https://doi.org/10.17221/151/2018-AGRICECON

Do natural rubber price bubbles occur?

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Citation: Su Ch.-W., Liu L., Tao R., Lobonț O.-R. (2019): Do natural rubber price bubbles occur? Agricultural Economics – Czech, 65: 67–73.

Abstract: In this paper, we employ the Generalized Supremum Augmented Dickey-Fuller test in order to identify the existence of multiple bubbles in natural rubber. This approach is practical for the using of time series and identifies the beginning and end points of multiple bubbles. The results reveal that there are five bubbles, where exist the divergences between natural rubber prices and their basic values on account of market fundamentals. The five bubbles are related to imbalance between supply and demand, inefficiencies of smallholders market, oil prices, exchange rate and climatic changes through analyses. Thus, the corresponding authorities are supposed to identify bubbles and consider their evolutions, which is beneficial to the stability of natural rubber price.

Keywords: bubbles; Generalized Supremum Augmented Dickey-Fuller test (GSADF); natural rubber price

This paper examines the multiple bubbles in natural rubber prices using Generalized Supremum Augmented Dickey-Fuller (GSADF) method emphasised by Phillips et al. (2013). Natural rubber is one of the world's most significant raw materials for the agro-based industry (Chang et al. 2011). Natural rubber price is an important economic parameter that profoundly affects a country, because of the strategic character of this resource (Goh et al. 2016). The price of natural rubber has begun to fluctuate dramatically since 2005, and the rubber situation on the global market has prompted high prices widely. As the economy is booming, China and India are the top two countries in importing rubber, which results in strong demand. Both importing and exporting countries are severely affected by natural rubber price fluctuations. For example, the global natural rubber market mainly refers to China, Europe, India, the U.S., and Japan, which were the top five countries in terms of natural rubber consumption in 2015 respectively. At the same time, the huge demand for natural rubber also affects exporting countries. Thailand is the most important natural rubber producer all over the world, and due to its production value, export revenues and employees in the natural rubber industry, it has a great economic and social significance in the country.

The world natural rubber industry will generate positive net trade flows, providing stable employment and income for the producing countries (Khin et al. 2011). Rubber prices in the world market fluctuate dramatically, being influenced by supply, weather, consumption, currency exchange, policy changes, crude oil prices and speculative forces (Njavallil et al. 2016). The natural rubber price has experienced multiple periods of high volatility from 1985 to 2017 and reached unprecedented heights in 2006, 2008 and 2011. Extensive fluctuations in prices are often accompanied by bubbles, resulting in an adverse impact on the supply and demand sides of natural rubber. Thus, the reasons behind natural rubber price bubbles and the relevant policies for supply and demand sides are discussed in this paper. The first reason is the gap between the demand and supply for natural rubber. The auto and tire industries in China increased the demand for natural rubber, and it is expected that the consumption of natural rubber would continue to grow and achieve 6 791 thousand tons by 2018.

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Second, the exchange rate has a major impact on global commodities, including natural rubber. For example, an appreciation in the exchange rate from Chinese Yuan against Thai Baht means that one Yuan can increase its value in Baht, which will affect the increase in demand for natural rubber. Third, another reason stems from the rising cost of oil, which signifies that natural rubber is more competitive than synthetic rubber. Synthetic rubber is a substitute commodity for natural rubber, with the synthetic rubber price declines, it affects the drops in the demand of natural rubber (Romprasert 2011). Fourth, the production of natural rubber is affected by weather and related damages caused by a variety of diseases and pests, which is related to the increase in the price of natural rubber. The last reason represents the high speculations, which result in high prices. Due to the quality of natural rubber, smallholders and traders can consequently bargain harder to obtain better prices for natural rubber.

We locate possible bubbles in the natural rubber market through Supremum Augmented Dickey-Fuller (SADF) and GSADF tests, which provided Phillips et al. (2013, 2014). Being different from previous recursive procedures, the Phillips et al. (2013, 2014) procedure is specifically useful as a real-time bubble detection algorithm, and it performs satisfactorily for structural breaks. Through detecting, bubbles are found and further explained by an imbalance among supply and demand, speculation, oil price, international market and stockpiling policy, important for the authorities in order to identify bubbles, notice their evolutions and ensure the natural rubber price stabilisation.

LITERATURE REVIEW

As far as natural rubber price, several papers were accomplished to predict short- and long-run rubber market. The short-term price model includes world total rubber consumption, world natural rubber production, world stocks, exchange rate and other factors. While significant external variables of natural rubber long-run price model are: changes in stocks, production and consumption in corresponding countries and regions. Lim (2002) estimated the short-term prices of natural rubber and evaluated 19 models' relative performance on account of four information sets and three different forecasting techniques. Compared with the simple regression models, the Generalised Autoregressive Conditional Heteroscedasticity Regression (ARCH) models performed well in predicting natural rubber prices. Arunwarakorn et al. (2017) developed demand and supply models in order to forecast the world natural rubber quantity and all explanatory variables in the demand and supply models. And finally, they estimated the equilibrium quantity and price for world natural rubber from 2017 to 2026.

Other scholars focused on the rubber plantation. In continental Southeast Asia, the rubber prices raised in the first decade of 20th century, which led to more land being converted into planting rubber trees. In Xishuangbanna, rubber plantations were economical and expanded remarkably, leaving little natural forest in the past two decades (Yi et al. 2014). This phenomenon caused higher greenhouse gas emissions, the damage of landscapes functions (e.g. erosion, hydrology) and high-biodiversity value (Jawjit et al. 2010; Ahrends et al. 2014). Furthermore, from a management perspective of rubber plantation, Sharib and Halog (2017) put forward the concept of industrial symbiosis and Rubber City, due to its promotion to rubber plantation in Kedah and Malaysia.

BUBBLE MODEL

The bubble model has been extensively proved in a number of relevant studies. If the prices of commodities or services violate their intrinsic values, bubbles may be present. That process can be depicted as follows:

$$P_t = P_t^f + b_t \quad (1)$$

where P_t^f is characterized as the natural rubber price and b_t is viewed as the bubble component. Hence, under log-linear approximation, the P_t is classified into two sections: the intrinsic P_t^f and the bubble b_t. According to Equation 1, under the condition of $b_t = 0$, the P_t is completely determined by the fundamental part P_t^f. However, when $b_t \neq 0$, the natural rubber is not determined by fundamentals but is influenced by b_t. At this time, Equation 1 can be used to explain that the price of natural rubber is higher than the fundamental values P_t^f.

The existing literature utilised different methods to examine bubbles, including the unit root test and the Momentum Threshold Autoregressive (MTAR) model. However, Evans (1991) shows that the traditional unit root tests would lose power in detecting periodic bubbles. The MTAR model is only utilised to judge whether periodic bubble behaviours exist in the sample (Zhang and Yao 2016). Based on these deficiencies, the GSADF approach is proposed to investigate and locate periods of bubble behaviours.

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Due to employing the unfixed window size in the recursive regression, this approach increases the accuracy in detecting bubbles. Hence, this approach is superior to previous ones in investigating multiple bubble behaviours.

METHODOLOGY

In order to overcome the traditional tests' restriction, Phillips et al. (2014) put forward the SADF test to consider explosive behaviour. The SADF has substantial power to locate periodic explosive behaviour. Phillips et al. (2014) study this phenomenon by a forward recursive test procedure, and their approach performs right-side Augmented Dickey-Fuller (ADF) and sup tests, which follows:

$$p_t = dT^{-\eta} + \theta p_{t-1} + \varepsilon_t \quad (2)$$

where p is natural rubber price, d means a constant, and T stands for the size of a sample, $\eta > 1/2$, $\varepsilon_t \sim NID(0, \sigma^2)$, and $\theta = 1$. Equation 2 takes a random walk process and asymptotically negligible drift into account. We assume that r_1 and r_2 are points of beginning and ending, respectively. r_w represents the window size and $r_2 = r_1 + r_w$. The regression equation forms as follows:

$$\Delta p_t = \alpha_{r_1,r_2} + \beta_{r_1,r_2} p_{t-1} + \sum_{i=1}^{k} \phi^i_{r_1,r_2} \Delta p_{t-i} + \varepsilon_t \quad (3)$$

where k means the number of lags and $\varepsilon_t \sim NID(0, \sigma^2_{r_1,r_2})$. $T_\omega = [T_{r_\omega}]$ presents the number of samples in the regression and $[\cdot]$ shows the integer part. $\text{ADF}^{r_2}_{r_1}$ stands for statistics of ADF in accordance with the above regression. Significance tests determine the lag order k. H_0: $\beta = 1$ is the unit root hypothesis. Meanwhile, H_1: $\beta > 1$ is the hypothesis for the right-tailed unit root.

The statistic value of the corresponding time series is used by SADF test in the check of the hypothesis. r_w extends from r_0 to 1 which means the window size. r_0 and 1 stands for the smallest and largest window size respectively. And the beginning point r_1 is usually fixed at 0. The ending pointing r_2 depends on r_w in terms of the equation $r_2 = r_1 + r_w$. We also argue $r_2 = r_w$. Thus, the sample range from 0 to r_2 is presented by $\text{ADF}^{r_2}_0$ statistic. The SADF approach is defined as $sup_{r_2} \in [r_0, 1]\text{ADF}^{r_2}_0$ and denoted by SADF(r_0).

According to Phillips et al. (2013), SADF would lose enough ability and cannot be adopted to explain the emergence of bubbles, when time series contain several periods of burst and exuberance. Phillips et al. (2013) reveal that instead of fixing the beginning point, GSADF approach can alter the initiating and terminating points of the recursion with flexible window size.

The ADF test Equation 3 is operated repeatedly by the GSADF method on a sample sequence, which is a longer sequence than the SADF approach. With regard to the GSADF approach, the variation range of ending point r_2 is from r_0 to 1, and the beginning point variation range is from 0 to $r_2 - r_0$. Due to the feasible beginning and ending points showed by r_1 and r_2, Phillips et al. (2013) argue that GSADF statistic is the largest ADF statistic. Meanwhile, GSADF(r_0) denotes this statistics, which follows:

$$\text{GSADF}(r_0) = sup_{r_2 \in [r_0,1], r_1 \in [0, r_2 - r_0]} \left\{ \text{ADF}^{r_2}_{r_1} \right\} \quad (4)$$

The above regression model contains an intercept. The null hypothesis is unit root, which has an asymptotically negligible drift (i.e. $dT^{-\eta}$ with $\eta > 1/2$ and constant d). The statistic of GSADF approach is depicted as follows in Equation 5.

In Equation 5, $r_w = r_2 - r_1$ is a standard Wiener process. It has independent increments with the distribution $P(r_2) - P(r_1) \sim N(0, r_w)$. The statistics of SADF and GSADF show an asymptotically valid test, following a standard normal distribution, when the process belongs to a random walk. For the sake of reaching the asymptotic critical values of the ADF statistics, it is proved to be a random walk by using the Monte Carlo simulation. It will only produce a finite number of limited points, due to the sequential and random process. The intervals such as $n_1, n_2, \ldots, n_N$ are supposed to be equally spaced. Compared with the SADF test, the right-tail critical value of the GSADF approach performs better.

DATA AND EMPIRICAL RESULTS

In order to assert the existences of bubbles in the natural rubber market, the monthly data from 1980: M01 to 2017: M12 (M stands for month) is used

$$\text{ADF}^{r_2}_{r_1} = \left\{ \frac{(1/2) r_w \left[w(r_2)^2 - w(r_1)^2 - r_w \right] - \int_{r_1}^{r_2} w(r) dr \left[w(r_2) - w(r_1) \right]}{r_w^{1/2} \left\{ r_w \int_{r_1}^{r_2} w(r)^2 dr - \left[\int_{r_1}^{r_2} w(r) dr \right]^2 \right\}^{1/2}} \right\} \quad (5)$$

https://doi.org/10.17221/151/2018-AGRICECON

in this paper. The data has been available to the public since 1980: M01, which stems from the International Monetary Fund (IMF 2018). The upper curve stands for natural rubber prices in Figure 1. The huge fluctuations are featured by the curve during the sample. The price of natural rubber began to fall since 2011: M02 until 2016: M01. As in the case of many other commodities, the natural rubber market is influenced by several factors, which can be categorised in hierarchical order. The pricing system is only a reflection of the balance of physical transactions in the economic theory of general equilibrium. Originally, supply and demand are the main factors affecting the price formation of natural rubber. However, except for fundamental factors, there are other factors, which influence natural rubber price determination and behaviour such as the development of world economy, exchange rates volatility (Budiman and Fortucci 2003), and the price of oil (Romprasert 2011).

The GSADF test is applied to detect the bubble periods in the natural rubber market. These values were replicated 10 000 times. Table 1 shows the SADF and GSADF statistics. The null hypothesis is rejected H_0: $r = 1$ at the 10% significance critical values (i.e. 5.519 > 2.076, 6.105 > 2.369). The results prove that explosive sub-periods does exist in natural rubber prices upon SADF and GSADF tests.

With 90% confidence intervals, we graph the estimations of the natural rubber price in Figure 1, employing the GSADF results. The upper line demonstrates the price of natural rubber. The middle one stands for the 90% threshold, and the bottom curve means the GSADF statistic. We identify the bubbles and make out the causes of them according to this.

The first bubble began in 1988: M02 and busted at the end of 1988: M11. The reason behind this bubble is related to the inefficiencies of rubber marketing by smallholders. Since 1981, Thailand has become the major producer and exporter of natural rubber and rubber commodities in the world, and it is mainly cultivated by smallholder farmers with farm holdings of less than three hectares. As well as the increase of sectorial development projects during the 1980s, smallholders increase their revenues by shifting to higher value products such as natural rubber (Simien and Penot 2011). Because farmers cannot obtain al-

Table 1. Results of the SADF and GSADF tests

Natural rubber price	SADF	GSADF
	5.519***	6.105***
Critical value (%)		
90	0.993	1.849
95	1.359	2.078
99	2.076	2.369

*** denotes significance at 1% level; SADF – Supremum Augmented Dickey-Fuller test; GSADF – Generalized Supremum Augmented Dickey-Fuller test

Source: Raw data from IMF statistics (IMF 2018) and calculated in Gauss 10

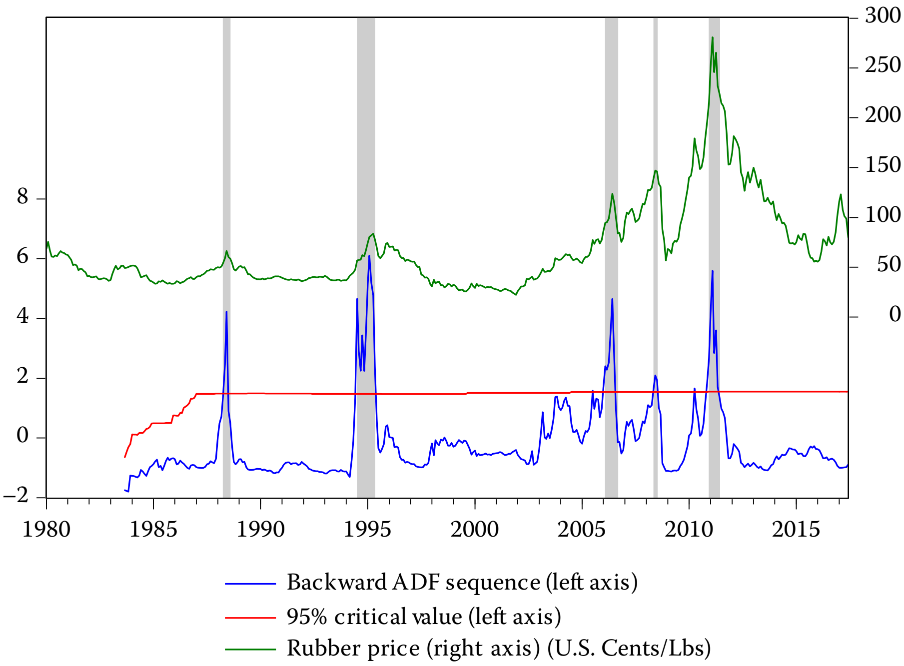

Figure 1. Generalized Supremum Augmented Dickey-Fuller test of the price of natural rubber

the shadows are sub-periods with bubbles; ADF – Augmented Dickey-Fuller test

Source: authors' elaboration based on IMF (2018)

https://doi.org/10.17221/151/2018-AGRICECON

ternative marketing channels, demand conditions and information on prices, they often experience weaker bargaining power in their marketing relationships with traders. It made the buyer's influence on market prices to be excessive, with farmers having minimal influence on the rubber pricing. The bubble busted at the end of 1988: M11, which is related to The Office of Rubber Replanting Aid Fund (ORRAF 2018). It was built in 1980 to increase the productivity of natural rubber in Thailand by formulating corresponding measures. ORRAF's main goals are beneficial to rubber smallholders to change low-yielding plantations with high-yielding rubber clones. With production increasing, the natural rubber price begins to drop.

The second bubble was observed from 1994: M07 and burst in 1995: M05. The benchmark interest rate of the Federal Reserve increased from 3.25 to 6% during this period, which made the U.S. Dollar appreciate. Natural rubber prices could be affected by exchange rates fluctuations directly or indirectly. The export price in the rubber trading countries would be affected by the exchange rates, which is the direct impact. Moreover, the provisional demand is the source of indirect impact, which may be either foreign exchange tentative or commodity tentative. While, due to changes in the foreign currencies of the exchange rate, rubber prices could be changed in the short term. At the same time, the increasing interest rate means economic boom, which stands for an increase in natural rubber demand (Romprasert 2011). In 1995, 24 countries signed the International Natural Rubber Agreement in Geneva to stabilise the price of natural rubber, which results in the bubble bursting fast.

The third bubble appeared in 2006: M02 and burst in 2006: M09. The reason for this short bubble is related to the high crude oil price since 2005. International major tire makers would turn to natural rubber if crude oil prices stay high (Khin et al. 2011). The synthetic rubber price will increase due to the high crude oil price of petroleum, which is the main raw material of synthetic rubber. Natural rubber's substitute is synthetic rubber, as the price of synthetic rubber rises, it helps reduce the demand for synthetic rubber, and impacts the increase in the demand of natural rubber (Romprasert 2011). Compared with synthetic rubber, natural rubber has a wider application due to its better performance. In China, the most significant economic plan was outlined by the 11th National Five-Year Program (11th NFYP 2006) during this period and identified objectives such as promoting the auto industry consumption to boost the domestic demand, resulting in huge natural rubber demand. After the high pricing period, the natural rubber price subsequently falls in the period of 2011: M06 to 2011: M09. The main explanation of the relative weakness of prices is that the market is much better supplied. After experiencing shortages of natural rubber, rising prices have stimulated better husbandry, greater use of fertilisers and increased production. As a result, the bubble bursts in 2006: M09.

The fourth bubble started in 2008: M05 and ended in 2008: M07. The global financial crisis can explain the sharp decline in natural rubber price. When the global financial crisis happened, the amount of capital outflows of the U.S. has increased. The commodity market was one of the main destinations for this money. As a result, bubbles happened in commodity markets such as natural rubber, gold and crude oil. The global financial crisis exerted a passive impact on the international economic linkage, real gross domestic product (GDP), reserve losses and current account deficit (Jun et al. 2016). In 2008, the growth of GDP in China was 9.63%, a great drop compared to previous years, which is affected by the global financial crisis. Thus, the depressed Chinese economy caused a reduction in the demand for natural rubber, but stable supply resulted in decreased natural rubber prices (Romprasert 2011).

The last bubble began in 2010: M12 and end in 2011: M06. The reason of this bubble is related to the gap between the limited natural rubber supply and growing demand. According to Fu (2009), diseases (i.e. red root disease, powdery mildew) and climatic factors (i.e. prolonged rainfall, typhoons), which happened in the natural rubber plantations area will cause its death and reduce its yield. Due to shortages in water for rubber processing, disease (powdery mildew) and reduced yields, a drought affecting plantations in South China, North Thailand, Vietnam and Laos led to a loss of USD 26.35 million in 2010. Moreover, in this year, the tree mortality of up to 22% happened after four months of low rainfall in Khon Kaen, Northeast of Thailand (Clermont-Dauphin et al. 2013). With the growing demand side, in 2011, China consumed 37% of global natural rubber production. China's auto market grew strongly and exported a large number of tire products in 2011. Therefore, the gap between the growing demand and limited supply drive the natural rubber price from its basic value and led to a bubble. As main natural rubber producing countries, Indonesia and Malaysia do not suffer natural disasters, which guarantee the production of rubber

https://doi.org/10.17221/151/2018-AGRICECON

in 2011 and makes the bubble burst. For example, the rubber production in Malaysia, the world's third-largest rubber producer and exporter, has reached 1 million tons in 2011, an increase of 6.5% compared to the last year of 0.93 million tons. With production increasing, the natural rubber price begins to drop.

From the five bubbles, the characteristics of the international natural rubber market can be summarised. First, the smallholder sector controls natural rubber price and production in large rubber producing countries. Although many professional institutions of rubber smallholders are supported by these countries, they still face challenges including lack of accountability and transparency, and poor communication between agencies and group. This has caused the unstable rubber prices. Second, the prices of natural rubber products (i.e. footwear, rubber tires, gloves) are expressed in U.S. Dollars (USD). Thus, fluctuations are significantly influenced by volatility in exchange rates between national currencies and the USD. Thirdly, synthetic rubber affects the price of natural rubber, which is an essential alternative crop of natural rubber (Fu 2009). In addition, climate and geography conditions have always been the main factors responsible for fluctuations of natural rubber yield, e.g. drought, typhoon, frost, continuous rainfall will reduce the output of natural rubber and make the price rise. Finally, International Rubber Consortium Limited was founded in 2004 and controls over 80% of the world's natural rubber resources, which dominate the pricing of the international natural rubber (Fu 2009).

In order to stabilise the global natural rubber price and avoid the bubble burst, some corresponding suggestions are supposed to be taken into account. The first one is that the government or associated agricultural organisations should train rubber smallholders groups and provide them with basic agricultural infrastructures and facilities. As a result of participation in the group, smallholders will increase their bargaining power. Second, the International Rubber Consortium Limited (IRCL) was established by Thailand, Indonesia and Malaysia, it controlls 80% of the world's natural rubber resources. Hence, IRCL should carry out the strategic market operations to achieve a long term price trend that is remunerative and stabilised toward the farmers. Finally, countries' monetary policies could be changed by the global financial crisis, especially the U.S., affecting the global economy significantly and results in asset bubbles. Hence, the passive influence of the exchange rate movements deserved more attention. In order to make out the reasons of price deviations from its basic value, bubble models can be used when meeting the natural rubber price bubble. Then, relevant policies are supposed to be implemented to avoid the passive effects of the natural rubber price bubble burst.

CONCLUSION

This paper demonstrates bubbles in international natural rubber markets, which includes the inefficiencies and other significant events. For the asset price bubbles' formation, invisible components and expectation perform an important role relying on the intrinsic bubble model. Whereas, we discover that the natural rubber bubbles mostly happen during periods of price fluctuations (i.e. 1994–1995, 2006–2011). This phenomenon is a consequence of many factors as currency exchange, weather, crude oil prices and speculative forces (Njavallil et al. 2016). In order to recognise the pivotal variables that make the departure of natural rubber price from its basic value, the location of the beginning and end points of bubbles that happened is essential. Many policy implications are put forward by corresponding analysis. First of all, in order to put pressure on natural rubber smallholders and strengthen the negotiating power, an alliance should be formed by the supply side. The IRCL should maintain a supply-demand balance to ensure an adequate supply of natural rubber in the market at fair prices. Second, as the world's largest consumer of natural rubber, China must solve the technical backwardness, lack of resources, the scale of economic problems of the natural rubber market (Fu 2009). Finally, market participants are supposed to pay attention to natural rubber price fluctuations and avoid passive shocks, on the condition that the possible effect of U.S. Dollars on its price bubbles.

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Received May 21, 2018
Accepted July 17, 2018