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Date-stamping the Tadawul bubble through the SADF and GSADF econometric approaches

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Abstract

In this research work, we have performed a complete date-stamping of one of the biggest financial bubbles that occurred during recent times, the so-called Tadawul Bubble, which took place in the financial markets of Saudi Arabia in 2006. Taking the analysis period 10/1998-04/2017 as reference, and using the SADF and GSADF econometric tests, it has been possible to establish two approximate starting and end points of this bubble, as well as finding how time later, throughout 2014, two minor or "micro bubbles" of a much more limited incidence also ocurred in this market. Given the chronology obtained, we can conclude that, most likely, the Tadawul Bubble was due to a reissue of the Technological Bubble that, with a year of delay with respect to most of the world financial markets, broke out, and with much more virulence, in the financial markets of Saudi Arabia.

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1 Introduction

Among all stock market crises occurred during the last 30 years, one of them deserves special attention, viz the financial bubble that hit the Saudi Stock Exchange (hereinafter, Tadawul) in 2006. It was surprising the speed with which it took place, less than two years, as well as the magnitude of its impact: A year before reaching its historic maximum, the Tadawul All-Share Index grew more than 110%, dropping to around 60% just one year later. In any case, the most intriguing aspect of this bubble is an important peculiarity of the Saudi financial market: Speculation is strictly prohibited by the *Qu'rān* (see, i.e., Algaoud and Lewis, 2007). This justifies that the Saudi authorities have to apply the Quranic law (*Sharī'ah*) for the complete eradication of this practice from society. Obviously, it was purely a stock market crash but, because of the exhaustive control of these authorities, it could never be considered a common speculative bubble *per se*, in the Western sense of the term, based on the conjunction of the rational expectations of participants in a financial market (see Blanchard, 1979; Blanchard and Watson, 1982).

The final outcome of this crisis was probably due to the lack of transparency in the Tadawul operations (Baamir, 2008; Onour, 2009), to the lack of a stable dividend policy by Saudi companies[1] (Osman and Mohammed, 2010; Al-Ajmi and Hussain, 2011; Alzomaia and Al-Khadhiri, 2013; Al-Qahtani and Ajina, 2017) and, mainly, to the function of the CMA (Capital Markets Authority). This regulatory authority adopted a relatively weak and non-restrictive position during the early phases of the bubble, in order to avoid a negative image for the growing number of small investors coming to the market (Alkhaldi, 2016), motivated by the numerous IPOs occurred at that time (Lerner et al., 2017).

Despite being a reference market in the field of Islamic finance, scientific literature expressly focused on the Tadawul bubble is quite scarce[2] compared to other recent stock cracks, being Alkhaldi (2015, 2016) one of the few sources that analyzed it in depth. In fact, to the extent of our knowledge, no study has yet been conducted that, using proven econometric methods, begins to give an explanation to the Tadawul Bubble. Precisely, Belabes (2011) has a similar opinion when pointing out that "in the absence of reliable econometric studies, the relationship between Islamic finance and financial stability cannot firmly be established".

[1] Although the lack of a predefined dividend policy is a constant among most of world's companies, they operate within the context of Western finance or in the field of Islamic Banking and Finance.

[2] See, among others, Alkhaldi (2015, 2016); Banafe and Macleod (2017) or Lerner et al. (2017) for details regarding the Tadawul bubble.

This manuscript aims to solve this deficit, by performing an econometric analysis of the Tadawul Crisis able to determine its starting and end dates. To do this, this paper has been structured as follows: Section 2 presents a brief summary of the methodology used, essentially, the SADF and GSADF tests ("Single periodically collapsing bubbles" and "Multiple periodically collapsing bubbles", see Phillips et al., 2011; Phillips and Yu, 2011; Phillips et al., 2015a), and Section 3 describes the data that will serve as a basis for obtaining, in Section 4, the empirical results of this investigation. Finally, Section 5 summarizes the conclusions that are derived from the econometric analysis and specifies some future lines of research.

2 Methodology

The explanatory model proposed by Phillips et al. (2015a) considers a random process, defined according to an asymptotically negligible drift term and characterized by a constant, a localization parameter that controls the magnitude of the drift and an error term. This model specification can be transformed into the alternative expression (1) in order to implement a series of econometric tests for the detection of financial bubbles, proposed by Phillips et al. (2011), Phillips and Yu (2011), Phillips et al. (2015a), and Caspi (2017):

$$y_t = \mu + \delta y_{t-1} + \sum_{i=1}^{p} \phi_i \triangle y_{t-i} + \varepsilon_t, \tag{1}$$

where y_t represents the analyzed financial variable (i.e., stock prices, indices closing prices, dividends yields ratios, etc.), μ denotes an intercept, p the maximum number of lags, ϕ_i (i=1,...,p) the different equation-lags coefficients, and ε_t the error term, independently and normally distributed with zero mean and constant variance. Phillips et al. (2015a) propose three statistical hypothesis tests based on the detection of unit roots in Eq. (1), with three different alternative hypothesis: *ADF* test ("Explosive process"), *SADF* test ("Single periodically collapsing bubble period") and *GSADF* test ("Multiple periodically collapsing bubbles"). In these tests, we have a normalized the sample $[r_1, r_2]$ as well as a fractional window size of regression, $r_w = r_2 - r_1$, being r_0 the starting initial window analysis, arbitrarily chosen. Basically, the differences between the tests come from how r_1 and r_2 are defined, in each case.

Testing the explosive behavior of a financial bubble is performed according to a derivation of the classic *ADF* unit root test (right-tail variation: see Dickey and Fuller, 1979), where the null hypothesis detects the presence of a unit root and the alternative is represented by a "mildly explosive autoregressive coefficient" (see Caspi, 2017):

$$\begin{cases} H_0: \delta=1, \\ H_1: \delta>1. \end{cases}$$

In the right-tailed version of the classic *ADF* unit root test, r_1 and r_2 are always fixed to the first and last observations of the analyzed sample, whereby $r_w=r_0=1$. The *SADF* statistic (Phillips et al., 2011) supposes an iterative calculation of the *ADF* statistic with a delimited starting point and a pliant window, being defined as the supremum value of the given ADF_{r_2} sequence for $r_2 \in [r_0,1]$:

$$SADF(r_0) = \sup_{r_2 \in [r_0,1]} \{ADF_{r_2}\}.$$

Phillips et al. (2015a) suggest a generalization of the *SADF* test, by enabling a more flexible valuation windows. In this case, oppositely to the *SADF* test, the analysis starting point, r_1, is enabled to variate within the range $[0, r_2 - r_0]$. Thus, the *GSADF* statistic is specified as:

$$GSADF(r_0) = \sup_{\substack{r_2 \in [r_0,1] \\ r_1 \in [0, r_2 - r_0]}} \{ADF_{r_1}^{r_2}\}.$$

Once the statistics *SADF* and *GSADF* have been defined, Phillips et al. (2011, 2015a) determine a crucial aspect in the analysis of financial bubbles: set, approximately, when they begin and when they finish, since the rejection of the null hypothesis proposed in both tests (H_0) allows to define a time horizon in which it is possible to infer the beginning and the end of the analyzed financial bubble.

According to the *SADF* test, the starting point of any financial crash corresponds, chronologically, to the first observation of the analyzed asset (T_{r_e}) which intersects, transversely, the sequences of critical values of the *SADF* statitstic (ADF_{r_2}) and the standard *ADF* statitstic (in its right tail).

Similarly, the determination of a bubble (T_{r_f}) would be given by the last date at which the transverse crossing between both sequences occurs. Therefore, by considering the percentage of critical value of the standard *ADF* statistic on T_{r_2} observations ($cv_{r_2}^{\beta_T}=100\times(1-\beta T)$), the temporal estimation of a bubble according to the *SADF* test is given by ("Single periodically collapsing bubble period", see Phillips et al., 2011):

$$\hat{r}_e = \inf_{r_2\in[r_0,1]}\{r_2\colon ADF_{r_2} > cv_{r_2}^{\beta_T}\}$$

and

$$\hat{r}_f = \inf_{r_2\in[\hat{r}_e,1]}\{r_2\colon ADF_{r_2} > cv_{r_2}^{\beta_T}\}.$$

Analogously, the estimated time range of one (or more) financial bubbles based on the *GSADF* test, is given by:

$$\hat{r}_e = \inf_{r_2\in[r_0,1]}\{r_2\colon BSADF_{r_2}(r_0) > cv_{r_2}^{\beta_{T_{r_2}}}\}$$

and

$$\hat{r}_f = \inf_{r_2\in[\hat{r}_e,1]}\{r_2\colon BSADF_{r_2}(r_0) > cv_{r_2}^{\beta_{T_{r_2}}}\}.$$

Following Caspi (2017), $cv_{r_2}^{\beta_T}$ represents the $100\times(1-\beta T)\%$ critical value of the *SADF* statistic implemented on T_{r_2} observations, being *BSADF* (r_0), for $r_2\in[r_0,1]$, the backward *SADF* statistic related with the *GSADF* statistic by the equality:

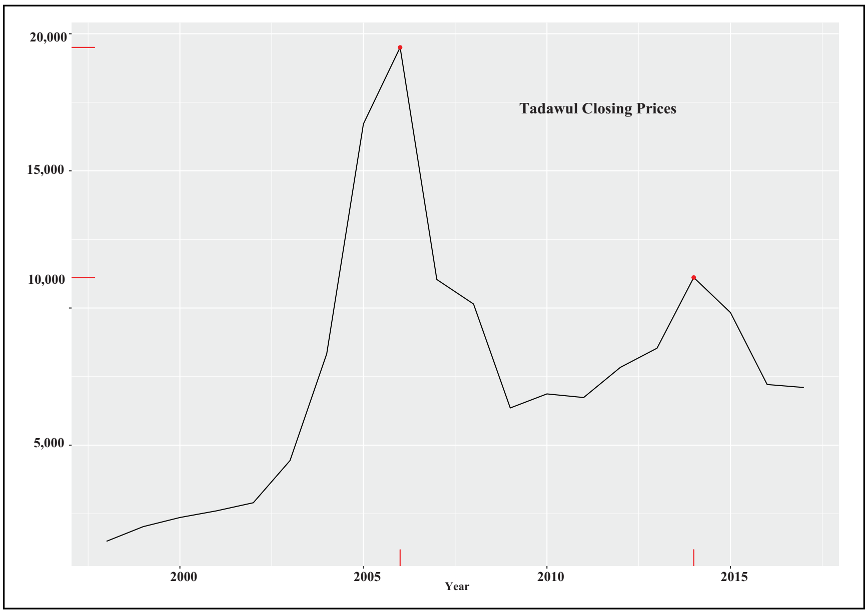
$$GSADF(r_0) = \sup_{r_2\in[r_0,1]}\{BSADF_{r_2}(r_0)\}.$$

3 Data description

Other scholars (Phillips et al., 2015a,b) use the price index-dividend ratio approach (Campbell and Shiller, 2015) as an empirical tool, by considering it as a representative measure of the expectation on future dividends; however, this procedure would make sense in the context of Islamic finance because of the fundamental role of *Zakat*, one of the 5 pillars of Islam, in the distribution of companies dividends. This ritual, consisting in the obligation of every muslim to donate a certain part of his/her generated wealth each year to charitable or almsgiving causes (see Abdul-Rahman, 2010), whose multidimensional character transcends beyond material aspects (Belabes, 2019), as well as the absence of a dividend policy commonly characterized in Saudi companies, determines that the use of dividends as an explanatory factor in the Tadawul Bubble may be considered irrelevant.

For this reason, we have been focused exclusively on the analysis of the Tadawul monthly adjusted closing prices, obtained from the Bloomberg database, during the period from 10/1998 to 04/2017, by obtaining a total of 223 monthly observations, schematically[3] displayed in Figure 1:

Figure 1: *A plot of the time series of the Tadawul adjusted closing prices.*



Source: Own elaboration.

The extreme magnitude of this bubble can be appreciated in Figure 1. It could be said that the Tadawul closing prices almost draw an "isosceles triangle" and, even more, that the range of data is relatively similar to the historical maximum, reached on February 2006, being essential the following statement to quantify the impact of this financial bubble (Banafe and Macleod, 2017):

> "(. . .) by Saturday 25 February 2006, the bubble in share prices was ready to burst. The market index stood at 20,966, having risen by a quarter since the start of the year. The valuations were extraordinarily stretched: by this time the average price earnings ratio was 46 times, and prices 11 times book values. The stock market was worth three times Saudi Arabias Gross Domestic Product (GDP)".

[3] Figure 1 exhibits the maximum annual values reached by the Tadawul Index throughout the period 10/1998-04 /2017.

4 Empirical results

Alternatively, any of the multiple pre-existing econometric procedures could have been used such as Homm and Breitung (2012); Baur and Glover (2012); Gutiérrez (2013), or Breitung (2014). However, we have opted for the *SADF* and *GSADF* tests as they represent a substantial improvement of the initial *ADF* test (Phillips et al., 2015a,b), considered by some scholars Homm and Breitung (2012) quite more robust than other tests (see Assenmacher and Czudaj, 2014).

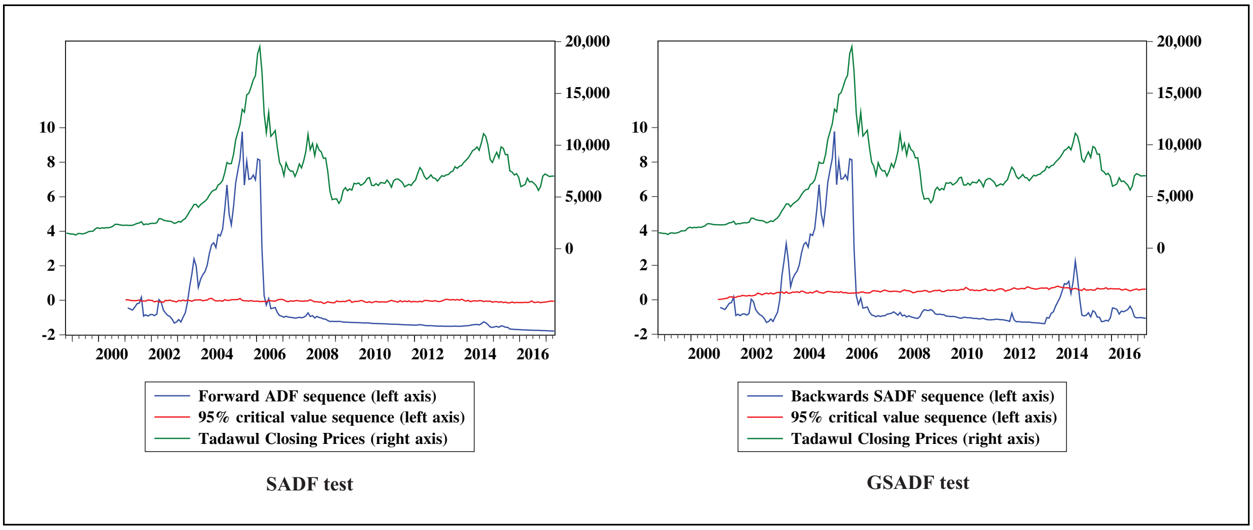
The results of implementating the *SADF* and *GSADF* tests formerly defined on the selected database, are collected in Table 1 and Figure 2:

Table 1: *Right Tailed ADF Tests: SADF and GSADF tests.*

		t-Statistic	Prob.*	
SADF test		9.767019	0.0000	*Right-tailed test
	99% level	1.844748		**Critical values are based on a Monte Carlo simulation.
Test critical values**	95% level	1.353368		
	90% level	1.079387		Sample: 1998M10-2017M04.
		t-Statistic	**Prob.***	
GSADF test		9.767019	0.0000	Null hypothesis: Tadawul closing price a has a unit root for the considered sample. Lag length: Fixed, lags 0 .
	99% level	2.627427		
Test critical values**	95% level	2.048380		Chosen window size (w): 29. $w{=}T \times \left(0.01 + \frac{1.8}{\sqrt{T}}\right)$.
	90% level	1.854323		

Source: Own elaboration.

Figure 2: *Tadawul bubbles date-stamping: SADF and GSADF tests.*



Source: Own elaboration.

It can be observed that in both tests, at 95% significance level for the critical values sequence, the null hypothesis must be rejected which allows dating the timeline of Tadawul financial bubble/s during the fixed time horizon. More specifically, Table 2 determines such periods associated with the formation of a bubble:

Table 2: *Tadawul bubbles date-stamping: Comparison of the results.*

Bubble periods	SADF test	GSADF test
1	2002:M4-2006:M4	2002:M4-2006:M4
2	—	2014:M2-2014:M5
3	—	2014:M7-2014:M11

Source: Own elaboration.

In other words, both tests indicate a complete chronology of the Tadawul Bubble, setting it approximately in the period from 2002:M4 to 2006:M4. In the same way, the *GSADF* test also indicates the formation of two "micro bubbles", intermittently, during 2014: one during in the interval from 2014:M2 to 2014:M5, and a second, circumscribed to the period from 2014:M7 to 2014:M11.

Taking into account that the *SADF* test detects a single bubble and the *GSADF* more than one, the occurrence of these two isolated crises during 2014, instead of signifying a failure of the *GSADF* procedure, represents a significant finding. In point of fact, it delimits another financial crisis subsequent to the Crash of Tadawul in 2006, of a fairly short duration, the oil crisis of 2014, densely studied in the literature (Alotaibi, 2019; Fattouh et al., 2015) that, in opinion of Bouri (2015), produced high uncertainty levels in the financial markets of MENA countries. This effect can be considered as obvious, given the interrelation between crude oil prices and financial markets (Le and Chang, 2015), even more noticeable in the Persian Gulf countries (Lescaroux and Mignon, 2008).

5 Conclusions

In this manuscript, we have dated by means of two different econometric procedures (*SADF* and *GSADF* tests) an approximate chronology of the Tadawaul Bubble, also finding what appears to be the formation of two bubbles of much lower intensity during 2014 (the oil crisis of 2014). From this work, the obtained date-stamping should be also related to those contemporary economic events which took place in the Kingdom of Saudi Arabia, in order to verify the robustness of the obtained results.

For instance, when observing that the bubble began in 2002:M4, this fact would endorse part of the conclusions by Alkhaldi (2016), who estimated that the crisis was due to the obsolescence of the technological infrastructures which, gradually and with more or less success, were modernized. In a certain sense, the Tadawul Bubble could be considered a reissue of the New Tech Bubble (1997-2001), whose impact began to be noticed in Saudi Arabia time after that in Western nations and whose pernicious effects were even greater. More specifically, Lerner et al. (2017) remarked: "the boom had been driven by momentum and speculation, enhanced by technology" whilst Banafe and Macleod (2017) pointed out: "new technologies made it easy to become a speculator".

In any case, it seems to be a process very similar to the so-called "Irrational Exuberance" (Greenspan, 1996; Shiller, 2016), in which investors were guided more by unrealistic expectations of self-sustained growth than by strictly rational investment criteria. Said in other words, the Tadawaul Bubble of 2006 defined a context of investment euphoria, according to which the behavior of agents in this financial market as a whole, motivated by an unjustified optimism, led to an irrational increase in the prices of assets that were completely inconsistent with the real fundamentals which, at that time, this market exhibited.

The *Islamic Banking and Finance* (or *Sharī'ah*-compliant finance) is based on its orthodoxy and scrupulousness when listing a series of limits and restrictive prohibitions for the exploitation of human beings, avoiding at all costs the interests in economic-financial transactions (*ribā*) and any type of practice leading to speculation (see ie Siddiqi, 2004; Siddique and Iqbal, 2017). Therefore, from a respectful and rational point of view towards this financial discipline, under no circumstances should it be considered the culprit of the Tadawul Bubble nor of the effects in the economies of Saudi Arabia and several Persic Gulf countries. The main causing factors were: 1) the late response from regulatory authorities[4], and 2) the characterization of the Tadawul during the course of the bubble as an "inefficient financial market"[5] (SCCR, 2005; Alkhaldi, 2015), fact empirically contrasted by Onour (2009), who would justify the irruption of this crisis, violating the Efficient Market Hypothesis (EMH) framework (Shiller, 2003, 2016). In this sense, the asset prices listed in the Tadawul would not accurately reflect all the available information, but could have been the result of a thoughtless, irrational and subjective decision process, most likely, describing a "bandwagon" effect (see Chernomas and Hudson, 2017).

[4] Whilst it is also true that, finally, the Capital Market Authority ("CMA": see CMA, 2006) decided to take action, warning or forbidding to several listed companies of investing out of the scope of the allowed activities in their corresponding articles of association.

[5] Needless to say, any market can be considered efficient or inefficient, regardless of whether its financial operations are carried out within the fields of Western finances banking or *Islamic Banking and Finance*.

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