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# A Financial Engineering Approach to Identify Stock Market Bubble

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**Abstract**

In this paper we adopt an engineering method based on Al-Anaswah and Wilfling, state space model with Markov-switching, to capture the speculative bubbles of stock markets in China and US. We present the VAR log linear asset pricing model in state space model with Markov-switching, so that we can capture the unobservable speculative bubbles. Based on the dataset from Stock markets in China and US, we find empirically that the engineering technique we choose detect the stock markets bubbles effectively, and that the switching probabilities between the surviving and collapsing regimes. In-the-sample and out-of-sample forecasting further support our empirical evidence.



*Keywords:*Bubble;VAR-loglinear asset pricing; State space model with Markov-switching; financial engineering

## 1. Introduction

After several decades of research, financial economists remain unsatisfied about how to measure and identify stock market bubble, especially how to capture and forecast the regime-switching behaviour of speculative bubbles, which is also essential to authorities and investors. Due to the fact that stock bubbles are unobservable, this question has puzzled people for a long time. What is more, since China's stock market is more complicated, could the bubbles be explained in the same way like other countries such as US? What are the similarities and the differences of the stock market bubbles between China and US?

In this paper, we express the VAR-loglinear asset pricing model into state space form in order to capture the unobservable bubble process by using Kalman filter. On top of that we add a two-state Markov-switching to analyse the regime features and the switching probabilities of bubbles. In other words, we adopt a state space model with Markov-switching to identify the stock market bubbles both in China and US.

We obtain an encouraging overall result that the econometric framework we adopt is able to detect bubble periods not only in US, but also in China. This result indicates that we are able to identify the surviving regime and the collapsing regime as well as the switching probabilities in our samples, by employing state space model with Markov-switching. In both countries, the stock market bubble collapses periodically after some asymmetric duration of one regime. However, the duration of the collapsing regime is longer in China than it is in US. Besides that, our in-the-sample and out-of-sample forecasting further support our empirical evidence.

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The contributions of this study are twofold. First, based on the dividend multiple measure of fundamentals, we succeed in overcoming the shortage of the data in China's stock market and in finding statistically significant regime-switching characteristics of the stock-price bubble processes in China as well as in US. Second, we find substantial similarities and differences of the stock market bubbles between China and US, consequently enriching the current empirical research of the stock market bubbles.

The rest of this paper is organised as follows. In section 2 we present the literature review of related research. In section 3 we derive the state space model with Markov-switching, and show how switching regression model can capture the characteristics of stock market bubbles. Section 4 presents the data, the methodology used to construct fundamental values, the main tests, and our estimate outcome, while in section 5 we examine the in-the-sample and out-of-sample forecasting ability. Section 6 concludes.

## 2. Literature review

It has been a long time for the economists to be concerned about the econometric detection of stock market bubbles. Initially, these studies focused on the indirect identification of speculative bubbles in stock market [2-5].However, indirect tests of stock market bubbles are often criticized, not only since speculative bubbles always display explosive growth but also because effects of bubble in stock prices could not be distinguished easily from the effects of unobservable market fundamentals, see [6-7]. For this reason, so-called direct bubble tests have been developed, which directly specify and examine the presence of a particular form of speculative bubble [7-9].West [8] sees bubble as an alternative regime definitely different from the stationary autoregressive process, and takes a statistically significant difference between two alternative estimators of one certain parameter as an indication of a speculative bubble.

Hall, Psaradakis and Sola [10] in the first time introduce Markov-switching (Hamilton [11, 12]) technique into ADF tests, in order to distinguish discrete regimes (surviving regime and collapsing regime) in time series data of bubbles. Although this technique is criticized for the size distortion by Van Norden and Vigfusson [13], the methodology of Markov-switching has been used by more and more people due to the fact that bubbles often switch between two or more regimes [14,15].

As for the China`s stock market bubbles, [16-18] employ three-regime model in their empirical research respectively. Fan, Lu and Wang [19] also use a three-regime MS-VECM model to study the relationship between China and US. However, based on the indirect test method, Meng, Zhou and Wang [20] obtain a two-regime behaviour formula that the price bubble fulfils and argue that the third regime is insignificant in China`s stock market. Apart from that, Zhao and Zeng [7] find that the monthly return process can be obviously divided into two states, namely, bubbles survival state and bubbles collapse state. Li [21] describes an expansion and collapsing process of speculative bubble in China`s stock market by suing a regime switch model to study the non-linear relationship of return and turnover. Based on the literatures above and the flexibility of computing, we choose a two-regime specification in this paper.

Due to the fact that asset bubbles are unobservable, state space model is frequently applied in research of asset bubbles. It is well known that, based on state space model, Kalman filter is a powerful econometric tool in estimating the unobservable variable. Wu [9] estimates the deviation of stock prices from the present-value model and construct the time series of S&P500 using the state space model and Kalman filter. In China, Hang, Liu and Cao [22] adopt this methodology in their research of estate bubble of Shanghai, Tang, Cai and Xie [23] use the dynamic distributed lag model and the state space model to analyses the stock market wealth. Wang [24] applies the state space model and the general Kalman filter method to the real estate market of the main cities in China.

Al-Anaswah and Wilfling [1] treat the bubble as an unobservable variable as in Wu [9] but extend the framework by allowing the bubble to switch between alternative regimes. Through this they succeeded in separating two distinct periods in the bubble process from each other. Technically speaking, we implement Markov-switching in our unobserved-components framework by adopting the methodology from Kim and Nelson [25] who show how to use state space models that are subject to regime-switching. Hitherto, this econometric technique has mainly been used for the detection of turning points in business-cycle research (see [26-28]) and its application to the stock market bubbles in China, compared to the US, constitutes the innovation of this paper.

## 3. State space model with Markov-switching