

Study of Pricing Bubble's formation process in Tehran Stock Exchange (TSE): Applying of Markov Switching Method

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Abstract

The pricing bubble is one of the issues facing the capital markets, which occurs at different stages in the capital markets and with its emergence and fall, many changes occur in the capital markets and the situation of investors. This article seeks to investigate the bubble formation and its fall in the Tehran Stock Exchange using the State-Space Model of the Markov Switching Method. To investigate this issue, the space-state system, two models of Wu [22], Campbell & Shiller [4, 5] have been used, which in one case considers bubble formation and in the other case bubble falling. The studied data were from April 2011 to September 2018 and on a daily basis, which was extracted from the archives of the Tehran Stock Exchange. The stock market has witnessed the bubble formation process a total of 19 times in the period under review, so that in 2011, 4 times, in May, December, February and March in 2012, 5 times in May, July, October, November and February price bubble occurred. Also, in 2013, a price bubble occurred 4 times, which included the months of May, July (2 times), and January. This sequence for 2014, including once in March and in 2015, occurred twice in April and February. In 2016 and 2017, the price bubble did not occur, and in 2018, in June, July and August, there were 3 price bubbles so far.

Keywords: pricing bubble, Markov Switching, state-space model.

1. Introduction

Investment is one of the most important economic variables, which is considered in both macro and micro dimensions in the theoretical economic literature. In the macro dimension, the accumulation of

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capital is one of the variables that determine economic growth in the future and guarantees economic development and stability, and they are available and invested in the right place and time. The capital market is one of the centers for attracting micro-capital, which on the one hand equips resources towards the macroeconomic dimension, and on the other hand, micro and macro investors in this market are towards maximizing their profits. The prominent index of the stock market, like its rival markets such as the gold and exchange markets, is the existence of fluctuations. Fluctuations come in many forms and are sometimes so severe that they are thought of as bubbles. Understanding the trend of these fluctuations is a very effective way to take advantage of the stock market to make a profit and also to make the right decisions in this market for both policymakers and investors. This article seeks to investigate the formation of the price bubble using the Markov Switching Method.

In this paper, the research literature is first discussed, which includes the theoretical and experimental background of the price bubble, then the next part of the research method is described and the research model is presented. In the following, the results obtained from Markov Switching Method and model estimation of Wu [22] and Campbell & Shiller [4, 5] are presented, and finally the conclusion of the research, suggestions and recommendations derived from it are explained.

2. Research Literature

The concept of the bubble has entered the economic literature since the 17th century; However, the price bubble has not been scientifically studied until the end of the twentieth century. Ever since the term bubble was coined in the Iranian capital market in 2003, any rapid price increase has been mistaken for a bubble, but this is not the case, because a bubble occurs when speculation in certain financial instruments, such as stocks, occurs the price to rise and this will lead to more speculation. Under these conditions, the market price reaches a completely irrational level. The bubble is usually faced with a sudden drop in prices, which is interpreted as a fall in the market. The word bubble is coined because prices rise like a soap bubble and eventually burst and fall sharply. Bubbles are often caused by real progress at the level of productivity and initial profitability of a firm or industry, but history has shown that investors are exaggerating the basic capabilities of this economy [10].

In economic history, there are well-known examples of economic crises that have occurred as a result of bubble bursts in asset prices. One of the first examples, often referred to in the bubble literature as a reference point, is the speculative crisis in the Dutch bulb flower during the period 1634-1637. But the first stock market bubbles in the new era of economic history belonged to the French company Mississippi and the South Sea of British Company in the early 18th century. One of the recurring events in the stock market is attracting investors to certain companies or industries, so that there is widespread speculation, but after a while, it is accompanied by a sharp drop in prices. For example, the collapse of the US market in 1929, 1989 and 1990 are clear examples of economic circles. One of the most recent crises is the financial crisis of a large group of industrial economies in 2007-2012 [9].

Interpreting the rate of short-term changes in asset prices within efficient and rational markets remains a challenge. Many experimental studies have shown that stock prices show a kind of "extreme volatility," meaning that prices change so much that they can be interpreted and explained by changes in fundamental elements such as dividends or fund flow is not possible. Another prominent feature of asset prices is the steady and intermittent jump of these prices relative to the estimation of their structural value, which is called the price bubble. This phenomenon can be found in the history of many evidences in different countries and markets [14]. The bubble phenomenon is a term that appears frequently in stock markets. In the following, the internal and external studies on the price

bubble have been studied.

Ansari et al. (2017) in an article have studied the corporate social responsibility and the price bubble in companies listed on the Tehran Stock Exchange. This study investigates the relationship between transparency and quality of financial information disclosure with the possibility of price bubble formation in the period 2010 to 2013, for 158 companies listed on the Tehran Stock Exchange, using Skewness tests, duration dependence and logistic regression. The results show that increases in the variables of transparency, floating stock, financial leverage, and book value to market value ratio and company size reduce the likelihood of stock price bubbles and institutional ownership increases the likelihood of stock price bubbles. In general, experimental results support the hypothesis that there is a negative and significant relationship between the level of transparency of financial information and the bubble of corporate stock prices.

Biyabani et al. (2016) in a study to test the existence of explosive behavior and identify possible bubble periods in the Iranian stock market in the period from January 2008 to September 2014. In this research, GSADF and SADF methods have been used, which are based on the root test of the second right ADF unit. Based on the results obtained in the 69 months studied, 15 months, including July to January 2013, the stock market has faced the bubble phenomenon.

Samimi and Balonejad [11] in a study have tested the existence of multiple price bubbles in the Tehran stock market. For this purpose, monthly data of total price and profit index for the period 2000 to 2013 have been used. In this study, Generalized Supremum Augmented Dickey-Fuller Method was used. The results of the research confirmed the hypothesis of a price bubble in the stock market.

Mirfeiz Fallah Shams Lialestani et al. (2013) in their study entitled "Investigation of the existence of bubbles in stock prices based on ARIMA estimates and using the techniques of kurtosis, skewness, sequencing and risk function" concluded that: Tehran Stock Exchange has witnessed many fluctuations since its reopening in 1989.

Price fluctuations are part of the nature of the market, but sometimes these fluctuations go out of their normal form and give way to libertine rises (bubbles) and sudden falls (crises) and inflict irreparable blows on the stock market. In this study, with given the importance of the stock price, we examine the existence of bubbles using daily and monthly data between 2003 and 2010 with sequence, kurtosis, skewness and risk function tests. The results of the kurtosis and sequence tests and the risk function for daily return prove the existence of bubbles in the Tehran Stock Exchange, but the skewness test denies the existence of bubbles in the stock market.

Abbasian et al. [2] in a study investigated the effect of monetary policy on the emergence of stock price bubbles in the Tehran Stock Exchange. The price bubble means a sharp and steady increase in the price of assets. This phenomenon is such that the initial price increases due to factors such as predicting future price increases will attract new buyers, speculation and hence further increase prices. To investigate this issue, the main hypothesis of this research is whether the sharp increase in stock prices on the Tehran Stock Exchange is determined by the fundamental factors of the market or whether speculation of market factors also play a role in determining the price? In order to examine the relationship between monetary policy and stock prices, the transfer mechanism is based on a linear model of rational expectations, assuming predictive behavior in stock prices within the framework of the new Keynesian school. Experimental studies of this issue using GMM instrumental variables method and using statistical data in the period of April 2000 to March 2009 show that the real rate of interest has a negative effect and the production has a positive but weak effect on the real return on stock. Also, the returns of previous periods have a positive feedback on current stock prices, which indicates the existence of speculative behaviors and price deviations from their intrinsic value.

Vakilifard et al. [21] in an article have studied the relationship between free float and creating a

price bubble in companies listed on the Tehran Stock Exchange. The results of testing with research hypotheses in the period 2002 to 2006 show that there is a significant relationship between the amount of free float of companies and the occurrence of pricing bubbles, and companies with less than 20 percent of their free floating are more likely to be exposed to price bubbles than other companies.

Asadi et al. [1] in their study examined stock price bubbles on the Tehran Stock Exchange according to the size of the company and the type of industry during the period 1991 to 2005 with a sample consisting of 70 active companies and using the co-integration method. The results of the study showed that there is a significant relationship between the size of the company and the price bubble, but there is no such relationship between the price bubble and the type of companies' industry.

In this article, Escobari et al. [8] identify price bubbles in Latin American stock markets. In their study, they used the generalized augmented Dickie Fuller Return Method and a similar Phillips-Peron Method. In their study, they found that price bubbles in the 2008 financial crisis preceded bubbles in the United States and lasted longer in the US market.

Klotz et al. [13] modeled the existence of a price bubble in the market. They conducted their research in Greece, Ireland, Portugal and Spain. Their results showed that in Spain and Ireland the price bubble was much larger than in Portugal and Greece from 2003 until the 2008 crisis that led to the bursting of the bubble. The results showed that the central bank's monetary and fiscal policies affected the interest rate and the volume of lending on the price bubble in these countries, and this exacerbated the problem.

In this study, Dow & Han [6] examined the effect of management contracts and debt constraints on creating a price bubble in assets. In the present study, the researcher predicts the existence of a price bubble in the asset, considering the issues related to debt and the risks arising from asset management. The results show that the replacement of assets does not lead to a price bubble, but the shortcomings in management contracts and the resulting conflict of interest cause to the creation of intermediaries that risk the creation of limited tenders and cause management to asset price optimism is stimulated. Ultimately, this creates a price bubble in contracts and documents the asset price bubble by restricting debt.

In this article, Narayan et al. [17] have studied the determinants of the price bubble in the stock market. With using data from 589 companies listed on the New York Stock Exchange, they found that trading volume and price tucks significantly affected the asset price bubble. They evaluated positively this effect in the electricity, energy, banking and finance sectors and the in the smallest companies.

Stephen and Porter (2010) examined the price bubble using its duration dependence by hypothesizing "whether stock price growth was due to government monetary and fiscal policies"; and VAR self-regression model was used to show the contribution of the return on the monetary policy. Studies have shown that the created bubble is a kind of rational bubble and policies with a delay of one month on the return of the created share based on the monetary policy of the past month can be predicted.

Miller & Ratti [16] examined the relationship between stock markets and crude oil prices and the existence of bubbles in these markets. In their study from 1971 to 2008, they used the vector error correction model. The results showed that in the long term, the stock market has a significant and negative reaction to oil prices and returns' stock decrease with increasing oil prices and vice versa.

Palshikar, et al. [19] showed that there are collective agreements and collisions that expose the market to the price bubble and its consequences. The results of studies regulate algorithms and diagrams that identify and predict market disease. In addition, and in different cases, the price in the selected fields nominates suspicious cases for collusion, and according to the defined indicators,

it measures the desired algorithm for these cases.

Nunes & Silva [18] investigated the existence of rational bubbles in 18 stock markets using both conventional and threshold co-integration models. According to the estimation results of both models, there are Explosive Bubbles in Chilean, Indonesian, Korean and Philippine stock markets, and Collapsing Bubbles in the stock markets of China, Brazil, Venezuela, Colombia, Chile, Indonesia, Korea and the Philippines. Qin et al. [20] in their study entitled "Markov Switch Unit Root Test: A Case Study of Real Estate Bubbles in Hong Kong and Seoul" concluded: Evans(1991) showed that the unit root test recommended by Hamilton & Whiteman (1985) and Diba & Grossman (1988) was able to identify the period of the collapse of the rational bubbles. Hall et al. (1999), however, showed that the strength of this test method could be improved by combining a variable with the Markov switching pattern. In the study by Zia Kane et al., Both methods were applied to selected data from Hong Kong and Seoul. The results show that in both methods, the probability of bubble collapse period, there is a series of prices under consideration, leading to the second method was more accurate at the time of bubble study. The Markov switching model is validated in this study with using the Symmetry and the Wald test.

Koustas & Serletis [15] used the Fractional Integration technique and the ARFIMA model to examine the existence of a unit root in the S&P 500 stock price logarithm and the hypothesis that exogenous shocks have a permanent effect. According to the experimental results, the null hypothesis of the existence of a unit root and consequently the existence of a rational bubble in the S&P 500 index is strongly rejected, which indicates that the dividend price logarithm is a kind of inverse mean process.

3. Research Method

This study from the point of view of purpose is fundamental due to the study of the relationship between variables and its novelty in this field, and because its results can be used in decisions, it is also included in the category of applied research. The method of data collection is library method. This study has used the Markov Switching Method to investigate the formation of a price bubble in the framework of the State-Space Model in the Tehran Stock Exchange. The model used is derived from the study of Wu [22] and Campbell and Shiller [4, 5]. This model considers two different modes: one mode is regime 1 and with the fall of the price bubble and the other mode is the regime 2 with the formation of the price bubble. This study focuses on the regime 2 that obtained from the estimates of the formation of price bubbles. The study period was from the beginning of April 2011 to the end of September 2016. The data are used on a daily basis and are collected from the archives of the Tehran Stock Exchange.

3.1. Research Model

In this section, the standard stock value model is reviewed based on the logarithmic-linear approximation proposed by Campbell and Shiller [4, 5]. Equation (3.1) shows the rational expectation model of stock price determination:

$$q = k + \psi E_t(P_t + 1) + (1 - \psi)d_t - P_t \quad (3.1)$$

Here, q represents the logarithmic rate of gross yield, $E_t(0)$ is an operator of the conditional mathematical expectation for all data on t , $p_t = \ln(P_t)$ is a logarithm real price on t , $dt = \ln(Dt)$ is a Logarithm and real returns' stock on t , and k & ψ are the linearization parameters which are in accordance with $0_p \psi_p 1$.

Equation (3.1) is a linear differential equation for the logarithm real stock price that can be solved by the following iterative solution. With considering the condition of transferability:

$$\lim_{i \rightarrow \infty} \psi^i E_t(P_t + i) = 0 \quad (3.2)$$

Here, is a unique non-accounting solution:

$$P_t^f = \frac{k - q}{1 - \psi} \sum_{i=0}^{\infty} \psi^i E_t(d_{t+i}) \quad (3.3)$$

The P_t^f non-computational solution in Equation (3.2) provides the conventional present value equation, which states that the stock price logarithm is equal to the expected stock return value logarithm. However, it is important to note that from a mathematical point of view, the high transferability condition does not apply here. In the previous case, the P_t^f non-bubble solution is only a specific solution to the differential Equation (3.1). The general solution is as follows:

$$P_t = P_t^f + B_t \quad (3.4)$$

Along with the process of $\{B_t\}$ Which is true in the exogenous differential equation (Cuthbertson & Nietzsche1, 2004):

$$E_t(B_{t+i}) = \frac{B_t}{\psi^i} \quad \forall i = 1, 2, \dots \quad (3.5)$$

Clearly, the general solution of Equation (3.4) consists of two components. The first component involves ap_t^f non-bubble solution and depends solely on the logarithm of stock returns, and is therefore often referred to as the fundamental market solution. The second component is the B_t mathematical component, which includes unusual or non-original market events and is considered as a rational bubble.

In order not to face the non-static problem, the model must be expressed in the form of the first difference, in the seventh order of Equations (3.2) and (3.3) can be:

$$\Delta p_t = \Delta p_t^f + \Delta B_t = (1 - \psi) \sum_{i=0}^{\infty} \psi^i [E_t(d_{t+i} - E_{t-1}(d_{t+i-1}))] + \Delta B_t \quad (3.6)$$

Here, shareholders' equity returns are assumed to have a unit root [23]. But the stock returns can be approximated using an auto regression moving average (ARIMA) model. Specifically, it is assumed that an ARIMA process $(h, 1, 0)$ is as follows:

$$\Delta d_t = \mu + \sum_{j=1}^h \phi_j \Delta d_{t-j} + \delta_t \quad (3.7)$$

Here, $\delta_t : N(0, \sigma_\delta^2)$ indicates white noise error, and h is a self-return order that can be estimated using the data.

In the following, the self-return order (3.6) can be defined. The vector $(h \times 1)$ is as follows:

$$y_t = (\Delta d_t, \Delta d_{t-1}, \dots, \Delta d_{t-h+1})', \quad u = (\mu, 0, 0, \dots, 0)', \quad v_t = (\delta_t, 0, 0, \dots, 0)'$$

And the matrix ($h \times h$) is equal to:

$$A = \begin{pmatrix} \phi_1 & \phi_2 & \phi_3 & \cdots & \phi_{h-1} & \phi_h \\ 1 & 0 & 0 & \cdots & 0 & 0 \\ 0 & 1 & 0 & \cdots & 0 & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & \cdots & 1 & 0 \end{pmatrix}$$

Equation (3.7) can be rewritten as follows:

$$y_t = u + Ay_{t-1} + v_t \tag{3.8}$$

This equation is based on the study of Shiller and Campbell [4, 5] and equation (3.6) for the stock price model can be calculated using the following formula:

$$\Delta p_t = \Delta d_t + m\Delta y_t + \Delta B_t \tag{3.9}$$

Here, m is a vector ($h \times 1$) defined as follows:

$$m = gA(I - A)^{-1} [I - (1 - \psi)(I - \psi A)^{-1}] \tag{3.10}$$

Here, g is a vector ($h \times 1$) defined as $g = (1, 0, 0, \dots, 0)'$ and I is a unit vector of ($h \times h$). According to Wu [23], a linear bubble process $\{B_t\}$ is considered. Hence, Equation (3.4) implies that:

$$B_t = (1/\psi)B_{t-1} + \eta_t \tag{3.11}$$

Here, η_t is a process with uniform and independent distribution $N(0, \sigma_\eta^2)$.

Therefore, η_t has not correlation with the δ_t in Equation (3.7).

When estimating equation (3.9) of stock prices, we face this problem that $\{B_t\}$ is invisible. This can be solved using the Kalman filter, which requires the present value model to be defined in the state-space form.

3.1.1. State-Space and Kalman filter Model

In this section, we define the present value model in the previous section in the form of state-space model, so that Kalman filter can be used to estimate the price bubble of invisible property, which is based on Wu's [22] method.

Suppose that β_t is a vector ($n \times 1$) of invisible variables that considered as state variables. Also, g_t and z_t two vectors ($m \times 1$) and (1×1) are visible variables that are considered as input and output variables, respectively. Therefore, the state -space model can be written as follows:

$$\beta_t = F\beta_{t-1} + \xi_t \tag{3.12}$$

$$Z_t = H\beta_t + Dg_t + \zeta_t \tag{3.13}$$

Here, ξ_t and ζ_t both vectors of the disorder ($n \times 1$) and (1×1) are present, and F , H , and D are the real fixed matrix of the consistent dimensions. It is assumed that the ξ_t and ζ_t disorder vectors are serially unrelated to each other as we have:

$$\begin{aligned} E(\xi_t) &= 0 & E(\zeta_t) &= 0 \\ E(\xi_t \xi_t') &= \Omega & E(\zeta_t \zeta_t') &= R \end{aligned}$$

Equations (3.12) and (3.13) are respectively transfer and action equations. The proposed economic model basically consists of 3 components:

1. ARIMA Process $(h, 1, 0)$ Shareholders 'Equity Return Δd_t of Equation (3.7)
2. Stock price process Δp_t of Equation (3.9)
3. Process B_t of equation (3.11)

The whole said economic model can be written in the form of state-space model as follows:

$$\begin{aligned} \beta_t &= (B_t, B_{t-1})', \quad Z_t = (\Delta d_t, \Delta p_t)', \quad g_t = (1, \Delta d_t, \Delta d_{t-1}, \Delta d_{t-2}, \dots, \Delta d_{t-h})' \\ \xi_t &= (\eta_t, 0)', \quad \zeta_t = (\delta_t, 0)' \end{aligned} \quad (3.14)$$

$$\begin{aligned} F &= \begin{pmatrix} 1/\psi & 0 \\ 1 & 0 \end{pmatrix}, \quad H = \begin{pmatrix} 0 & 0 \\ 1 & -1 \end{pmatrix}, \\ D &= \begin{pmatrix} \mu & 0 & \phi_1 & \phi_2 & \dots & \phi_{h-1} & \phi_h \\ 0 & (1+m_1) & (m_2-m_1) & (m_3-m_2) & \dots & (m_h-m_{h-1}) & -m_h \end{pmatrix} \end{aligned} \quad (3.15)$$

Here, m_i is an i of the vector component $(h \times 1)$ belongs to the variable m in Equation (3.10). The Ω and R covariance matrices are defined as follows:

$$\Omega = \begin{pmatrix} \sigma_\eta^2 & 0 \\ 0 & 0 \end{pmatrix}, \quad R = \begin{pmatrix} \sigma_\delta^2 & 0 \\ 1 & 0 \end{pmatrix}, \quad (3.16)$$

Finally, the asset price bubble behaves invisibly in the proposed state-space model, and here, the equations can be divided into two categories of transition and action. Both Equations (3.11) represent the transfer of the bubble process, while the first equation of action (Equation (3.6)) shows the process of shareholders' equity return and the second equation of action in Equation (3.9) shows the price process.

3.1.2. Kalman Filter Technique

In this section, the Kalman filter process used to estimate asset price bubbles is given in general. Here, the main issue is to estimate the invisible vector of the β_t state. Here, $\beta_{t|T}$ is the best estimate β_t of the square mean of the model in τ time. $\beta_{t|T}$ and its covariance matrix can be obtained from the following equations:

$$\begin{aligned} \beta_{t|t-1} &= F\beta_{t-1|t-1} \\ P_{t|t-1} &= FP_{t-1|t-1}F' + \Omega \\ \zeta_{t|t-1} &= z_t - H\beta_{t|t-1} - Dg_t \\ \beta_{t|t} &= \beta_{t|t-1} + K_t\zeta_{t|t-1} \\ K - t &= P_{t|t-1}\dot{H}[HP_{t|t-1}\dot{H} + R]^{-1} \\ P_{t|t} &= [I - K_tH]P_{t|t-1} \end{aligned}$$

Here, the covariance matrix of $1 \leq t \leq T$ errors over time consists of the following two equations:

$$P_{t|t-1} = E[(\beta_t - \beta_{t|t-1})(\beta_{t|t-1})'] \quad (3.17)$$

$$P_{t|t} = E[(\beta_t - \beta_{t|t})(\beta_t - \beta_{t|t})'] \quad (3.18)$$

The above equations form the Kalman filter and are calculated backwards. More efficient estimates using all the information up to T time can be obtained using a more uniform complete sample:

$$\beta_{t-1|T} = \beta_{t-1|t-1} + J_{t-1}(\beta_{t|T} - F\beta_{t|t-1})$$

$$P_{t-1|T} = P_{t-1|t-1} + J_{t-1}(P_{t|T} - P_{t|t-1})J'_{t-1}$$

$$J_{t-1} = P_{t-1|t-1} \dot{F} P_{t|t-1}^{-1}, \quad t = T - 1, T - 2, \dots, 1$$

The more uniform equations above are estimated backwards.

Kalman Filter considers the model parameters as known parameters. In practice, the parameters of matrices such as F, H, D, and R are unknown and need to be estimated. By summing the unknown parameters in the α vector, we can be estimated by the following likelihood exponential function method (Hamilton, 1994):

$$L(\alpha|z, g) = const - \frac{1}{2} \sum_{t=1}^T \left(In[\det(HP_{t|t}\dot{H} + R)] + \zeta_{t|t-1}' \dot{H} + R \right)^{-1} \zeta_{t|t-1} \quad (3.19)$$

In Equation (3.19), both $\zeta_{t|t-1}$ and $P_{t|t-1}$ implicit phrases and functions of the unknown vector α are examined using the Kalman filter. When obtained using the maximum likelihood of α it estimates the uniformity of the state vector, and its error covariance matrix can be determined using the Kalman filter and the complete sample of the high uniformity state.

3.1.3. State-Space Model using Markov Switching

In this section, two distinct regimes are introduced in the context of the state-space model from the previous section. This idea is based on the fact that alternative regimes allow us to distinguish between periods of mild and explosive growth of bubble formation processes (Evans, 1991). This study limits its focus to modeling two regimes. The econometric methodology of this section follows the study of Kim and Nelson [12], which assumes the general state of $M \geq 2$ regimes.

3.1.4. Model Specification

In this part, we begin with the dynamic system of transitional equations and action (3.12) and (3.13). In this section, it is assumed that the parameters F, H, D, and R fluctuate between the two regimes, and therefore the state-space model can be expressed as follows:

$$\beta_t = F_{S_t} \beta_{t-1} + \xi_t \quad (3.20)$$

$$Z_t = H_{S_t} \beta_t + D_{S_t} g_t + \zeta_t \quad (3.21)$$

$$\begin{pmatrix} \xi_t \\ \zeta_t \end{pmatrix} \sim N \left(0, \begin{pmatrix} \Omega_{S_t} & 0 \\ 0 & R_{S_t} \end{pmatrix} \right) \quad (3.22)$$

Here, S_t it shows how the parameters in the upper matrix are controlled in a random two-state regime and what mode the parameters are in $tS_t = (S_t = 1, 2)$. In this section, we show the probabilistic nature S_t using the Markov first-order process and fixed transfer probabilities $p_{ij} = Pr[S_t = j | S_{t-1} = i]$ which are summarized in the transfer probability matrix:

$$\Pi = \begin{pmatrix} P_{11} & 1 - p_{12} \\ 1 - p_{11} & P_{22} \end{pmatrix} \quad (3.23)$$

4. Results

The Markov Switching Model is a good model for estimating if the pattern of data examined is nonlinear. An LR test is used to ensure that the data pattern is nonlinear. The statistical value of this test is calculated from the maximum displacement values of two competing models, one model with one regime (linear model) and the other model with two regimes (nonlinear model) and has a Chi square distribution.

If the statistical value is higher than the critical values at the desired confidence level, it can be concluded that the linear model at that confidence level is not a suitable model and a nonlinear model should be used. Table 1 shows the results of the LR test:

Table 1: LR test: presence or absence of nonlinear pattern

Possibility	Statistical value
0.000	29.86

As the results of the table above, the studied variables follow a nonlinear pattern; therefore, linear methods are not suitable for estimating model parameters and non-linear methods should be used to obtain the relationships between variables. Table 2 presents the estimated coefficients of the price index:

Table 2: Results from model estimation

Coefficients	value	Z statistic	Possibility
Price index (regime 1)	-0.43	0.03	0.00
Price index (regime 2)	-6.25	0.06	0.00

As can be seen from Table 2, the coefficients obtained are significant for the price index. The following is the variable process in Kalman filter model. First, Figure 1 shows the real index of Tehran Stock Exchange, which includes the period from April 2011 to September 2016. Figure 2 shows the Kalman filter model obtained by estimating the Markov Switching method.

As Figure 1 shows, there are a lot of fluctuates in the real rate of the Tehran Stock Exchange. The cross-sectional line shows the linear trend of this index, which shows that the index as a whole has a positive trend during the study period. It is noteworthy that the real rates of the index in 2013 are equal to the index in 2018, except for 2013, that the index increased steeply; For the rest of the year, it has seen a slight increase in slope, and it looks like we will see an increase in the index with a steep slope in 2018, but it is not clear how much this increase will increase with this slope or, like in 2013, it will be a definite and long-term increase in the period under study.

Figure 2 shows the regime 2 and the bubble formation regime. According to this chart, the stock market has witnessed a total of 19 bubble formation processes in the period from April 2011 to September 2018. Therefore, in 2011, a price bubble occurred 4 times in May, December, February and March, in 2012, 5 times in May, July, October, November and February. Also, in 2013, a price bubble occurred 4 times, which included in May, July (2 times), and January. This sequence for 2014 includes once in March and in 2015, it happened twice in April and February. In 2016 and 2017, the price bubble did not occur or was not identified, and so far, there have been 3 price bubbles in 2018, in the months of June, July and August.



Figure 1: Real index of total price of Tehran Stock Exchange

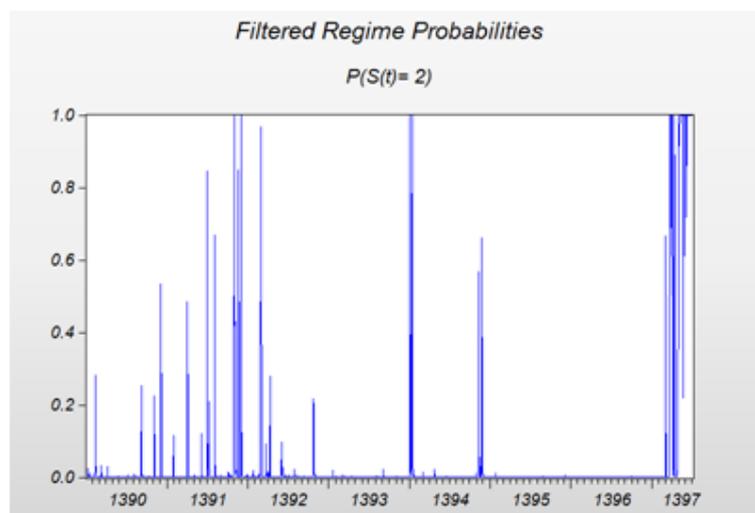


Figure 2: Examination of regime 1 by Kalman filter diagram

Table 3: Transmission probabilities between the two regimes

Type of regime	regime 1	regime
Regime 1	0.994	0.005
Regime 2	0.139	0.860

The following are the results of the probability matrix of both regimes. These probabilities can be seen in Table 3.

As can be seen from Table 2, both regimes are highly stable, but diet 1 is more stable because of price bubble falling. But overall, both regimes are highly stable. Here, the price bubble formation regime is less stable and the price index is less likely to be present and remain in this regime than the price bubble falling regime.

5. Conclusion

Price bubbles in the markets are a common phenomenon that are more present in the capital markets. This phenomenon has severe consequences for the situation of investors in terms of profitability and psychologically. On the other hand, knowing the process of financial markets helps to make better investment decisions. This paper uses the model of Wu [22] and Campbell and Shiller [4, 5] in the framework of a two-mode state-space model, namely a bubble formation regime and a bubble-falling regime, which is investigated using Markov Switching Method to investigate the bubble in the Tehran Stock Exchange.

The results of this study showed that based on the model used, the stock market has witnessed a bubble formation process a total of 19 times in the period from April 2011 to September 2018; therefore, a price bubble occurred in 2011, 4 times in May, December, February and March, and in 2012, 5 times in May, July, October, November and February. Also, in 2013, a price bubble occurred 4 times, which included the months of May, July (2 times), and January. This sequence for 2014 includes once in March and in 2015 happened twice in April and February. There was no price bubble in 2016 and 2017, and in 2018, there were 3 price bubbles in June, July and August. The results also show that both regimes have a high probability of a transfer matrix, that indicating the high stability of these two regimes. Of course, regime 2, which is a price bubble formation regime, is less stable than regime 1, which is a regime with a falling bubble.

Finally, it is suggested that the dimensions of other indicators of the Tehran Stock Exchange be examined using the size of the models and the study of different diets in the state-space model. Also, it should be examined from different perspectives such as the effect of social and political variables on the formation of price bubbles in the Tehran Stock Exchange.

References

- [1] Gh. Asadi, M.R. Hamidizade, A. Soltani, Study of pricing bubble in Tehran stock exchange based on company size and type of industry, *Journal of accounting studies*, 14 (2006): 39-71.
- [2] E. Abbasian, M. Nazari, E. Farzanegan, Effect of money policy in emergence of the price bubble in Tehran stock exchange, *Journal of Financial Exchange*, 18 (2012): 75-92.
- [3] K. BiyabaniKhamen, S. Khazaei, A.H. Afsharian, Test of bubble and explosive behavior in Iran stock market, *Journal of financial knowledge and analysis of stock exchange*, 29 (2016): 111-125.
- [4] J.Y. Campbell, R.J. Shiller, The Dividend-Price Ratio and the Expectations of Future Dividends and Discount Factors, *Review of Financial Studies* 1.3 (1988a): 195-228.
- [5] J.Y. Campbell, R.J. Shiller, Stock Prices, Earnings and Expected Dividends, *Journal of Finance* 43.3 (1988b): 661-676.
- [6] J. Dow, J. Han, Contractual incompleteness, limited liability and asset price bubbles, *Journal of Financial Economics*, 116.2 (2015): 383-409.
- [7] M.H. Ebrahimi Sarvolia, M. FallahShams, Sh. Azarang, Study of effective factors on pricing bubble in Tehran stock exchange. *Journal of financial engineering and stock exchange management*, 17 (2013): 107-115.
- [8] D. Escobari, S. Garcia, C. Mellado, Identifying bubbles in Latin American equity markets: Phillips-Perron-based tests and linkages. *Emerging Markets Review*, 33 (2017): 90-101.
- [9] J.E. Gomez-Gonzalez, J.N. Ojeda-Joya, C. Rey-Guerra, N. Sicard, Testing for Bubbles in Housing Markets: New Results Using a New Method. *Federal Reserve Bank of Dallas, Working Paper*, 164 (2013).
- [10] A. Greenspan, Risk and Uncertainty in Monetary Policy. Remarks at the Meetings of the American Economic Association, San Diego, California, January 3rd, 2002.
- [11] A. Jafari Samimi, R. Balunejad, Test of multiple pricing bubble in stock market: General Supreme method generalized DK-Fuller, *Journal of Economic Modeling Research*, 21 (2015): 7-33.
- [12] C.J. Kim, C.R. Nelson, *State Space Models with Regime Switching*, MIT Press, Cambridge, 1999.
- [13] P. Klotz, T.C. Lin, S.H. Hsu, Modeling property bubble dynamics in Greece, Ireland, Portugal and Spain, *Journal of European Real estate research*, 9.1 (2016): 52-75.
- [14] G. Komaromi, Was There a Stock Market Bubble in Hungary? *Competitio*, 3.1 (2004): 169-178.

- [15] Z. Koustas, A. Serletis, Rational bubbles or persistent deviations from market fundamentals?. *Journal of Banking & Finance*, 29.10 (2005): 2523-2539.
- [16] J.I. Miller, R.A. Ratti, Crude oil and stock markets: Stability, instability, and bubbles. *Energy Economics*, 31.4 (2009): 559-568.
- [17] P.K. Narayan, S. Mishra, S. Sharma, R. Liu, Determinants of stock price bubbles. *Economic Modelling*, 35 (2013): 661-667.
- [18] M. Nunes, S. Da Silva, Rational bubbles in emerging stockmarkets, 2007.
- [19] G.K. Palshikar, M.M. Apte, Collusion set detection using graph clustering, *Data Mining and Knowledge Discovery*, 16 (2008): 135-164.
- [20] X.I.A.O. Qin, G.K.R. Tan, Markov-switching unit root tests: a study of property price bubbles in Hong Kong and Seoul, In *The 35th Australian conference of economists (ACE)*, 2006.
- [21] H.R. Vakilifard, Gh. Talebnia, M. Kiyani, Study of free float ratio relation with pricing bubble in accepted companies in Tehran stock exchange, *Journal of financial engineering and portfolio management*, 4 (2010): 67-87.
- [22] Y. Wu, Are there rational bubbles in foreign exchange markets? Evidence from an alternative test. *Journal of International Money and Finance* 14 (1995): 27-46.
- [23] Y. Wu, Rational Bubbles in the Stock Market: Accounting for the U.S. Stock-Price Volatility. *Economic Inquiry* 35 (1997): 309-319.