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DETECTION OF HEALTHCARE BUBBLES IN IRAN: A LEFT-TAILED AUGMENTED DICKEY-FULLER (LTADF) APPROACH

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Abstract

Healthcare bubbles can cause instability in healthcare system. This study investigates the possibility of single and multiple healthcare bubbles in Iran healthcare market. We applied ADF, SADF and GSADF methods of Left-Tailed Augmented Dickey-Fuller to locate single and multiple healthcare bubble episodes. In particular, this study focuses on the explosive behavior of the pharmaceutical products indicator in the Tehran Stock Exchange (TSE) from November 2008 to August 2017. Our results show that the Iran healthcare market has experienced 8 bubbles over the period of 2008-2017, some of which are single, and others are multiple. The first bubble has occurred in June 2010. Other healthcare bubbles have appeared from 2011 until August 2014. However, the seventh bubble appears two years later in August 2016. The peak in healthcare bubbles can be seen in March to April in 2013. Healthcare policymakers should monitor the market to recognize the bubbles so that they can mitigate the consequences of the bubble in the market and orient the prices of medical and pharmaceutical commodities

Keywords: Healthcare, Pharmaceutical Market, Single and Multiple Bubbles, Mild Explosive Behavior

JEL: E3, G11, G12

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Introduction

Since the US subprime mortgage crisis in 2007 and housing bubble burst, the detection of economic bubbles to feed the market with preemptive information, has turned into a major discipline in economy literature (Chen et al., 2016; Etienne et al., 2014; Phillips et al., 2014; Phillips et al., 2013; Bettendorf & Chen, 2013; Bohl et al., 2013; Gormus et al, 2011). Bubble refers to the rise of asset price in a continuous process in which the initial rise of price provokes the expectation for future increases in price, thereby leading to the attraction of new buyers (Hatefi Madjumerd et al., 2017). However, the increase and deviation in price is typically reversed over time, resulting in a sudden drop in price which can lead to financial crises (Kindleberger, 1991). The main cause of the economic bubbles in the marketplace is the policies that allow easy access to financial resources through lowering interest rates and increasing government liabilities, as well as budget shortage (Reinhart & Rogoff, 2009; Foy, 2012).

In a recent study on how healthcare bubbles are created and how it is burst, Foy (2012) noted that inappropriate government policies on lending at low-interest rates have led to the bubbling of the U.S. health market. Moreover, it is maintained that the emergence of healthcare bubbles is the result of an increase in the cost of medical technologies and a lack of research on pain scope (Dentzer et al., 2008; Green, 2008). Kauffman (2011) proposed a measure for ending the healthcare bubble in the US healthcare system. He suggested focusing on a system that could provide healthcare services to more patients at lower prices.

The healthcare market of Iran, a developing country in the Middle East, is characterized by features that make it a good case for exploring the likelihood of the presence of bubbles. The first feature is that about 63 percent of the total health expenditures in Iran are spent on medical care and 17 percent on medication, in total 80 percent. The second feature is that the healthcare costs at current prices have grown at the rate of 26.5 percent over the period of 2002 to 2011, whereas healthcare sector has on average witnessed an annual growth rate of 7.4 percent with respect to the constant price of 2004 - given the inflation and rise of commodity and service prices in Iran throughout these years. In addition, the total healthcare costs relative to gross domestic product (GDP) in Iran has experience a stable growth over 2002-2011; yet it has had a low productivity in health care sector (Middle East Bank Economic Research Group, 2015). Furthermore, in contrary to the OECD (Organization for Economic Co-operation and Development) countries where healthcare system mainly relies on social insurance system, (Frogner et al., 2011),

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Iran utilizes private health insurance (PHI), where 56 percent of healthcare expenditures are paid by people, and only 18 percent by the government[4]. Therefore, PHI might play a significant role in the formation and the type of healthcare bubbles in developing countries such as Iran.

Whilst bubbles might exist in the healthcare market of Iran, the possibility of single or multiple bubble formation in this market has not been explored before. A single bubble is a bubble that disappears after its collapse. But in multiple bubbles, before the collapse phase, a new bubble forms which can be even larger than the previous bubble.

Considering the negative consequences of healthcare bubbles on the healthcare system, investigating single and multiple bubbles enhances the capabilities policymakers in managing the market. Exploring the bubble burst in the healthcare sector could also assist in predicting bubbles before their occurrences. Accordingly, we address the following questions:

- How many healthcare bubbles have been formed from 2008 to 2017?
- In which years healthcare bubbles have been formed, burst and completely disappeared?
- What types of healthcare bubbles have been formed in Iran (single or multiple)?

Methodology

In this study we employed a novel method for locating healthcare bubbles in Iran, which was proposed by Phillips et al (2016). The study of rational bubbles in the market, dates back to the study of Lucas (1978), "Asset Prices in an Exchange Economy". Afterwards, numerous economic methods were employed to examine the explosive bubbles. The studies and theories of Tirole (1982, 1985), Shiller (1984) and De Long et al. (1990) revealed that the asset or commodity prices may deviate from their base price due to the speculative bubbles or information bubbles. A famous model to test the intrinsic bubble is the following equation[5]:

$$P_t = (1+r_f)^{-1} E_t (¢_{t+1} + U_{t+1}) \qquad (1)$$

[4] http://muhc.ir/index.php?option=com_content&view=article&id=75&catid=22&Itemid=189

[5] These equations are derived from Phillips et al (2013)

Where P_t represents the stock price at period *t*, r_f represents the risk-free rate, E_t denotes expectations, $¢_{t+1}$ expresses earnings in period *t* + 1, and U_{t+1} represents the invisible component of the market.

$$P_t^f = \sum \left(\frac{1}{1+r_f} \right)^i E_t \left(¢_{t+i} + U_{t+i} \right) \; for \quad i = 0,1,2 \tag{2}$$

where P_t^f is the base price, and $¢_{t+i}$ represents stock dividend in period *t* + *i*.

$$B_t = \left(1 + r_f\right)^{-1} E_t \left(B_{t+1}\right)$$

which includes any sequence of random variables that satisfy the equation of homogeneous expectations.

$$P_t = P_t^f + B_t \tag{3}$$

Equation (4) is the general answer to Equation (1). It shows the sum of the essential market and bubble components.

$B_t = 0$ implies that there is no bubble. Therefore, the point price is equal to the base price that is determined by supply and demand. If $B_t \neq 0$, it can be concluded that the bubble will not terminate until its detection due to the expectations.

Diba and Grossman (1988) proposed the strategy of the use of stationary test for the logarithm of asset price and visible market basics according to the explosive nature of the bubbles. The conventional stationarity test is based on standard ADF test or Phillips-Perron test (Phillips & Perron, 1988) that includes other explosive assumptions. The model is as follows:

$$\Delta p_t = \sim + \quad p_{t-1} + \sum \cdot_i \Delta p_{t-i} + «_t \tag{4}$$

where p_{t-1} is the logarithm price of asset $«_t \approx N\left(0, \pm^2\right)$, and *k* is the number of lags that is determined by the empirical running of significance tests. The null hypothesis is $\quad = 1$ that implies that p_{t-1} is a process with unit root (Δp_t is stationary). The opposite assumption is $\quad > 1$, meaning that p_{t-1} is explosive (Δp_t is non-stationary).

However, Phillips and Yu (2011) state that their tests have the discrimination potential because they are sensitive to the variations when a process changes from unit root to explosive mild root and vice versa. They are more sensitive to the left-tailed unit root tests. However, this test does not suffice for bubbles with periodic explosion (Evans, 1991).

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To cope with this drawback, Phillips and Yu (2001) proposed the use of recursive supremum determined by t-statistic of ADF.

The SADF test replicates the ADF model in different sub-intervals of the sample to find the best response. The size of window r_w can fluctuate in the range of r_0 to 1 in which r_0 is the smallest window of the sample and 1 is the largest one which is equal to entire sample size. The starting point of r_1 is 0 and its end point of each sample r_2 is equal to r_i; that is, it varies in the range of r_0 and r_1. ADF statistic for a sample that fluctuates in the range of 0 and r_2 is represented by $ADF_0^{r_2}$. The SADF statistic is defined as below:

$$SADF\left(r_0\right) = \sup_{r_2 \in [r_0, 1]} \left\{ADF_{r_2}\right\} \tag{5}$$

The SADF test acts better when there is just a single bubble in the sample. However, when the sample period prolongs, there is evidence showing the presence of multiple asset price bubbles. Phillips et al. (2012, 2013) stated that when the sample period has multiple episodes of booms and crashes, the SADF test may not be able to recognize the bubbles correctly. This drawback is more profound in long-term time series or in markets with extensive fluctuations in where there may be more than one boom period. To solve this drawback and work with multiple booms and crashes, the GSADF test is applied in which flexible windows are employed (Phillips et al., 2012, 2013). Instead of setting the beginning point on the first observation, the GSADF test varies the beginning and end points in a possible range of flexible windows. Therefore, since the GSADF test covers more subsamples and has more flexible windows, it outperforms the SADF test in detecting explosive behavior when addressing multiple episodes in data.

In fact, the GSADF test follows the idea of recursive run of ADF test in a sample sequence; the only difference is that, here, the sample sequence is wider than that of the SADF test. Additionally, for the fluctuation of the end point of regression r_2 from r_0 to 1, the GSADF test allows the variation of the beginning point in a possible range (i.e. from 0 to $r_2 - r_0$). The GSADF test outperforms the SADF in detecting explosive behavior of multiple bubbles since it covers more subsamples and uses more flexible windows. The better performance of the GSADF test has been studied in simulation and in comparison of the two tests in terms of their sizes and the power to detect the explosion. Phillips et al. (2012, 2013) define the GSADF statistic as the biggest ADF statistic in possible range from r_1 to r_2 and denote it with $GSADF(r_0)$. It means that

$$GSADF\left(r_0\right) = SUP_{r_2 \in [r_0, 1], r_1 \in [0, r_2 - r_0]} \left\{ ADF_{r_1}^{r_2} \right\} \tag{6}$$

When the regression model includes the *y*-intercept and the null hypothesis is equal to the random walk, then the GSADF test statistic will be distributed as below:

$$SUP_{r_2 \in [r_0, 1], r_1 \in [0, r_2 - r_0]} \left\{ \frac{(1/2) r_w \left[w\left(r_2\right)^2 - w\left(r_1\right)^2 - r_w \right] - \int_{r_1}^{r_2} w\left(r\right) dr \left[w\left(r_2\right) - w\left(r_1\right) \right]}{r_w^{1/2} \left\{ \int_{r_1}^{r_2} w\left(r\right)^2 dr - \left[\int_{r_1}^{r_2} w\left(r\right) dr \right]^2 \right\}^{1/2}} \right\} \tag{7}$$

where $r_w = r_2 - r_1$ is a standard Wiener process. Phillips et al. (2012, 2013) found that the GSADF test is, in fact, the same as the SADF test in specific conditions. In other words, if the correct process is the random walk, then the SADF and GSADF statistics will converge towards standard normal distribution. Phillips et al. (2012, 2013) resorted to simulation to find the asymptotic critical values for ADF statistic distribution (assuming the null hypothesis that the correct process is the random walk). In this case, the standard Wiener process forms one of the preliminary steps of simulation. Since the Wiener process is continuous and random, only one sample path can be produced with definite number of points. Assume that $n_1 n_2 \ldots n_N$ are located with definite, uniform distances. At each point, a Gaussian random variable is produced with the average of zero and the variance of 1/N. The critical values of the right-tailed GSADF test are greater than those in the SADF test. The asymptotic critical values are obtained by numerical simulation, and the bootstrap methodology is used to calculate the definite sample distribution in these tests. Pavlidis et al. (2012) stated that the presence of explosive root in asset price determinants would not influence this methodology and would provide a strategy for date stamping of data.

Data

We used ADF, SADF and GSADF tests to discover the bubbles in the market of pharmaceutical materials in the Tehran Stock Exchange (TSE), and the two method of SADF and GSADF were used to data bubbles from November 2008 to August 2017 (data before 2008 was not available). The data have been extracted from the website of Tehran

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Stock Exchange[6]. The daily data of the pharmaceutical products were averaged and converted into monthly data. The variations of the pharmaceutical products over the studied years are illustrated in Figure 1. As is evident, the pharmaceutical products indicator in the TSE has had an ascending trend. It has experienced its peak at the end of the studied period, reaching from 478 units in 2008 to 9308 units in 2017.

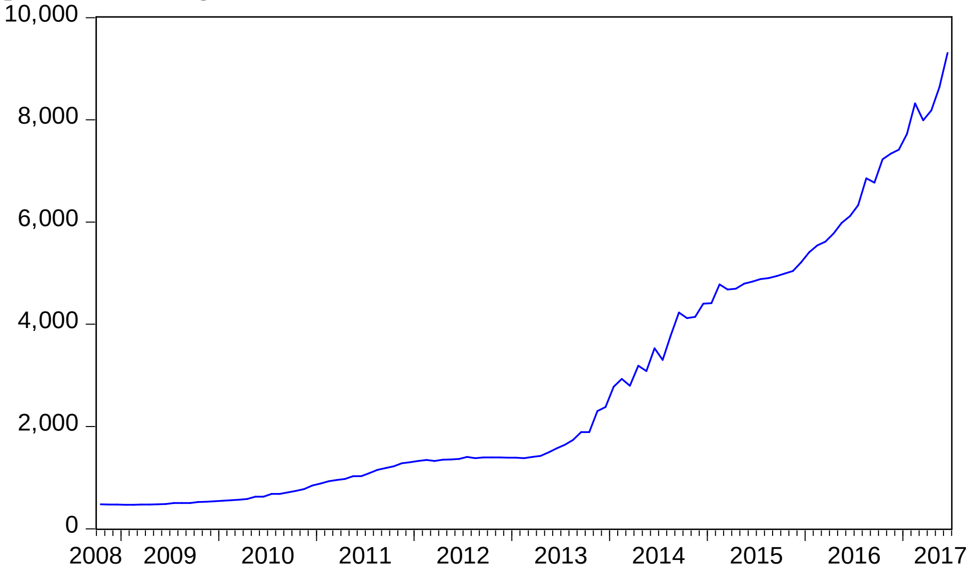

Figure 1: Pharmaceutical indicator in the Tehran Stock Exchange

Results

The estimation model is composed of two sections. The first section describes bubble detection process. The second section deals with bubble date stamping.

Bubble detection

The null hypothesis holds that there is no healthcare bubble in TSE. The rejection of this hypothesis implies the existence of a price bubbles. Table 1 presents the test results for bubble detection. The results reject the null hypothesis. In other words, results indicate the existence of healthcare bubble in TSE.

[6] http://tse.ir/listing.html

Table 1: Tests for bubble detection

Indicator	Statistics		
	ADF	SADF	GSADF
Pharmaceuticals	0.99 (0.00)	3.46 (0.00)	4.12 (0.00)

Bubble date stamping

This section addresses the date-stamping of the bubbles. In Figure 2, the green line represents the pharmaceutical products indicator, the blue line represents the method applied for bubble detection, and the red line shows the critical boundary between 'the presence of a bubble and 'the lack of a bubble'. When the blue line interjects the critical area (the red line) and goes above it, a bubble has been formed. The time for bubble burst is when the blue line reaches its peak. In addition, the disappearance refers to a condition in which the blue line interjects the red line and falls below it.

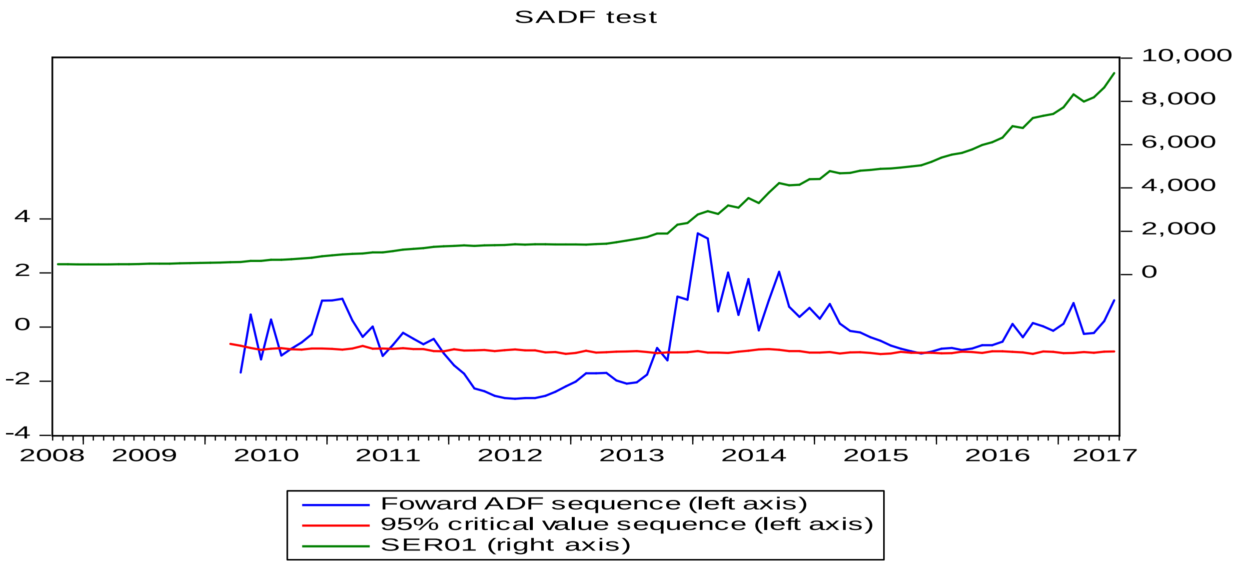

Figure 2: The occurrences of bubbles from 2008 to 2017 using the SADF regression test

As shown in Figures 2 and 3, after the appearance of the bubble, it continues to grow, eventually reaching its peak and bursting. After the explosion, the bubbles do not disappear at once, but they start to fall slowly. This drop may lead to a complete bubble crash (called a single bubble), or other bubbles may form before the complete crash which

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might even be larger than the former bubble (in which case, it is called the period of multiple bubbles). The SADF and GSADF tests revealed seven and ten bubbles in the pharmaceutical market of the TSE, respectively. Since the GSADF test is the augmented version of the SADF test, the findings are analyzed with respect to the GSADF test.

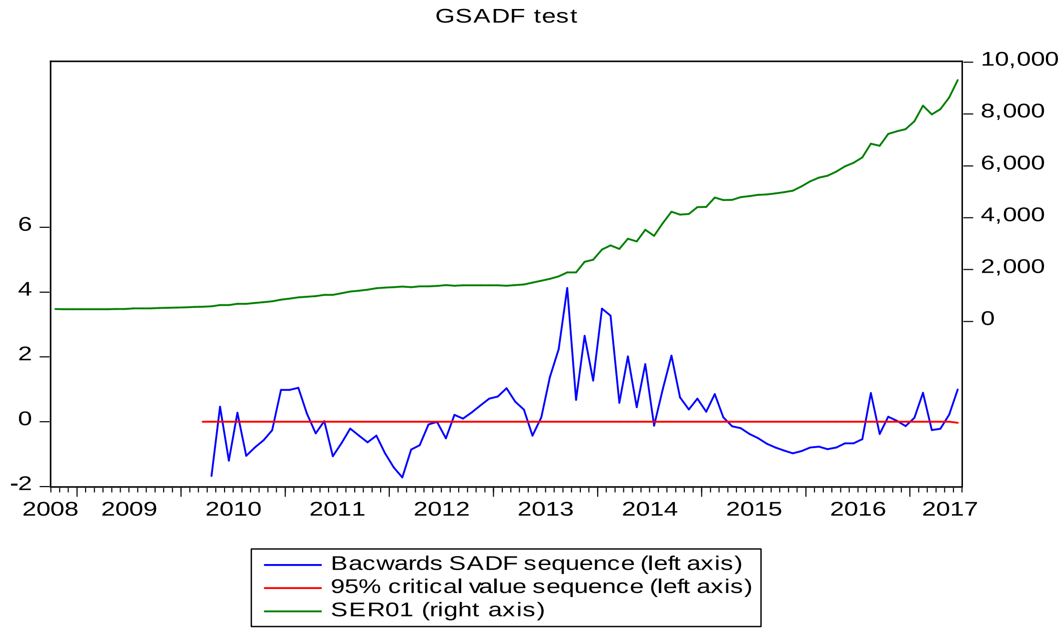

Figure 3: The occurrences of bubbles from 2008 to 2017 using the GSADF regression test

The first bubble is formed from the June to July of 2010. It peaks in the same month, then starts to fall, and its effects on market disappears in a short time. The second bubble in market forms from August to September of 2010. It reaches its peak in a short time in the September and then, starts to crash and disappear. The third bubble forms from December of 2010 to January of 2011 and after reaching its peak in the March to April of 2011, begins to fall and disappears in the market in June to July.

The fourth bubble forms from the September to October of 2012, peaks in the March to April of 2013 and then, starts to fall. There is no bubble in the market from the June to July for a short time. However, the fifth bubble immediately forms. It peaks in October to November and then, and the market becomes bubble-free after a long-term fluctuating process in August to September. The market experiences its sixth bubble in August to September, reaches its peak in October to November, starts to crash and disappears in June of 2015. It is then followed by the formation of the seventh bubble in August to September of 2016. This bubble peaks in the next month and the market becomes bubble-free in October to November. But, a bubble again forms in the market in the December. This bubble peaks in December and disappears in the next month. The ninth bubble forms in February to March of 2017, peaks in March to April, and disappears in April to May. At the end of the studied period, the tenth bubble appears.

Discussion

The causes of the first to third bubbles could be the global financial crisis and the European debt crisis. Chen et al. (2016); Tsenkov & Stoykova, (2017) reported that the variations in the 2 to 4 month bonds in 2008-2010 matched the global financial crisis and the European debt crisis. This crisis has led to the increase of global prices of commodities, profitability, and suitable perspective for enterprises as the major reason for the pharmaceutical products indicator growth. Mladovsky et al. (2012) have also noted the influence of financial crises on the healthcare system.

Table 2: Date-stamping of bubbles in pharmaceuticals indicator

		Bubble type	Starting date	Explosion date	Date of disappearance
SADF	First bubble period	Single	May-Jun 2010	Jun-Jul 2010	Jul-Aug 2010
	Second bubble period	Single	Jul-Aug 2010	Aug-Sep 2010	Sep-Oct 2010
	Third bubble period	Multiple	Oct-Nov 2010	Mar-Apr 2011	Jul-Aug 2011
	Fourth bubble period	Multiple	Jul-Aug 2011	Sep-Oct 2011	Jan-Feb 2012
	Fifth bubble period	Multiple	Nov-Dec 2013	Feb-Mar 2014	Nov-Dec 2015
	Six bubble period	Single	Jun-Feb 2016	Mar-Apr 2016	May-Jun 2016

	Seventh bubble period	Multiple	Apr-May 2016	-	-
GSADF	First bubble period	Single	Jun-Jul 2010	Jun-Jul 2010	Jun-Jul 2010
	Second bubble period	Single	Aug-Sept 2010	Aug-Sept 2010	Aug-Sept 2010
	Third bubble period	Single	Dec 2010-Jan 2011	Mar-Apr 2011	Apr-May 2011
	Fourth bubble period	Single	Sep-Oct 2012	Mar-Apr 2013	Jun-Jul 2013
	Fifth bubble period	Multiple	Jul-Aug 2013	Oct-Nov 2013	Aug-Sept 2014
	Six bubble period	Multiple	Aug-Sept 2014	Oct-Nov 2014	May-Jun 2015
	Seventh bubble period	Single	Aug-Sept 2016	Sep-Oct 2016	Oct-Nov 2016
	Eighth bubble period	Single	Nov-Dec 2016	Nov-Dec 2016	Dec 2016-Jan 2017
	Ninth bubble period	Single	Feb-Mar 2017	Mar-Apr 2017	Apr-May 2017
	Tenth bubble period	Single	Feb-Mar 2017	-	-

The fourth, fifth and sixth bubbles emerged in September to October of 2012, October to November of 2012 and August to September of 2014, respectively. These three bubbles may be rooted in the intensified sanctions on Iran in 2011-2013, which resulted in the pharmaceuticals raw materials shortage and the obstacles in changing Iran's currency to US dollars for international transportation (Middle East Bank Economic Research Group, 2015). The formation of the last two bubbles could be related to Iran's government policy in restraining importing foreign goods, alternatively relying on and supporting domestic products. Meanwhile, policies have been enforced to increase the export of medical equipment and medicines, which in turn has had an impact on the formation of bubbles in the medical and pharmaceutical market (Middle East Bank Economic Research Group, 2015). The causes of the seventh to tenth bubbles might be two major political events: the withdrawal of the UK from the UN and the US presidential election in. In addition, oil price fluctuations and the regional and geopolitical developments have had roles to play.

Like many other studies, this study has its own limitations. The data before 2008 was not available, mainly due to the 1979 Islamic Revolution in Iran, the Iran-Iraq war from 1980 to 1988. It is impossible to explore the effects of the Islamic Revolution and the war on the bubbles in the pharmaceutical market due to the lack of data.

Conclusion

Current study addresses the existence of bubbles and their types in the healthcare market of Iran. We used a new method suggested by Phillips et al. (2016) within the ADF, GSADF and SADF models to explore the existence of bubbles, to date stamp possible bubbles, and to determine their type. Results indicate that Iran is now is in the middle of a healthcare bubble.

The results of the model estimation reveal that several bubbles exist in Iran healthcare market, three of which are single and four multiple, based on the SADF method. Employing GSADF test, there are 10 bubbles, two of which are multiple, and the rest are single. The multiple bubbles are formed from July 2013 to September 2014 and September 2014 to June 2015. These bubbles have been continuous in the market and they are likely to continue occurring in the market. However, it should be noted that the bubble in the healthcare market is not an asset bubble, but it is a phenomenon similar to bubble with the risk and applications similar to asset bubble (Colombo & Montecucco, 2013).

Policymakers should be sensitive to the ramifications of healthcare bubble to the improper allocation of resources to this sector which can cause instability in the healthcare system. Policymakers should consider that healthcare bubbles influence the resource allocation in the healthcare sector negatively and hurt the stability of this system. Thus, they should monitor the market to recognize the bubbles so that they can mitigate the consequences of the bubble in the market and orient the prices of medical and pharmaceutical commodities.

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