların faiz oranlarına ilişkin aldığı kararların; kredi borçluları, mevduat sahipleri, tasarruf ve tüketim harcamalarını kapsayacak şekilde ekonomideki tüm aktörlere etkisi bulunmaktadır. Bu çalışmada, Türkiye'de bankaların mevduatlar için çeşitli vadelere göre uyguladıkları ağırlıklı ortalama faiz oranlarındaki balon varlıkları "Genelleştirilmiş Supremum Augmented Dickey Fuller (GSADF)" birim kök testi ile incelenmiştir. Son 10 yıllık (2014-2024) dönemdeki haftalık mevduat faiz oranları dikkate alınarak; 1 aylık, 3 aylık, 6 aylık ve 12 aylık vadeli faizlerin hepsinde 0.01 anlamlılık düzeyinde istatistiksel olarak anlamlı balonlar bulunmuştur. Bir balonun patlamasını izleyen ekonomik krizin varlık türüyle ilişkisinin arka planında balonun finansmanıyla ilgisi bulunmaktadır. Bu çalışmanın, bankaların likidite sıkışıklığı yaşamamaları açısından olağandışı durumları göz önünde bulundurarak rezerv miktarlarını güncellemelerine yol gösterici olması beklenmektedir. Balon oluşumu araştırıldıktan sonra, balon tarihleriyle eşzamanlı olarak Türkiye'de gerçekleşen önemli olaylara bakılmıştır. 2017 yılındaki halk oylaması ile 2018 ve 2023'te gerçekleşen cumhurbaşkanlığı seçimi ve genel seçimlerle aynı dönemlerde 1, 3 ve 6 ay vadeli mevduat faizlerinde balon varlıkları gözlenmiştir.

**Anahtar Kelimeler**: GSADF Testi, Mevduat Faiz Oranları, Vade, Balon Varlıkları, Balon Tarihleri.

## 1. Introduction

An economic cycle known as a financial bubble is defined by an asset's prices rising quickly to an unsustainable level, at which point the asset either bursts or loses value. We can talk about a price bubble when an asset's (e.g. stocks, bonds, real estate, or commodities) price rapidly rises without underlying fundamentals to justify the price spike (Liberto, 2022).

Financial bubbles' life cycle contains five stages: displacement, boom, euphoria, profit-taking, and burst (Segal, 2023). The cycle starts with the displacement stage, in which investors speculate that the price of an asset will increase. In the beginning its price increases slowly. Then institutional investors come to the market and the boom stage begins. As more buyers enter the market, prices increase amazingly, and the asset attracts media attention. As a result of the perception that this asset will rise forever and the increasing tendency towards the market, the euphoria phase begins. We may consider the euphoria phase, the most important stage of the bubble cycle (Abolafia & Kilduff, 1988). This stage is initialized and maintained by entrepreneurs who market financial instruments that promise high returns. Including investment companies, stock exchanges, and stock portfolios; bankers competing to lend to these ventures and speculators contribute to the euphoria phase. However, at this point, institutional investors realize their profits and begin to exit the market. Burst is inevitable. The cycle is completed with the burst in the form of disappointments, collapses, and bankruptcies.

When investors purchase an asset with the hope of selling it to other investors who have similar expectations at a higher price, this is known as a rational bubble. Purchasing the asset at a premium won't be an issue as long as there is demand for it, as investors hope to profit from the difference between the purchase and selling prices. Since the investors aim to make a profit from the difference between the buying and selling prices, buying the asset at a high price will not cause a problem as soon as there is demand for it. These are rational price formations in the market. However, if the price of an asset is much higher than its fundamental

value, it is possible that not only those who invest in this asset but also other national and even global investors will turn to it. The recent Dot-Com (2000) and US real estate (2008) bubbles are examples of this situation.

Policy changes or advancements in the economy, such as financial liberalization or new economic plans can also cause bubble formation (Yavuz, 2003, p. 15). Besides, the extreme conditions in the market are often caused by the existing or expected uncertainty. However, some investors may remain in the asset market despite extraordinary movements in prices due to their expectations of obtaining high returns. At the same time, an asset that undergoes significant changes in its market value may cause concerns due to the negative tendencies of the consumption expenditure decisions of companies and/or individuals (Harris, 2002, p. 105). This situation may cause incorrect spending tendencies and long-lasting contractions in economic activities.

Interest rates, price, and financial stability in an economy are important short-term monetary policy tools of central banks. It is expected that the interest rates determined by central banks will also affect the banks and they will make decisions accordingly (Li et al., 2021, p. 257). Since all components of the economy interact, decisions about interest rates can affect other financial variables, ranging from investment to consumption expenditures. (Salihoğlu & Hepsağ, 2021, p. 41). When banks make decisions regarding interest rates, they affect the savings and consumption expenditures of borrowers and depositors, and therefore all actors in the economy.

Interest rates constitute important income and expense items of bank balance sheets. Banks try to collect funds from individuals and corporate customers in order to create resources. In this case, although the resulting deposit interest rates are an expense item for the bank, the loan interest rates obtained from loan sales constitute an important income item. Loan interest rates are usually greater than deposit interest rates. Therefore, banks use the funds (deposits) of those who supply (commercial) funds to meet the (credit) needs of those who request funds and make a profit.

In this study, we examined asset bubbles with the GSADF unit root test in the average deposit interest rates for 1, 3, 6 and 12-month terms. In the literature, it is possible to come across various application areas of the relevant test. However, the majority of those studies have been carried out on investment instruments. The motivation of this study was to examine the deposit interest rates according to various maturities and comment on the co-occurrence of bubbles and important events in Türkiye. Undoubtedly, while interest revenue from loans is an important investment of banks, the most important source of funds for them are deposits. Therefore, with the influence of the current economic and political conjuncture, we analyzed bubbles in interest rates for the last 10 years. It has been expected that banks will determine interest rates at a rate parallel to the policy interest rates of the Central Bank. Banks are institutional investors. In this study, we examined the balloon assets of banks in the interest rates they applied because we aimed to contribute to policymakers, investors, and banks in preventing a possible crisis. For example in 2008, the United States economy experienced a crisis stemming from bubbles in the real estate sector. Therefore, the originality of this study is

investigating the bubbles in the average deposit interest rates applied by the banks, which are the leading investors in the market.

## 2. Literature Review

In the literature researchers have used the GSADF test to investigate the bubbles of stock market, asset market (e.g. real estate, currency, cryptocurrency), credit (e.g. consumer or business loans, debt instruments), and commodity (e.g. gold, oil, industrial metals or crops). The most important feature that distinguishes this study from the bubble studies in the literature is that, instead of examining bubble assets in financial investment instruments, it examines bubbles in deposit interest that affect banks' expenses. Banks act as a monetary bridge between institutions, companies, and individuals. So, we have investigated the bubble existence of banks' deposit interest rates.

Bubbles in stock markets have been widely investigated. One study searched for the speculative bubbles in the stock markets in the United States (Mulla et al., 2018). In another paper, speculative bubbles in spot and forward quotations were discussed (Pavlidis et al., 2017). In an article written in April 2000, the focus was on speculative bubbles in the Nasdaq crash (Johansen & Sornette, 2000). In a study focusing on the effects of pandemic on the Dow Jones stock market, they observed a bubble effect on February 26, 2020 (Chang et al., 2021). Liaqat, Nazir, and Ahmad dealt with the existence of bubbles in emerging markets, and Chinese stock prices were investigated using the GSADF method (Liaqat et al., 2019).

There are many examples of commodity bubble analysis in the literature. While one study determined the existence of bubbles in fuel prices in developing economies (Ahmed et al., 2022); in another study, they examined the existence of bubbles in the behavior of oil futures with weekly data. (Khan et al., 2021; Perifanis, 2019). Zhao, Wen, and Li analyzed Chinese data to check bubble occurrence and the correlation between oil and stock prices (Zhao et al., 2021). In another study, Cretí and Joëts investigated the existence of bubbles in the European Union Emission trading program (Creti & Joëts, 2017). In an article conducted to determine bubbles in copper prices, the presence of more than one bubble was found (Su et al., 2020). Another study analyzed Baltic Dry Index data and found bubbles in shipping freight market (Tarkun, 2024).

After the 2008 mortgage crisis, exuberance in the real estate sector is a trending research topic. In a study, Naoui and Bassem applied the sequential ADF test to the US real estate prices in order to examine the existence of speculative bubbles (Naoui & Bassem, 2015). In another research paper examining the bubble effect with data on real estate investment trusts in the US, they applied the GSADF method (Escobari & Jafarinejad, 2016). Hu and Oxley identified the US regional house price bubbles with respect to states (Hu & Oxley, 2018). In recent studies, bubble existance in Australian cities' house prices (Shi et al., 2016), in the Swedish housing market (Asal, 2019), and in house prices in Germany (Chen & Funke, 2013) were examined. In a study conducted on speculative bubbles in housing prices in China, they concluded that the basic findings regarding the existence of bubbles were weak (Liu et al., 2016).

On the other hand, it is possible to access many studies on Bitcoin and altcoins, which are cryptocurrencies. Studies on cryptocurrencies have shown that the bubble effect has been

observed in this market in almost every period (Corbet et al., 2018; De Souza et al., 2017; Demmler & Dominguez, 2022; Kyriazis et al., 2020; Malhotra & Maloo, 2014).

## 3. Methodology and Research Methods

In this study, we applied the Generalized Supremum Augmented Dickey-Fuller (GSADF) unit root test, introduced to the literature and recommended by Phillips, Shi, and Yu (Phillips et al., 2015) to identify multiple bursts or bubbles, to determine the exuberance in the average interest rates applied by banks to certificate of deposits for various maturities in Türkiye. We preferred the GSADF test because if more than one bubbles exist, it can detect all of them.

Philips, Shi, and Yu proposed a recursive test for exuberance, similar to normal ADF unit root testing against stationery (Philips et al., 2015). A rolling window ADF type regression implementation is used in this recursive test. If the rolling window regression subsample starts from the fraction $r_1$ of the sample T and ends at the fraction $r_2$, the first equation can be written as:

$$\Delta y_t = \hat{a}_{r_1,r_2} + \hat{\gamma}_{r_1,r_2} y_{t-1} + \sum_{i=1}^{k} \hat{\Psi}^{i}_{r_1,r_2} \Delta y_{t-i} + \hat{\varepsilon}_t \quad (1)$$

Where $\Delta y_t$ denotes a generic time series.

The focus of the right-tailed unit root tests is usually on the alternative hypothesis and these tests are informative about explosive behaviour in the time series data. The GSADF is a right-tailed unit root test, too. The hypothesis of right-tailed ADF tests are as follows (Philips et al., 2011, p. 207):

$H_0$: $\gamma = 1$ (unit root exists)

$H_1$: $\gamma > 1$ (explosive unit root exists)

$r_w$ is the fractional window size of the regression and $rw > 0$.

$r_2 = r_1 + r_w$ (2)

The GSADF statistic was defined as the largest ADF statistic in this double recursion over all feasible ranges of $r_1$ and $r_2$ as given in equation 3 (Philips et al., 2015, p. 1049).

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2 - r_1]}} \left\{ ADF_{r1}^{r2} \right\} \quad (3)$$

The first theorem of Philips, Shi, and Yu states that "when the regression model includes an intercept and the null hypothesis is a random walk with an asymptotically negligible drift, the limit distribution of the GSADF test statistic is:

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0, 1] \\ r_1 \in [0, r_2 - r_1]}} \left\{ \frac{\frac{1}{2} r_w [W(r_2)^2 - W(r_1)^2 - r_w] - \int_{r_1}^{r_2} W(r)\,dr\,[W(r_2) - W(r_1)]}{r_w^{1/2} \left\{ r_w \int_{r_1}^{r_2} W(r)^2\,dr - \left[ \int_{r_1}^{r_2} W(r)\,dr \right]^2 \right\}^{1/2}} \right\} \quad (4)$$

where $r_w = r_2 - r_1$ and W is a standard Wiener process." (Philips et al., 2015, p. 1049).

This test allows for the detection of several bubbles by allowing the window size to vary between 0 and $r_2 - r_1$, as recommended in the SADF test article (Philips et al., 2011). The SADF process uses a forward-expanding window to test for bubbles one after the other. Given a user-specified minimum window size $r_0$, the GSADF test, generalized version of the SADF test, uses all feasible subsamples of a time series to test for exuberance (Vasilopoulos et al., 2022, p. 6).

Minimum fractional window size r0 can be calculated as follows:

$$r_0 = 0.01 + 1.8/\sqrt{T} \quad (5)$$

As a rule of thumb, a bubble should long more than a minimum period in order to be considered as a bubble. This minimum period may be calculated by $\delta \log(T)$. T is the number of data and $\delta$ is a frequency-dependent parameter (Philips et al., 2015, p. 1052).

## 4. Results

We downloaded the data published by the Central Bank. These data can be obtained from the electronic data distribution system (EVDS, 2024). We used the average weekly deposit interest rates applied by Turkish banks in this study. The data set includes 523 weeks' interest rates for various maturities between January 10, 2014 and January 12, 2024, i.e. 10 years' data. In addition to examining bubbles in these data, we investigated the coincidence between the bubbles and important events in Türkiye's last 10 years. We considered the events like the coup attempt (2015), the plebiscite (2017), the general elections (2018, 2023), Covid-19 pandemic (2020). The descriptive statistics of data for the four different maturities are given in Table 1.

**Tablo 1**

*Some Statistics*

| | 1-Month Maturity | 3-Month Maturity | 6-Month Maturity | 1-Year Maturity |
|---|---|---|---|---|
| Mean | 13.96 | 16.55 | 15.20 | 14.84 |
| Median | 11.28 | 13.34 | 13.33 | 13.33 |
| Standard deviation | 6.56 | 8.45 | 7.10 | 6.32 |
| Minimum | 6.87 | 8.03 | 7.33 | 7.19 |
| Maximum | 44.05 | 52.60 | 51.67 | 45.12 |
| Kurtosis | 8.05 | 7.72 | 11.52 | 8.48 |
| Skewness | 1.97 | 2.05 | 2.55 | 2.04 |
| Jarque-Bera goodness of fit | 894.05 | 850.64 | 2146.50 | 1018.00 |
| Probability | 0.00 | 0.00 | 0.00 | 0.00 |
| Observations | 523 | 523 | 523 | 523 |

We applied the descriptive statistics to the interest rates of all terms. We used R package moments (Komsta & Novomestky, 2022) to calculate descriptive statistics and codes are given in the appendix. According to the Jarque-Bera test applied by R (Trapletti et al., 2023), none of the series exhibited a normal distribution. The highest average interest was realized in 3-month maturity. On the other hand, the lowest interest rate was given to deposits with 1-month maturity.

We converted the data to tibble (Wickham et al., 2023) data structure to process accordingly. We drew the graphs using ggplot2 (Wickham, 2016) and ggfortify (Masaaki & Yuan, 2016) R packages. R codes are listed in the appendix.

After the descriptive statistics, the time path graphs of the relevant certificate of deposit percentage yields were shown in Figures 1-4.

**Figure 1**

*One-Month Certificate of Deposit Percentage Yield*

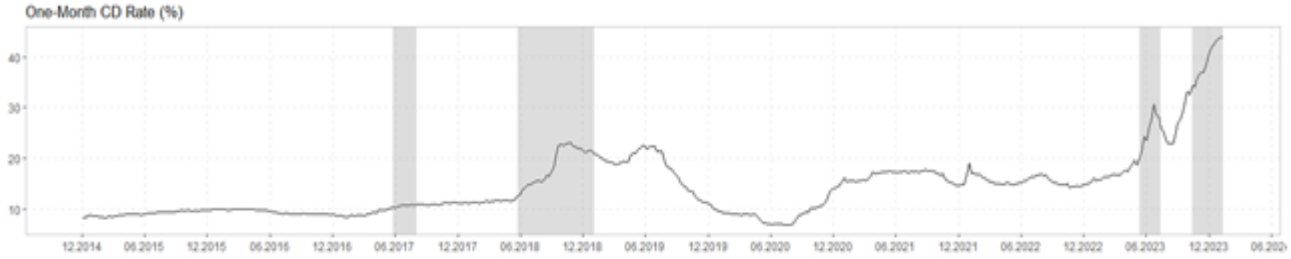



**Figure 2**

*Three-Month Certificate of Deposit Percentage Yield*

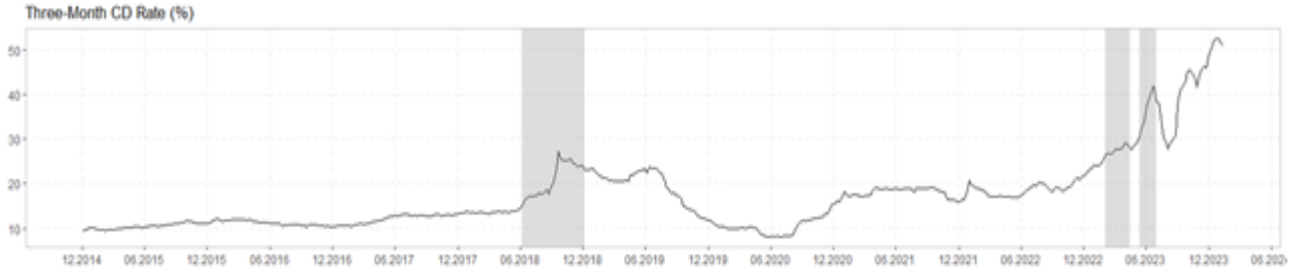
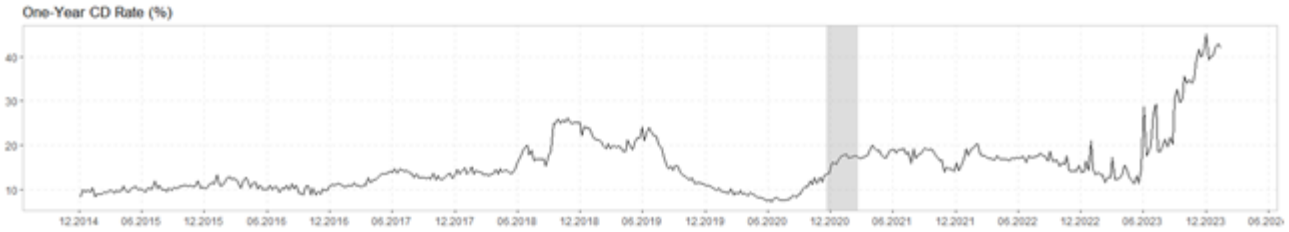



**Figure 3**

*One-Month Certificate of Deposit Percentage Yield*

**Figure 4**

*One-Year Certificate of Deposit Percentage Yield*




We obtained the weighted average interest rates applied to deposits opened in banks in terms of TRY from the Central Bank. We used the flow data and analyzed weekly interest rates (EVDS, 2024).

We observed the first rapid pace of the interest rates after the general elections on June 24, 2018. The interest rates started to decrease in the second half of 2019. In 2020 Covid-19 pandemic broke out and in the second half of 2020 the interest rates increased again. After the general elections on May 14 and May 29, 2023 in Türkiye, the Central Bank declared an interest rate increase policy on June 22, 2023. The increase in interest rates has been continuing by the time we made the analysis in January 2024.

We searched for the possible exuberance in the certificate of deposit rates of various terms by applying the GSADF test. In the analysis, we calculated the window size as 46 using equation 4 and multiplying the fractional window size by the number of observations. To perform the test, critical values for 523 observation values were calculated with Monte Carlo simulation.

We conducted the GSADF test by R using the exuber package (Vasilopoulos et al., 2022).

$H_0$: There is no bubble episode in certificate of deposit interest rate date.

$H_1$: There are one or more bubble episodes in data.

**Table 2**

*Critical values*

| | | 1-Month Maturity | 3-Month Maturity | 6-Month Maturity | 1-Year Maturity |
|---|---|---|---|---|---|
| GSADF | | 8.81 | 5.93 | 3.52 | 3.33 |
| Probability | | 0.000 | 0.000 | 0.002 | 0.003 |
| Critical Value*: | 99% | 2.720 | | | |
| | 95% | 2.244 | | | |
| | 90% | 1.998 | | | |

*Monte Carlo simulation has been done by R (exuber package) with 2000 iterations.

In Table 2 we compared the right-tailed GSADF test statistics with the critical values which were calculated with Monte Carlo simulation. For all certificates of deposit maturities, we observed statistically significant bubbles at the 99% confidence level. Hypothesis $H_0$ was rejected at the 1% significance level for all maturities.

**Figure 5**

*Exuberance in the One-Month CD Rate*


**Figure 6**

*Exuberance in the Three-Month CD Rate*

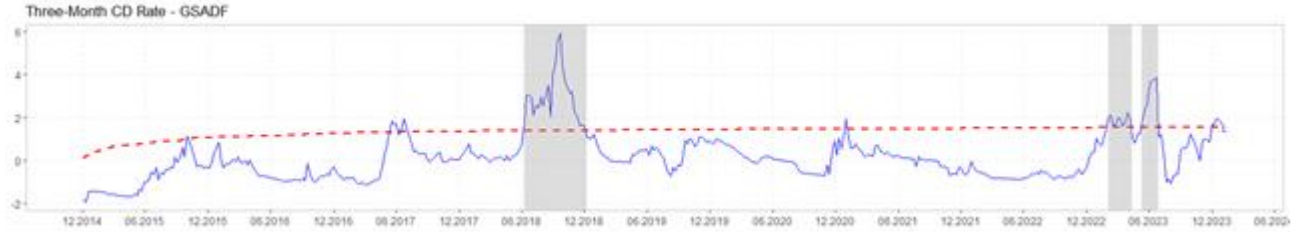



**Figure 7**

*Exuberance in the Six-Month CD Rate*


**Figure 8**


*Exuberance in the One-Year CD Rate*

In Figures 5 – 8, the red dashed lines are the critical values that have been calculated by Monte Carlo simulation. The blue solid line shows GSADF values. Usually if the GSADF values are greater than the critical values, we can talk about a bubble in time series. The gray shaded

parts of the graphs show the bubbles according to 95% significance level. For all maturities, there are statistically significant bubbles.

For minimum duration either δ log(T) or δ log(T)/T may be used as suggested by Philips, Shi, and Yu. (Phillips et al., 2015). exuber package supports caluculation of minimum duration using one of these rules (Vasilopoulos et al., 2022). We preferred the δ log(T) formula and the minimum duration was calculated as 6 weeks. So, we considered bubble episodes that last at least 6 weeks.

The significant events coinciding with the bubble episodes are listed in Table 3.

**Table 3**

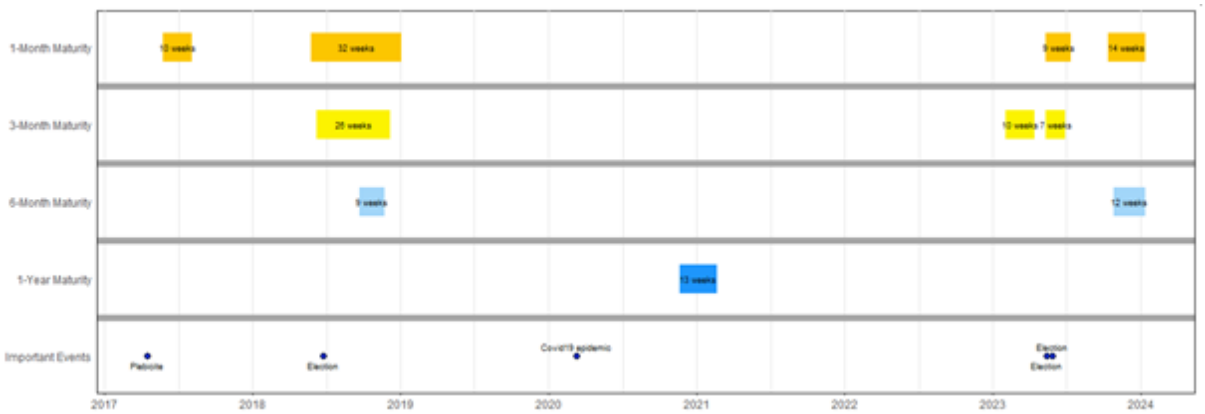
The Dates of the Bubbles

| 1-Month Maturity | 3-Month Maturity | 6-Month Maturity | 1-Year Maturity | Event |
|---|---|---|---|---|
| 26.05.2017-<br>04.08.2017<br>(10 weeks) | | | | 16.04.2017<br>Plebiscite |
| 25.05.2018-<br>04.01.2019<br>(32 weeks) | 08.06.2018-<br>07.12.2018<br>(26 weeks) | 21.09.2018-<br>23.11.2018<br>(9 weeks) | | 24.06.2018<br>Presidential/General Elections |
| | | | 20.11.2020-<br>19.02.2021<br>(13 weeks) | 11.03.2020<br>Covid pandemic starts in Türkiye |
| 12.05.2023-<br>14.07.2023<br>(9 weeks) | 12.05.2023-<br>30.06.2023<br>(7 weeks) | | | 14.05.2023,<br>28.05.2023<br>Presidental/General Elections |
| 13.10.2023-<br>12.01.2024<br>(14 weeks – ongoing) | | 27.10.2023-<br>12.01.2024<br>(12 weeks – ongoing) | | 22.06.2023<br>Central Bank's interest lift policy starts |

We drew the timeline using vistime (Raabe, 2023) and purrr (Wickham & Henry, 2023). The R codes are given in the appendix.

**Figure 9**

*The Timeline of CD Rate Bubbles and Important Events in Türkiye*




In this study, we examined average certificate of deposit rates applied by the banks in Türkiye in the last 10 years. Considering the bubbles that lasted at least 6 weeks, no bubble was observed in the deposit rates until 2017. We observed the first bubble in one-month CD rate after the constitutional amendment referendum (plebiscite) held on 16.04.2017 and it lasted for 10 weeks. After the presidential and parliamentary elections held on June 24, 2018, we observed a balloon effect in 1-month, 3-month, and 6-month deposit interest rates. The longer the maturity, the fewer weeks the bubble effect lasted. We noticed the only bubble effect that may be related to the Covid-19 pandemic in 1-year forward accounts and occurred 8 months after the pandemic was declared. After the presidential and parliamentary elections of 14 and 28 May 2023, we again observed a balloon effect in 1-month, 3-month, and 6-month maturity deposit interest rates and these bubbles have been continuing as of January 2024, when we wrote the article. We thought that the interest rate increase policy announced by Central Bank on June 22, 2023, after the elections, also had an impact on these bubbles.

## 5. Conclusions, Discussions and Recommendations

A price bubble arises when the value of an item, such as stocks, bonds, property, or commodities, increases rapidly without any reason for the price increase. (Liberto, 2022). The cycle starts with the speculation about a price increase in the displacement stage (Segal, 2023). In the boom stage, investors pay attention to that asset and price increases faster. As more buyers enter the market, prices increase amazingly, and the asset attracts media attention. As a result of the perception that this asset will rise forever and the increasing tendency towards the market, the euphoria phase begins. However, at this point, institutional investors realize their profits and begin to exit the market. The cycle is completed with the burst in the form of disappointments, collapses, and bankruptcies.

Banks accept deposits from people and companies and pay interest in return. In other words, banks use incoming funds to meet the demand for credit. Deposit rates affect the expense and credit rates affect the income of the banks. Banks earn from the loans and pay for the interest of deposits. When earnings from the loans are greater than the spending for the interest, they generate income from the interest rate spread (Hayes, 2023).

In this study, we examined asset bubbles in the certificate of deposit interest rates applied by banks according to various maturities for the last 10 years (2014-2024) of Türkiye. For all certificate of deposit terms (1, 3, 6, and 12-month) we observed statistically significant bubbles at the 99% confidence level.

We analyzed the average Turkish lira deposit rates published by the Central Bank. Between 2014 and 2016 no bubble was observed. The first occurrence of the bubble was after the 2017 plebiscite. Concurrently with the 2018 and 2023 general elections, we noticed bubbles in 1, 3, and 6-month deposit interest rates. With the Covid-19 pandemic started in 2020, a bubble also formed in 12-month interest rate in the same year. In 2019 no bubble was observed. Due to the absence of a bubble effect in 2019, we thought that the local elections held in 2019 didn't affect the deposit interests. Just as bubbles we observed in 1, 3, and 6-month maturity deposit interest rates during the period of general elections (presidential and parliamentary), a bubble occurred in 1-month interest rates simultaneously with the plebiscite held in 2017. The duration of bubbles that occur during election periods increases as the maturity gets shorter. Following the interest rate increase policy announced by the Central Bank on June 22, 2023, bubbles formed in 1 and 6-month deposit interest rates for the second time in 2023, and these bubbles have been continuing at the beginning of 2024.

It is expected that the interest rates determined by central banks will also affect the banks and they will make decisions accordingly. Since all components of the economy are interrelated, we can say that interest rate policy can affect all parameters ranging from investment to consumption expenditures. Due to both the profit motives of banks and the aim of hedging against future risks, asset bubbles have emerged in various maturity interest rates. The 5 stages of financial bubbles are displacement, boom, euphoria, profit-taking, and panic (Segal, 2023). After the euphoria stage, the initial investors sell and take their profit. The demand for the asset decreases, its price starts to decrease and panic starts. Therefore, factors that existed prior to or during the rise of bubbles, such as an expansionary monetary policy, lending booms, capital inflows, or financial innovations, may have contributed to the construction of bubbles. The funding of the bubble and its correlation with the asset type are key factors to consider in the aftermath of its burst.

Undoubtedly, banks increase their precautions by updating their reserve amounts with various forecast models in economically or politically uncertain periods to prevent a liquidity squeeze. Thus, banks will be able to cover loans with the remaining funds after allocating reserves. These findings bring up the discussion of different situations for banks. Firstly, in uncertainty periods banks increase the short-term deposit interest rates or apply an interest policy above the basic rates in order to increase their profit expectations. In other words, they try to turn the uncertainty into opportunity. On the other hand, if banks in Türkiye do not have enough funds to transfer deposits in extraordinary periods, this may be considered as a disadvantage for the banks.

The present study investigated bubbles in deposit interest rates in Türkiye. The results provide signs of exuberant behavior in the deposit rates. In future work, this methodology can be applied to deposit rates of other countries like BRICS or other types of interest rates.

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ETHICS
The authors declare that this article complies with ethical standards and rules.

AUTHOR CONTRIBUTION

Sibel Kuzgun Akın I Literature review; Design; Interpretation of data/findings; Data collection/analysis; Drafting; Critical; Final approval and accountability. General contribution rate: 55%.

Erkan Işığıçok I Concept/idea; Design; Interpretation of data/findings; Critical review; Supervising; Final approval and accountability. General contribution rate: 45%.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

## References

Abolafia, M., & Kilduff, M. (1988). Enacting Market Crisis: The Social Construction of a Speculative Bubble. Administrative Science Quarterly, 33(2), 177. https://doi.org/10.2307/2393054.

Ahmed, M., Irfan, M., Meero, A., Tariq, M., Comite, U., Abdul Rahman, A. A., Sial, M. S., & Gunnlaugsson, S. B. (2022). Bubble Identification in the Emerging Economy Fuel Price Series: Evidence from Generalized Sup Augmented Dickey–Fuller Test. Processes, 10(1). https://doi.org/10.3390/pr10010065.

Asal, M. (2019). Is There a Bubble in the Swedish Housing Market? Journal of European Real Estate Research, 12(1), 32–61. https://doi.org/10.1108/JERER-03-2018-0013.

Chang, T., Hsu, C. M., & Wang, M. C. (2021). Bubbles During Covid-19 Period: Evidence from the United States Using the Generalized Sup ADF Test. HOLISTICA – Journal of Business and Public Administration, 12(1), 49–56. https://doi.org/10.2478/hjbpa-2021-0005.

Chen, X., & Funke, M. (2013). Renewed Momentum in the German Housing Market: Boom or Bubble? CESifo Working Paper Series, 4287. https://doi.org/10.2139/ssrn.2286048.

Corbet, S., Lucey, B., & Yarovaya, L. (2018). Datestamping the Bitcoin and Ethereum Bubbles. Finance Research Letters 26, 81–88. https://doi.org/10.1016/j.frl.2017.12.006.

Creti, A., & Joëts, M. (2017). Multiple Bubbles in the European Union Emission Trading Scheme. Energy Policy, 107(April), 119–30. https://doi.org/10.1016/j.enpol.2017.04.018.

De Souza, D. C., De Souza, E. T. D. C., & Pereira, H. C. I. (2017). Cryptocurrencies Bubbles: New Evidences. The Empirical Economics Letters, 16(7), 739–46.

Demmler, M., & Dominguez, A. O. F. (2022). Speculative Bubble Tendencies in Time Series of Bitcoin Market Prices. Cuadernos de Economía, 41(86), 159–83. https://doi.org/10.15446/cuad.econ.v41n86.85391

Escobari, D., & Jafarinejad, M. (2016). Date Stamping Bubbles in Real Estate Investment Trusts. Quarterly Review of Economics and Finance, 60, 224–30. https://doi.org/10.1016/j.qref.2015.10.003

EVDS. (2024) The Central Bank of the Republic of Türkiye Electronic Data Delivery System. https://evds2.tcmb.gov.tr/index.php

Harris, L. (2002). Trading and Exchanges: Market Microstructure for Practitioners (a Review). Oxford University Press.

Hayes, A. (2023). Net Interest Rate Spread: Definition and Use in Profit Analysis. Investopedia https://www.investopedia.com/terms/n/net-interest-rate-spread.asp

Hu, Y., & Oxley, L. (2018). Bubbles in US Regional House Prices: Evidence from House Price–Income Ratios at the State Level. Applied Economics, 50(29), 3196–3229. https://doi.org/10.1080/00036846.2017.1418080.

Johansen, A., & Sornette, D. (2000). The Nasdaq Crash of April 2000: Yet Another Example of Log-Periodicity in A Speculative Bubble Ending in A Crash. European Physical Journal B, 17(2), 319–28. https://doi.org/10.1007/s100510070147.

Khan, K., Su. C. W., Umar, M., & Yue, X. G. (2021). Do Crude Oil Price Bubbles Occur? Resources Policy, 71, 101936. https://doi.org/10.1016/j.resourpol.2020.101936.

Komsta L., & Novomestky F. (2022). moments: Moments, Cumulants, Skewness, Kurtosis and Related Tests. R package version 0.14.1. https://CRAN.R-project.org/package=moments

Kyriazis, N., Papadamou S., & Corbet, S. 2020. "A Systematic Review of the Bubble Dynamics of Cryptocurrency Prices." Research in International Business and Finance 54:101254. https://doi.org/10.1016/j.ribaf.2020.101254.

Li, X. L., Si, D. K., & Ge, X. (2021). China's Interest Rate Pass-through after the Interest Rate Liberalization: Evidence from a Nonlinear Autoregressive Distributed Lag Model. International Review of Economics and Finance, 73 (January), 257–274. https://doi.org/10.1016/j.iref.2020.12.031.

Liaqat, A., Nazir, M. S., & Ahmad, I. (2019). Identification of Multiple Stock Bubbles in An Emerging Market: Application of GSADF Approach. Economic Change and Restructuring, 52(3), 301–26. https://doi.org/10.1007/s10644-018-9230-0.

Liberto D., (2022). How Do Asset Bubbles Cause Recessions? Investopedia – Economy. https://www.investopedia.com/articles/investing/082515/how-do-asset-bubbles-cause-recessions.asp

Liu, T. Y., Chang, H. L., Su, C. W., & Jiang, X. Z. (2016). China's Housing Bubble Burst? Economics of Transition, 24(2), 361–89. https://doi.org/10.1111/ecot.12093.

Masaaki, H., & Yuan, T. (2016). ggfortify: Data Visualization Tools for Statistical Analysis Results. https://CRAN.R-project.org/package=ggfortify

Malhotra, A., & Maloo, M. (2014). Bitcoin Is It a Bubble? Evidence from Unit Root Tests. SSRN Electronic Journal. https://doi.org/10.2139/ssrn.2476378.

Mulla, P., Shalari, O. & Gumeni, A. (2018). An Examination of the Occurrence of Speculative Bubbles in the US Stock Markets. The Romanian Economic Journal, 21(67), 98-109.

Naoui, K., & Bassem, A. (2015). Speculative Bubbles and the Real Estate Market Application of the Sequential ADF Test. American Journal of Finance and Accounting, 4(2), 113. https://doi.org/10.1504/ajfa.2015.072592.

Pavlidis, E. G., Paya, I., & Peel, D. A. (2017). Testing for Speculative Bubbles Using Spot and Forward Prices. International Economic Review, 58(4), 1191–1226. https://doi.org/10.1111/iere.12249.

Perifanis, T. (2019). Detecting West Texas Intermediate (WTI) Prices' Bubble Periods. Energies 12(14), 1–16. https://doi.org/10.3390/en12142649

Phillips, P. C. B., Shi, S., & Yu, J. (2015). Testing for Multiple Bubbles: Historical Episodes of Exuberance and Collapse in the S&P 500. International Economic Review, 56(4), 1043–78. https://doi.org/10.1111/iere.12132.

Phillips, P. C. B., Wu, Y., & Yu., J. (2011). Explosive Behavior in the 1990s Nasdaq: When Did Exuberance Escalate Asset Values? International Economic Review, 52(1), 201–26.

Raabe, S. (2023). vistime: Pretty Timelines in R. R package version 1.2.4. https://CRAN.R-project.org/package=vistime

Salihoğlu, E., & Hepsağ, A. (2021). Banka Faiz Oranı Geçişkenliği : RALS Eşbütünleşme Yöntemiyle Normal Dağılmamayı Dikkate Alan Bir Yaklaşım [Bank Interest Rate Pass-Through: A Non-Normal Approach With RALS Regression and Cointegration Method]. Bankacılar Dergisi (117), 40–57.

Segal, T. (2023). 5 Stages of a Bubble. Investopedia, – Investing – Markets, para. 11. https://www.investopedia.com/articles/stocks/10/5-steps-of-a-bubble.asp

Shi, S., Valadkhani, A., Smyth, R., & Vahid, F. (2016). Dating the Timeline of House Price Bubbles in Australian Capital Cities. Economic Record, 92(299), 590–605. https://doi.org/10.1111/1475-4932.12284.

Su, C. W., Wang, X. Q., Zhu, H., Tao, R., Moldovan, N. C., & Lobonţ, O. R. (2020). Testing for Multiple Bubbles in the Copper Price: Periodically Collapsing Behavior. Resources Policy, 65 (January). https://doi.org/10.1016/j.resourpol.2020.101587.

Tarkun, S. (2024). Baltık Borsası Endekslerindeki Balon Varlıkları. Erzurum Teknik Üniversitesi Sosyal Bilimler Enstitüsü Dergisi. 19, 14-24. https://doi.org/10.29157/etusbed.1441108..

Trapletti, A., Hornik, K., & LeBaron, B. (2023). tseries: Time Series Analysis and Computational Finance. R package version 0.10-55. https://CRAN.R-project.org/package=tseries

Vasilopoulos, K., Pavlidis, E., & Martínez-García, E. (2022). Exuber: Recursive Right-Tailed Unit Root Testing with R, Journal of Statistical Software, 103(10), 1-26. https://doi.org/10.18637/jss.v103.i10.

Wickham, H. (2016). ggplot2: Elegant Graphics for Data Analysis. Springer-Verlag New York.

Wickham, H., & Henry L. (2023). purrr: Functional Programming Tools. R package version 1.0.1. https://CRAN.R-project.org/package=purrr

Wickham H, Vaughan D., & Girlich M. (2023). tidyr: Tidy Messy Data. R package version 1.3.0. https://CRAN.R-project.org/package=tidyr

Yavuz, E.. (2003). Davranışsal Finans Açısından Finansal Kriz Süreçlerinde Hisse Senedi Piyasası. İstanbul Üniversitesi SBE Yüksek Lisans Tezi 142.

Zhao, Z., Wen, H., & Li, K. (2021). Identifying Bubbles and the Contagion Effect between Oil and Stock Markets: New Evidence from China. Economic Modelling, 94, 780–788. https://doi.org/10.1016/j.econmod.2020.02.018

## Appendix – R Codes

```
# Remove the comments to install the libraries.
# install.packages("exuber")
library(exuber)
# Read the data.
faiz = read.csv('EVDS_2014_2024_hepsi.csv', sep=';', header=TRUE)

# Data have been read as data frame.
# Convert DD-MM-YYYY date strings to Date.
haftalar <- seq(as.Date("2014-01-10"), as.Date("2024-01-12"), by = "1 week")

# For tibble:
# install.packages("tidyr")
library(tidyr)

# install.packages("ggplot2")
library(ggplot2)

# install.packages("ggfortify")
library(ggfortify)

tFaiz <- tibble (hafta = haftalar, vade1 = faiz$vade_1, vade3 = faiz$vade_3, vade6 =
faiz$vade_6, vade12 = faiz$vade_12)

# DESCRIPTIVE STATISTICS
summary(tFaiz)
library(moments)
kurtosis(tFaiz)
skewness(tFaiz)
sd(tFaiz$vade1)
sd(tFaiz$vade3)
sd(tFaiz$vade6)
sd(tFaiz$vade12)
#install.packages('tseries')
library(tseries)
jarque.bera.test(tFaiz$vade1)
jarque.bera.test(tFaiz$vade3)
jarque.bera.test(tFaiz$vade6)
jarque.bera.test(tFaiz$vade12)

# GSADF TEST CODES
min_dur <- psy_ds(tFaiz)
min_dur
# Minimum duration: 6 weeks

# r0 = 0.01 + 1.8/sqrt(T)
# T: nrow(tFaiz)     sample size
```

```
min_w <- psy_minw(tFaiz)
min_w
# Window size: 46

# GSADF unit root test
radf_faiz <- radf(tFaiz, minw = min_w, lag = 1)

# Monte Carlo simulation to calculate critical values
mc_critical_values <- radf_mc_cv(nrow(tFaiz), minw=min_w, nrep=2000, seed=145)
mc_critical_values
summary(radf_faiz, mc_critical_values)

# Result of the hypothesis test
diagnostics(radf_faiz)

# Probability values
calc_pvalue(radf_faiz)

# Dates of bubbles
datestamp_res <-datestamp(radf_faiz, mc_critical_values, min_duration= min_dur)
datestamp_res

# 1-month maturity
autoplot2(radf_faiz, mc_critical_values, select_series = c("vade1"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "One-Month CD Rate (%)", y = "", x = "") + scale_x_date(date_breaks="6 months",
date_labels="%m.%Y")

autoplot(radf_faiz, mc_critical_values, select_series = c("vade1"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "One-Month CD Rate - GSADF", y = "", x = "") +
scale_x_date(date_breaks="6 months", date_labels="%m.%Y")

# 3-month maturity
autoplot2(radf_faiz, mc_critical_values, select_series = c("vade3"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "Three-Month CD Rate (%)", y = "", x = "") +
scale_x_date(date_breaks="6 months", date_labels="%m.%Y")

autoplot(radf_faiz, mc_critical_values, select_series = c("vade3"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "Three-Month CD Rate - GSADF", y = "", x = "") +
scale_x_date(date_breaks="6 months", date_labels="%m.%Y")

# 6-month maturity
autoplot2(radf_faiz, mc_critical_values, select_series = c("vade6"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "Six-Month CD Rate (%)", y = "", x = "") +
```

```
scale_x_date(date_breaks="6 months", date_labels="%m.%Y")

autoplot(radf_faiz, mc_critical_values, select_series = c("vade6"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "Six-Month CD Rate - GSADF", y = "", x = "") +
scale_x_date(date_breaks="6 months", date_labels="%m.%Y")

# 12-month maturity
autoplot2(radf_faiz, mc_critical_values, select_series = c("vade12"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "One-Year CD Rate (%)", y = "", x = "") +
scale_x_date(date_breaks="6 months", date_labels="%m.%Y")

autoplot(radf_faiz, mc_critical_values, select_series = c("vade12"), min_duration = min_dur,
sig_lvl = 95) +
labs(title =  "One-Year CD Rate - GSADF", y = "", x = "") +
scale_x_date(date_breaks="6 months", date_labels="%m.%Y")

# TIMELINE
# install.packages("vistime")
library(vistime)
# install.packages("purrr")
library(purrr)
a <- data.frame(event = map_chr(datestamp_res$vade1$Duration, paste, "weeks"), start =
datestamp_res$vade1$Start, end = datestamp_res$vade1$End, group = "1-Month Maturity",
color = '#FCC600')

b <- data.frame (event = map_chr(datestamp_res$vade3$Duration, paste, "weeks"),
start = datestamp_res$vade3$Start,
end = datestamp_res$vade3$End,
group = "3-Month Maturity",
color = '#FCF300')

c <- data.frame (event = map_chr(datestamp_res$vade6$Duration, paste, "weeks"),
start = datestamp_res$vade6$Start,
end = datestamp_res$vade6$End,
group = "6-Month Maturity",
color = '#A2D6F9')

d <- data.frame (event = map_chr(datestamp_res$vade12$Duration, paste, "weeks"),
start = datestamp_res$vade12$Start,
end = datestamp_res$vade12$End,
group = "1-Year Maturity",
color = '#1E96FC')

e <- data.frame (event = c("Plebicite", "Election", "Covid19 pandemic", "Election", "Election"),
start = c("2017-04-16", "2018-06-24", "2020-03-11", "2023-05-14", "2023-05-28"),
end = c("2017-04-16", "2018-06-24", "2020-03-11", "2023-05-14", "2023-05-28"),
```

```
group = "Important Events",
color = '#072AC8')

cizelge <- gg_vistime(rbind(a, b, c, d, e))
for (kat in 1:5) {
  cizelge$layers[[kat]]$aes_params$size <- 2.5
}
cizelge + scale_x_datetime(date_breaks = "year", date_labels = "%Y")
```