ANALYZING MULTIPLE BUBBLES IN THE USDKZT EXCHANGE RATE USING THE GSADF TEST

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ABSTRACT

Since most of the financial crisis caused by the bursting bubble of financial assets, the investigation of bubble behaviors and the early detection for the prevention of adverse economic consequences is important. This paper investigates whether multiple price bubbles exist in USDKZT exchange rate on the basis of a recursive right tailed Generalized Supremum Augmented Dickey Fuller Test (GSADF) developed by Phillips, Shi and Yu (2015), as well as to determine date stamps of the price bubbles. In this regard, we performed GSADF test by using weekly closing prices of the nominal exchange rate for the period between 23.08.2015 to 04.04.2021. In line with the empirical findings obtained, two explosive bubbles are detected in 2018 and 2020 when USDKZT exchange rate deviates from fundamental value. Our findings suggest that due to the possibility of bubble repetition, GSADF has been verified to be a better test for detecting bubbles.

Keywords: Multiple Bubbles, USDKZT Exchange Rate, GSADF Unit Root Test

JEL Code: C58, G10, E60
INTRODUCTION

Bubbles caused by excessive price inflation in financial asset prices and the explosion of these bubbles in the following periods threaten economic stability (Afsar and Dogan, 2019). As a matter of fact, as seen in the latest 2008 global crisis experience, the financial collapse as a result of the explosion of bubbles, their contagious effects through trade and/or capital movements and the large-volume rescue packages created to prevent contamination are the most serious indicators of this (Ahmed et al., 2016). For this reason, the investigation of ballooning behavior in asset prices and their frequency over time is of great importance for global economic stability, especially in emerging markets.

The rapid and continuous increases in asset prices suggest that there is a price bubble that is not considered rational. The price bubble is expressed as a situation where the actual value in the market increases rapidly and diverges from the fundamental value (Ghosh, 2016; Hepkorucu and Genc, 2019; Iskenderoglu and Akdag, 2019; Diba and Grossman, 1988). If these two values are not equal, it means that risk and uncertainty are gradually increasing (Hu and Oxley, 2017). Price bubbles are associated with a collapse following rapid increases in real and financial asset prices (Malkiel, 2010). Price bubbles create a self-sustaining cycle by adding new buyers on the basis of the “herd psychology” of the investors.

Asset price bubbles are affected by demand-side shocks. After a while, investors start selling assets in their portfolios, thinking that asset prices have reached the highest level. This time, as a result of herd psychology operating in the opposite direction, asset prices are falling dramatically (Buyukduman, 2014; Kansu, 2011: 22-26; Lind, 2009). This process refers to the formation, growth and eventual explosion of the price bubble.

Traditionally, in order to detect bubbles in the prices of assets, Chow and CUSUM tests are recommended, as well as variance, stationarity, unit root and/or cointegration tests. However, SADF (Supremum Augmented Dickey-Fuller) and GSADF (Generalized Supremum Augmented Dickey-Fuller) tests, proposed in Phillips et al. (2011) and Phillips et al. (2015) studies, have been widely used determining price bubbles.

The recursive GSADF test, which analyzes the time series at a single level from beginning to end, examines in more detail and therefore contains more information than similar methods that take into account right-tailed distributions. This situation allows the analysis of the multi-price bubble structure in the whole time series (Hepkorucu and Genc, 2019). GSADF method has a datestamping strategy that captures both the existence of price bubbles and the beginning and ending points of a bubble (Phillips et al., 2011).

The main purpose of this study is to examine the presence of price bubbles in USDKZT exchange rate with GSADF test, as well as to determine datestamps of the price bubbles. The distinctive contribution of the study is that as far as we have determined, there was no previous study on the determination of price bubbles on the USDKZT exchange rate in the literature.

The remainder of this paper proceeds as follows. Section 2 attempts to review the relevant literature. Section 3 details the general models. Section 4 describes the USDKZT exchange rate data and presents the empirical results. Section 5
contains some concluding remarks.

LITERATURE REVIEW

There are many studies in the literature that have investigated the existence of price bubbles in stock markets, foreign exchange markets, commodity markets, precious metal markets, crypto money markets and housing markets.

Although various methodologies are used to determine price bubbles, the GSADF test used by Phillips, Shi and Yu in 2015 has come to the fore in the determination of multiple price bubbles in recent years. Some studies using the GSADF test are grouped as follows:


METHODOLOGY

The regression model used in determining price bubbles can be written as follows (Phillips et al. 2015):

\[ y_t = dT^n + \theta y_{t-1} + \epsilon_t, \epsilon_t \sim iid N(0, \sigma^2), \theta = 1 \]  

Here; \( d \) is the intercept term, \( T \) is the number of observations, the coefficient \( \eta \) is constant and \( T \to \alpha \) is the localization-confinement coefficient which controls the magnitude of drift, and \( y_{t-1} \) means a delayed value of the respective asset series; \( \epsilon_t \) represents the error term with constant variance that has mean 0. In the Phillips, Shi and Yu approach, the null hypothesis (H_0) assumes that the asset price follows a random walk process with an asymptotically negligible shift, while under the alternative hypothesis (H_1), it shows the existence of a bubble in prices (Ceylan et al., 2018). When equation (1) is solved, the following equation is obtained, which gives the deterministic shift \( \frac{d}{T^n} \):

\[ y_t = \frac{d}{T^n} \sum_{i=1}^{t} \epsilon_i + y_0 \]  

(2)
Here, with $\eta > 0$, the drift is small compared to a linear trend. If $\eta > \frac{1}{2}$, the drift is small relative to the martingale component of $y_t$. In the case of $\eta > \frac{1}{2}$, the standardized $r^{1/2}_{\eta}$ output treats asymptotically like Brownian motion involving drift. In the study, $\eta > \frac{1}{2}$ case, in which the magnitude level of $y_t$ is the same as the pure random walk has been discussed.

The recursive approach includes an ADF-style regression with drift windows for stationarity testing. The regression with a drift window starts from the $r^\text{th}$ portion of the total sample (T) and ends at the $r^\text{th}$ portion. Where $r_i = r_\text{st} + r_w$ ve $r_\text{st} > 0$ is the partial window size of the regression. The empirical regression model, including $H_{i_r}: \hat{\beta} = 1$ ve $H_{i_r}: \hat{\beta} > 1$ ve can be written as:

$$\Delta y_t = \tilde{\alpha}_{D, \tau} + \tilde{\beta}_{D, \tau} y_{t-1} + \sum_{i=1}^{k} \tilde{\psi}_{D, \tau} \Delta y_{t-i} + \tilde{\epsilon}_t$$

(3)

Here, $k$ (temporary) is the number of delays, $r_\text{st} = [r_\text{st}]$ is the base function showing the integer part $[\cdot]$, including the total number of observations. This is shown ADF$^\tau$ in the form of ADF statistics based on regression. Thus, it is understood that this type of floating window regression is used especially for multiple bubble detection. Asymptotic critical values of GSADF test statistics are determined by Monte Carlo simulations.

The GSADF test statistic is defined as the largest ADF statistic in all applicable $r_\text{st}$ and $r_w$ ranges in this double iteration, and GSADF ($r_0$) is shown as follows (Phillips et al., 2015; Enoksen et al., 2020). The GSADF test is based on recursively repeated ADF test regressions on sub-samples of the total number of observations. The window size ($r_w$) spreads from $r_0$ (the smallest sample window size) to 1 (the largest sample window size) and expresses the total sample size. The $r_1$ (starting point of the sample) is fixed at 0. The window size is equal to $r_w$, with $r_2$ at the sample ending point. The sample starting point $r_1$ changes between $r_0$ to 1. It is shown as the ADF statistics of a sample ranging from 0 to $r_1$ (Zeren and Esen, 2018). Figure 1 below shows the GSADF process in the context of floating windows in the sample range (Caspi, 2013).

**Figure 1.** GSADF Test Process Sampling Range [0,1]

Source: Author’s estimates

In the GSADF test, the sample starting point is not fixed and is shifted over the starting and ending points. Thus, it becomes possible to detect multiple bubbles with the GSADF test. Nonlinear structures and structural breaks also take into account by GSADF (Cagli and Mandaci, 2017).

The GSADF test statistic is defined as the largest ADF statistic in all applicable $r_1$ and $r_2$ ranges in this double iteration, and GSADF ($r_0$) is shown as follows (Phillips et al., 2015; Enoksen et al., 2020).
If the GSADF test statistics calculated with the help of equation (4) and therefore equation (5) are greater than the critical values calculated as a result of Monte Carlo simulations, the null hypothesis claiming that there are no financial bubbles is rejected (Celik et al., 2019). The rejection of the null hypothesis indicates the existence of rational bubbles in price series (Gokce and Guler, 2020).

Actually, if \( T \) is small, then \( r_0 \) should be large enough to allow sufficient observation for the initial prediction. If \( T \) is large, \( r_0 \) may be smaller so that the GSADF test can detect an early burst / bubble event. A rule in simple functional form in the form of

\[
\frac{1}{2} r_0 \left( 1 - \frac{1}{T} \right) + \frac{1}{4} \frac{1}{T} \left( \frac{1}{T} \right) \left( \frac{1}{T} \right) \int W(r)^2 dr
\]

is proposed for the selection of the appropriate window size based on extensive simulation findings. When \( r_0 \) (the minimum window size) gets smaller, the critical value of the GSADF test statistic increases (Phillips et al. 2015).

After detecting the presence of bubbles, the formation periods of the bubbles are determined using retrospective SADF (Backwards sup ADF - BSADF) statistics series. BSADF statistical sequences are obtained using right-tailed ADF tests for samples of a backward expanding structure. BSADF and GSADF statistics can be represent as follows (Caspi, 2013):

\[
\left\{ BSADF_{r_0}(r) \right\}_{r_0 \in [0, 1]} \quad \text{GSADF}(r_0) = \sup_{r_0 \in [0, 1]} \left\{ BSADF_{r_0}(r) \right\}
\]

By comparing the BSADF sequences with the set of right-tailed critical values the dates of formation of the bubbles are determined (Ceylan et al., 2018).

**DATA AND EMPIRICAL RESULTS**

Because of the weakening of the Chinese yuan and the decrease in the price of Brent crude oil from early 2015, the pressure on the economy of Kazakhstan was exacerbated. This economic condition forced the National Bank of Kazakhstan to switch to a floating rate in August 20, 2015. Hence, analysis period started from the date of regime change. In the study, the existence of speculative price bubbles in USDKZT exchange rates since 2015 and the bubble formation dates were determined by the right-tailed GSADF unit root test proposed by Phillips et al. (2015). It has been tried to be determined. weekly closing prices
of USDKZT exchange rates between 23.08.2015-04.04.2021 were used in the study. The data are taken from investing.com database.

The empirical findings of the study have been interpreted by presenting them with the help of tables and graphics. The appropriate window size for the USDKZT exchange rate series was calculated with the \( r_c = 0.01 + \frac{1.8}{\sqrt{T}} \) formula and was determined as 34.

The usual descriptive statistics for USDKZT exchange rate series are summarized in Table 1. According to Table 1, while the maximum and minimum values are 448.1250 and 240.2500 respectively, the volatility (standard deviation) value is also high (40.50798). The coefficient of skewness (0.056524) is positive and there is a right skewed distribution. The kurtosis coefficient is 2.58028 and there is a platykurtic feature. It means that USDKZT exchange rate series exhibit asymmetric and platykurtic properties. Additionally, by Jarque-Bera statistics and corresponding p-value we accept the null hypothesis that exchange rate series are well approximated by the normal distribution.

Table 1. Descriptive statistics of USDKZT exchange rate series

<table>
<thead>
<tr>
<th>USDKZT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
<tr>
<td>Standard Deviation</td>
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<tr>
<td>Skewness</td>
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<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Jarque-Bera (Prob.)</td>
</tr>
</tbody>
</table>

Source: Author’s estimates

From the descriptive graph presented in Figure 1, several increase periods can be observed especially in 2018 and 2020. These graphical expositions show that USDKZT exchange rate series exhibit price bubbles.

Figure 1. Weekly closing prices for USDKZT exchange rate series

Source: Author’s estimates

In the USDKZT exchange rate series, it is important to determine whether the
upward trends experienced especially in 2018 and 2020 after the regime change are price bubbles, as well as the start and end dates of the bubble. In this context, the GSADF method can offer an “early warning” tool (Ceylan et al., 2018: 268).

Table 2 shows the GSADF test statistics given in equation (4) and equation (5) for the USDKZT exchange rate series. Critical values are obtained with 2000 trials based on Monte Carlo simulations according to the appropriate window size (Gokce and Guler, 2020). Accordingly, (294-34) x 2,000 = 520,000 regressions were estimated. In this context, a GSADF test ended in a calculation process of approximately 12 hours. The GSADF test statistic is significantly greater than the critical value at 99% confidence level. Statistically, it has been understood that there are price bubbles in the USDKZT exchange rate series for the period of 23.08.2015-04.04.2021.

Table 2. GSADF Test Statistic Results

<table>
<thead>
<tr>
<th>Variable</th>
<th>GSADF Test Statistic</th>
<th>Test Critical Values</th>
<th>Window Size</th>
<th>Lags</th>
<th>Price Bubbles</th>
</tr>
</thead>
<tbody>
<tr>
<td>USDKZT</td>
<td>3.840692*</td>
<td>2.930127 (99%)</td>
<td>2.120765 (95%)</td>
<td>1.951242 (90%)</td>
<td>34</td>
</tr>
</tbody>
</table>

Source: Author’s estimates

According to Table 1, one can specify that the USDKZT exchange rate contains explosive sub-periods. The null hypothesis that $H_0: r = 1$ at 1% significance critical value is rejected because the GSADF test statistic (3.840692) is greater than the critical value (2.930127).

After determining the existence of price bubbles, the number of bubbles formed during the analysis period and the start-end dates of the bubbles can be observed with the BSADF method as explained before. The critical value of the BSADF sequence indicates the starting point of the price bubble, and the crossing downwards indicates the ending point of the price bubble. In addition, the larger the part of the BSADF sequence that remains above the critical value, the higher the impact of the speculative price bubble on the market will be.

In Figure 2, the BSADF series estimated from USDKZT exchange rate series, are compared with the critical value series obtained at 95% confidence level. The start and end dates of speculative price bubbles are shown in shades. The USDKZT exchange rate, the 95% critical value, the GSADF statistic are represented by upper, middle and bottom curves, respectively. The shadows are sub-periods with bubbles.
From Figure 2, if we ignore the minor violation of December 19, 2017, we identify two significant price bubbles in 2018 and 2020. The first bubble originates on July 29, 2018 and bursts on September 16, 2018 which is a duration of nearly eight weeks. The second bubble begins on March 8, 2020 and collapses on April 5, 2020 which is a duration of nearly 5 weeks. For the first bubble period; US sanctions on Turkey and Russia, escalation of US-China trade disputes, interest rate rising in Turkey and Russia can be listed among the important developments in the relevant date range. For the second bubble period; the plummeting oil prices due to the Covid-19 pandemic and the Saudi–Russian price war weakened tenge. At the beginning of April 2020, the USDKZT exchange rate fell to a record low with a loss of 14.6% in the last month due to the sudden drop in oil prices.

CONCLUSION

Asset prices can fluctuate greatly due to speculative movements. This study investigates whether multiple price bubbles exist in USDKZT exchange rate, as well as to determine date stamps of the price bubbles. In this regard, by using weekly closing prices of the USDKZT nominal exchange rate for the period between 23.08.2015 to 04.04.2021, a recursive right tailed Generalized Supremum Augmented Dickey Fuller Test (GSADF) proposed by Phillips et al. (2015) performed.

The empirical findings show that there have been two explosive bubbles in 2018 and 2020. It can be said that especially price bubbles are caused by shocks originating from foreign or domestic economic events. Price bubbles create a self-sustaining cycle by adding new buyers on the basis of the “herd psychology” of the investors. Herd behavior can become increasingly important when the market is dominated by large institutional investors. For the measurement
of herd psychology, the Markov Switching approach as well as Cross-Sectional Absolute Deviation (CSAD) developed by Chang et al. (2000). But analysis of herd behavior is not within the scope of this study.

Due to the price bubbles seen on analysis period, it can be said that the USD-KZT exchange rate is sensitive to speculative movements. Therefore, it can be emphasized that both investors, policy makers and/or financial market regulators should take the necessary precautions regarding these speculative movements. Within the scope of preventive measures against speculative movements, it would be appropriate to support the possible damages that investors and/or speculators may cause to the system with deterrent monetary penalties or taxes.
REFERENCES


