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Study on the Impact of Climate Change on the Long-term and Short-term Impact of China's Natural Rubber Futures Price

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Abstract

At present, affected by public health events, global pessimism spreads, rubber demand is restrained, and rubber prices fall sharply. The world economy is still in a period of deep adjustment. Therefore, it is also necessary to comply with the trend of the times and carry out new economic transformation and development. China's financial economy is facing a difficult transition period, and China's financial derivatives market is also in an important transition and development stage. Under the background of this actual economic environment, this paper selects natural rubber products in China's futures market as the research object, uses monthly data, constructs vector autoregressive model, Johansen Co-integration model and VECM error correction model, Combined with economic factors and climate factors, this paper analyzes the variables affecting China's natural rubber futures price, obtains the impact on China's natural rubber futures price in the short and long term, and uses China's daily data in the same period to conduct a regional two-level test on the natural factors of the main reclamation areas, so as to give market participants a reference through the construction of professional mathematical models, It is convenient for them to analyze the future price trend of natural rubber futures price, ensure the natural rubber production capacity and promote the sustainable development of China's natural rubber industry.

Keywords: Climate; Vector Autoregressive Model; Johansen Co-integration Model; VECM Error Correction Model; Two-Level Test

1. Introduction

In recent years, global pessimism has spread because of the current public health events causing a decrease in rubber demand and rubber prices to fall sharply. The world economy is still in a period of deep adjustment. Faced with the new challenges brought about by the world economic situation, China remains among the ranks of developing countries. Therefore, the country still needs to comply with the trend of the times and carry out new economic transformations and development. China's financial economy is facing a difficult transition period, and its financial derivatives market is also at an important transition and development stage. Under the background of this actual economic environment, this paper selects natural rubber products in China's futures market as the research object, uses monthly data, and constructs vector autoregressive model, Johansen co-integration model, and VECM error correction model. By combining economic and climate factors, this paper analyzes the variables that affect China's natural rubber futures price and determines its effects on China’s natural rubber futures price in the short and long term. Then, this paper uses China's daily data in the same period to conduct a regional two-level test on the natural factors of the main reclamation areas to give market participants a reference through the construction of professional mathematical models. The models make it more convenient to analyze the future price trends of natural rubber futures price, ensure the natural rubber production capacity, and promote the sustainable development of China's natural rubber industry.

Vector autoregressive model (VAR) was proposed by Sim (1980). The model is not based on economic theory but rather uses the endogenous variables of each equation in the model to regress the lag values of all endogenous variables of the model to estimate the dynamic relationship of all endogenous variables. Engle & Granger (1987) proposed the co-integration theory, including the definition of co-integration, E-G two-step method, Granger expression theorem, and its proof. The E-G two-step method has become the most pioneering research achievement in the field of the co-integration test. The error correction model (ECM) in this theory combines the advantages of the short-term dynamic model and the long-term equilibrium model in the time series analysis. It not only solves the problem of ignoring "pseudo regression" in traditional econometric models but also overcomes the deficiency of ignoring horizontal variable information in difference models, and has been widely used for modeling and analysis in non-stationary time series.

Phillips & Ouliaris (1988) compared the asymptotic properties of several residual tests by considering the ADF unit root test and deduced the asymptotic distribution of the EG two-step co-integration test.

Based on the co-integration model, Hasblock (1995) decomposes the long-term partial variance in the co-integration equation, calculates the contribution of each factor to the total variance, determines the contribution of each market to price discovery, and further analyzes the information transmission between markets.

In 1990, Johansen proposed a co-integration test method based on vector VAR based on Granger and Engle's research. This method does not rely on the least square method but directly establishes the research method on the maximum likelihood estimator. This method compensates for the deficiency of Granger and Engle co-integration test in multivariate tests to a certain extent. Later, an increasing number of scholars began to consider using different methods for the co-integration test.

In 2003, Hansen considered the change in structure and extended the co-integration vector autoregressive model. Taking the given change time points and the number of co-integration relations through a new estimation technology, estimation under various assumptions is possible, and the derivation of likelihood ratio test is simple. After considering these structural changes, we cannot deny the long-term effects of the expectation hypothesis.

Johansen (2010) focused on the identification of the VECM model, deduced the asymptotic distribution of constrained co-integration and adjustment vector coefficient estimation, and discussed the identification of medium-, long-, and short-term shocks in the VECM model.

2. Affecting factors

This paper aims to identify the factors affecting the price fluctuation of natural rubber futures by analyzing the characteristics of natural rubber futures in China and studying the linkage relationship between various influencing factors and natural rubber futures price by using the co-integration theory and error correction model to better measure the influence of several factors on natural rubber futures price. The study has practical guiding significance for rubber farmers and investors in planting and investment to a certain extent, as it can assist them in ensuring natural rubber production capacity, achieving the targeted poverty alleviation and promoting the sustainable development of China's natural rubber industry.

Considering the economic and natural factors, this paper takes the main continuous contract of natural rubber futures (shtj), producer price index (PPI), money supply (M2), consumer price index (CPI), rubber tire products, WTI crude oil price (WTI), and the exchange rate of RMB against the US dollar (exchange rate, ex) and average humidity (hum), average temperature (Temp), and sunshine hours in the main reclamation areas as variables and uses the vector autoregressive model to carry out the JJ co-integration test and establish the error correction model of the influencing factors of natural rubber futures price in Shanghai Futures Exchange. An empirical analysis conducted based on the monthly data of each variable from January 2008 to December 2019, and the natural rubber period is established after the variables pass the ADF unit root stationary test and Granger causality test VAR model of influencing factors of goods price.

3. Econometric model

After screening and dealing with the above influencing factors, this paper deals with the logarithmic return on investment of the futures price of the main continuous contracts of Shanghai natural rubber futures.

$$R_t = \ln\left({}^{P_t}/_{P_{t-1}}\right)$$

Before constructing the VAR model, we should first test the stationarity of variables. The results of the stationarity test show that the two groups of data are non-stationary and thus, the VAR model is created to establish the optimal lag order. The optimal lag period should be identified to build the optimal VAR model. According to the AIC and SC criteria, the following var (2) model is constructed.

$$Y_t = c + A_1 Y_{t-1} + A_2 Y_{t-2} + \mu_t$$

$$Y_t = \left(\text{r(shtj)、r(ppi)、r(m2)、r(cpi)、r(product)、r(wti)、r(ex)、r(hum)、r(temp)、r(hours)}\right)^T$$

Where, C is 10 × Constant sequence vector of order 1, A is 10 × 10th order parameter matrix, μ_t is 10 × Order 1 random error column vector.

After the VAR model is built, an AR root test is needed to ensure the stability of the model and ensure the effectiveness of the analysis. When the reciprocal of all root modules of the VAR (2) model is less than 1, it means that it falls within the unit circle. Hence, it is stable, as shown in the figure below.

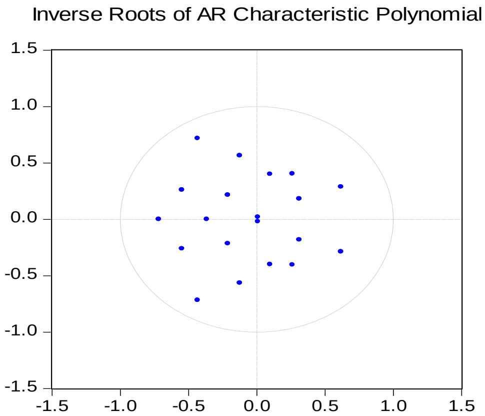

Figure1 Distribution diagram of reciprocal of characteristic root of VAR(2)

The results of the co-integration test are shown in Table 1. At the significance level of 5%, at least three groups of co-integration equations between 10 variables can be observed, that is, a co-integration relationship exists between 10 variables, and they also have a long-term equilibrium relationship between them.

Table 1 The results Johansen Co-integration test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.462819	331.1000	239.2354	0.0000
At most 1 *	0.414124	243.4798	197.3709	0.0000
At most 2 *	0.337650	168.0947	159.5297	0.0156
At most 3	0.251909	110.0082	125.6154	0.2989

* significance level of 5%

According to the estimation results of the Johansen method, the long-term equilibrium relationship of variables is as follows:

$$\begin{aligned}\mathrm{RSHTJ} = &-0.872701\mathrm{RTEMP} + 0.431286\mathrm{RPRODUCT} + 2.470132\mathrm{RPPI} + 6.150966\mathrm{RM2} \\ &- 1.340979\mathrm{RHUM} - 1.044340\mathrm{RHOURS} - 3.556752\mathrm{REX} + 3.752448\mathrm{RCPI} \\ &- 0.787613\mathrm{RWTI} + 0.055213\end{aligned}$$

From the above model, we can observe the following:

1. The ex-factory price index of industrial products, consumer price index, and money supply have a significant positive pulling effect on the price of natural rubber futures. It shows that the increase in the total ex-factory price level of industrial products will result in an increase in the price level of consumer goods and services purchased by households, the total amount of money available for various transactions in a country's economy, and the price of natural rubber futures. The output of rubber tire casing, that is, the output of downstream products, has a weak positive correlation with the futures price of natural rubber. The main use for natural rubber are tires. The prosperity of the automobile and tire industry has a direct effect on the natural rubber market.
2. The change of exchange rate has a significant negative correlation with the price of natural rubber futures, indicating a certain negative correlation between the US dollar and bulk commodities. WTI has a weak negative correlation with natural rubber futures prices. The change in international crude oil price will cause the opposite change of natural rubber futures price in China in the long run.
3. Natural factors, such as average temperature, sunshine time, and average humidity have a weak negative correlation with natural rubber futures price. The growth environment of natural rubber is one that is of high temperature and rainy, and thus, with the increases in average temperature, sunshine time, and average humidity, the natural rubber increases, causing a decline in prices.

Overall, the ex-factory price index of industrial products, money supply, exchange rate, and consumer price index have a significant pulling effect on the price of natural rubber futures, and the effect of natural factors on the price of natural rubber futures is weak.

The short-term equilibrium relationship of variables is determined by establishing a vector error correction model. The previous VAR model indicated that the optimal lag order is 2, and thus, lag order of the vector error correction model is 1 and the VECM model is established to explore the short-term dynamic and long-term stability characteristics.

$$\begin{aligned}\Delta\mathrm{RSHTJ}_t = &-0.011000\mathrm{vecm}_{t-1} - 0.483529\Delta\mathrm{RSHTJ}_{t-1} + 1.381329\Delta\mathrm{RPPI}_{t-1} \\ &+ 0.063315\Delta\mathrm{RM2}_{t-1} - 0.177684\Delta\mathrm{RCPI}_{t-1} - 0.034103\Delta\mathrm{RPRODUCT}_{t-1} \\ &+ 0.133687\Delta\mathrm{RWTI}_{t-1} - 0.651526\Delta\mathrm{REX}_{t-1} + 0.031180\Delta\mathrm{RHUM}_{t-1} \\ &- 0.005483\Delta\mathrm{RTEMP}_{t-1} + 0.017724\Delta\mathrm{RHOURS}_{t-1} + 0.000446\end{aligned}$$

The coefficient of error correction term is -0.011, which is less than zero, indicating that it conforms to the reverse correction mechanism, that is, a long-term equilibrium relationship between the natural rubber futures price and other factors. When the level of influencing factors is higher than the equilibrium level, the increase in this period will be reduced due to error correction. On the contrary, the price of the current period will increase when the price of the previous period is lower than the equilibrium value. It will take approximately 90 (1/0.011) months to repair, indicating that rubber prices will naturally fall after rising for a certain period.

The above model shows that the various short-term factors have different degrees of influence on the price of natural rubber. In comparison, the rubber futures price has the most sensitive response to the ex-factory price index of industrial products and has a positive effect on the rubber price in the early stage. For every 1% increase in the logarithm of the ex-factory price index of industrial products, the rubber futures price will increase by 1.381329% in the form of logarithm. Among several influencing factors, the rubber futures price is the most insensitive to natural factors, which may be because the period reflected by natural factors is longer than the due date of agricultural products and thus cannot be reflected in time. Futures prices will also change because of investors' psychological mood, but the change in natural factors cannot change investors' psychological mood and the futures price of agricultural products.

According to the absolute value of the cointeq1 coefficient of the variable, the T statistics of natural attributes are not significant, and thus cannot effectively explain the problem. In the short-term equilibrium structure for economic factors, WTI (0.207089) and product (0.303597) are large, indicating that when the system deviates from the equilibrium, WTI and product will make a positive adjustment to the price of the next phase. It also shows that WTI and product are more vulnerable to the latest information than other economic factors, with greater correction range, faster speed, and faster guidance to the price.

Finally, the Granger causality test can be used to verify statistically whether the investigated factors are the Granger cause of natural rubber price. The test results show that a two-way Granger causality can be observed between natural rubber futures price (shtj) and industrial product ex-factory price index (PPI), consumer price index (CPI), and money supply (M2). It further shows that a two-way influence and interaction relationship between variables exists. A one-way Granger causality between money supply and WTI crude oil price and exchange rate can also be observed, indicating that the effect of M2 on the exchange rate has an indirect effect on the fluctuation of WTI crude oil price while PPI has a one-way Granger causality to CPI. According to the price transmission mechanism, PPI has considerable effect on CPI. The fluctuation of the overall price level diffuses to the downstream industries through the industrial chain, and finally reaches consumer goods. A one-way Granger causality exists between CPI and WTI, which shows that the CPI index has a certain relationship with inflation, which then affects WTI. The WTI crude oil price is closely related to natural rubber futures price (shtj), industrial ex-factory price index (PPI), rubber tire products, and exchange rate (Ex).

For natural factors, a two-way Granger causality can be observed between average humidity (hum) and average temperature (Temp), average temperature (Temp), and sunshine hours. Sunshine hours are the one-way Granger cause of humidity.

From the above conclusions, it can be seen that the Granger reasons for the change of rubber futures price are the ex-factory price index of industrial products and wit, while money supply, exchange rate, and rubber tire output are not the Granger reasons for the change, which does not fully meet the theoretical expectations. However, the Granger causality test is only a statistical causality test and does not represent a real economic causality test. Therefore, the ex-factory price index of industrial products can be roughly determined and the price of crude oil has the greatest effect on the futures price of natural rubber.

The above empirical results show that the influence of natural factors on natural rubber futures price is not significant in the JJ test and VECM model. Therefore, using the daily data with shorter time intervals and secondary analysis of the main producing areas, we further study whether natural factors have a significant effect on the price of natural rubber futures. The empirical steps are similar to the above test.

The daily data of main continuous contracts (shtj) of natural rubber futures in Shanghai Futures Exchange are selected as the research object, and the average humidity (hum), average temperature (Temp), and sunshine hours in Yunnan Province, Hainan Province, and Guangxi Province are selected to measure the natural influencing factors of natural rubber. All data intervals selected are from January 2008 to December 2019.

3.1 Effects of the natural factors on the price of natural rubber futures in Yunnan Province

The daily natural factor data (temperature, sunshine hours, and humidity) of Yunnan Province are captured by the base stations in the main reclamation areas rich in rubber in Yunnan Province, including Baoshan, Lancang, Lincang, Mengla, and Simao.

3.1.1 JJ Co-integration test

Table 2 Results of JJ co-integration test in Yunnan Province

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.256601	2306.511	47.85613	1.0000
At most 1 *	0.245244	1442.741	29.79707	1.0000
At most 2 *	0.191824	623.1386	15.49471	0.0001
At most 3	0.000941	2.741513	3.841466	0.0978

* significance level of 5%

According to the estimation results of Johansen method, the long-term equilibrium relationship of variables is:

$$\mathrm{RSHTJ} = -\ 13.14061\mathrm{RTEMP} +\ 12.12372\mathrm{RHUM} + 0.409001\mathrm{RHOURS} +\ 0.004500$$

3.1.2 Vector error correction model

$$\Delta\mathrm{RSHTJ}_t = -0.000120\mathrm{vecm}_{t-1} - 7.158624\Delta\mathrm{RHUM}_{t-1} - 21.93401\Delta\mathrm{RTEMP}_{t-1} +\ 0.311494\Delta\mathrm{RHOURS}_{t-1} - 0.046366$$

The coefficient of error correction term is -0.000120, which is less than zero, indicating that it conforms to the reverse correction mechanism. Compared with other natural factors, the rubber futures price is the most sensitive to the average temperature of the base stations in the main reclamation areas of Yunnan Province and has a negative effect on rubber price in the early stage. For every 1% increase in the logarithm of the average temperature of the base stations in the main reclamation areas of Yunnan Province, the rubber futures price will decrease by 21.93401% in the form of logarithm. It is sensitive to the average humidity of the base station in the main reclamation area of Yunnan Province and has a negative effect on the rubber price in the early stage. For every 1% increase in the logarithm of the average humidity of the base station in the main reclamation area of Yunnan Province, the rubber futures price will be reduced by 7.158624% in the form of logarithm. Meanwhile, for sunshine hours, the reaction of rubber futures price to it is weak.

3.2 Effects of the natural factors on the price of natural rubber futures in Hainan Province

The daily natural factor data (temperature, sunshine hours, and humidity) of Hainan Province are captured by the base stations in the main reclamation areas rich in rubber in Hainan Province, such as Danzhou, Qionghai and Qiongzhong.

3.2.1 JJ Co-integration test

Table 3 Results of JJ co-integration test in Hainan Province

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.366629	1976.710	47.85613	1.0000
At most 1 *	0.191510	646.3442	29.79707	0.0001
At most 2 *	0.008336	27.07723	15.49471	0.0006
At most 3	0.000924	2.692892	3.841466	0.1008

* significance level of 5%

According to the estimation results of Johansen method, the long-term equilibrium relationship of variables is:

$$\mathrm{RSHTJ} = -116.8377\mathrm{RTEMP} + 28.74428\mathrm{RHUM} + 14.94272\mathrm{RHOURS} + 0.263598$$

3.2.2 Vector error correction model

$$\Delta\mathrm{RSHTJ}_t = -0.000515\mathrm{vecm}_{t-1} - 4.837193\Delta\mathrm{RHUM}_{t-1} - 6.951914\Delta\mathrm{RTEMP}_{t-1} + 1.221330\Delta\mathrm{RHOURS}_{t-1} + 0.012491$$

The coefficient of error correction term is -0.000515, which is less than zero, indicating that it conforms to the reverse correction mechanism. Compared with other natural factors, the rubber futures price is the most sensitive to the average temperature of the base stations in the main reclamation areas of Hainan Province and has a negative effect on the rubber price in the early stage. For every 1% increase in the logarithm of the average temperature of the base stations in the main reclamation areas of Hainan Province, the rubber futures price will be reduced by 6.951914% in the form of logarithm; It is sensitive to the average humidity of the base station in the main reclamation area of Hainan Province and has a negative effect on rubber price in the early stage. For every 1% increase in the logarithm of the average humidity of the base station in the main reclamation area of Hainan Province, the rubber futures price will decrease by 4.837193% in the form of logarithm. For sunshine hours, the reaction of rubber futures price to it is weak.

3.3 Effects of the natural factors on the price of natural rubber futures in Guangxi Province

The daily natural factor data (temperature, sunshine hours, and humidity) of Guangxi Province are captured by the base stations in the main reclamation areas rich in rubber in Guangxi Province, including Baise and Qinzhou.

3.3.1 JJ Co-integration test

Table 4. Results of JJ co-integration test in Guangxi Province

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.203130	1684.007	47.85613	1.0000
At most 1 *	0.199729	1023.024	29.79707	0.0001
At most 2 *	0.119878	374.4369	15.49471	0.0001
At most 3	0.000933	2.718167	3.841466	0.0992

* significance level of 5%

According to the estimation results of Johansen method, the long-term equilibrium relationship of variables is:

$$\mathrm{RSHTJ} = -1.764339\mathrm{RTEMP} + 23.67344\mathrm{RHUM} + 3.493217\mathrm{RHOURS} + 0.039716$$

3.3.2 Vector error correction model

$$\Delta\mathrm{RSHTJ}_t = -0.004752\mathrm{vecm}_{t-1} - 2.257827\Delta\mathrm{RHUM}_{t-1} - 7.469872\Delta\mathrm{RTEMP}_{t-1} + 0.767801\Delta\mathrm{RHOURS}_{t-1} - 0.003245$$

The coefficient of error correction term is -0.004752, which is less than zero, indicating that it conforms to the reverse correction mechanism. Compared with other natural factors, the rubber futures price is the most sensitive to the average humidity of the base station in the main reclamation area of Guangxi Province and has a positive effect on the rubber price in the early stage. For every 1% increase in the logarithm of the average temperature of the base station in the main reclamation area of Guangxi Province, the rubber futures price will increase by 7.469872% in the form of logarithm. It is sensitive to the average temperature of the base station in the main reclamation area of Guangxi Province and has a negative effect on the rubber price in the early stage. For every 1% increase in the logarithm of the average humidity of the base station in the main reclamation area of Guangxi Province, the rubber futures price will decrease by 2.257827% in the form of logarithm. For sunshine hours, the reaction of rubber futures price to it is weak.

Through the above test of the natural factors of the three main producing areas, we find that the natural rubber futures price has the same sensitivity to the natural factors of agricultural reclamation in Yunnan, Hainan, and Guangxi: it is the most sensitive to the average temperature and has a negative effect, but is more sensitive to average humidity, which has a negative effect on the rubber price in the early stage. For sunshine hours, rubber futures prices reacted weakly to it.

4. Conclusion

After understanding and analyzing the specific linkage relationship between the above economic and non-economic factors on the natural rubber futures price, the competing pricing power of natural rubber should also be explored because it ca also help relevant enterprises and practitioners maximize profits and minimize losses and make more reasonable decisions. Given the above conclusions, some suggestions are put forward from the following aspects:

(1)Improve the ability to deal with risks

The Ministry of Agriculture and the heads of rural areas predict that with the occurrence of moderate and severe rubber tree diseases and insect pests in 2020, the continuous decrease and volatility of rubber prices, and the reduced downstream demand may further pose challenges to the enthusiasm for upstream rubber cutting and aggravate the sentiment to abandon cutting and pipe in rubber plantations. Therefore, relevant enterprises should focus on rubber plantation management and observe daily the changes in temperature, humidity, rainfall, and sunshine hours in the main reclamation area where the rubber plantation is located. Particular attention should be given to major meteorological changes and diseases and insect pests to stabilize investor sentiment and avoid the significant effects of the lack of management, monitoring, and early warning that has resulted in the decline in new rubber production throughout the year, otherwise, the situation could further worsen or pose a greater threat to the strategic security of the domestic natural rubber industry.

Major production, processing, and trading enterprises can improve their ability apply financial instruments, use the above model, lock in costs in advance by hedging in the financial futures market, hedge the risks of global political and economic uncertainty and abnormal market fluctuations to normalize production and operation, and control the enterprise's production costs, profit margins, and operational risks within a reasonable range.

(2)Actively participate in combination with policies

The government should participate actively in the industrial poverty alleviation pilot of rubber "futures + insurance" of the Shanghai Futures Exchange to stably control the processing of rubber raw materials. At present, everyone is actively promoting the pilot work of the poverty alleviation model of "futures + insurance" of natural rubber, ensuring the stable income of rubber farmers, promoting the production enthusiasm of rubber farmers, and maintaining the sustainable development of the rubber industry through the price insurance model.

(3)Establish subsidy mechanism

A subsidy or reserve adjustment mechanism should be established. The provincial Party committee and the provincial government should offer subsidies to areas where the rubber price is lower than the cost price. Moreover, in case of major meteorological disasters in the main reclamation area, the government should offer more disaster relief funds from the relevant departments at a higher level to ensure the basic life of rubber workers.

(4)Control the price fluctuation of natural rubber in China

With the current international situation, China needs to engage in joint efforts of rubber farmers, enterprises and investors if it wants to improve the country’s competitiveness in the natural rubber futures trading market and build a natural rubber market into a futures trading market with pricing initiative. The government should also stabilize the natural rubber futures price. To a certain extent, this study offers practical guiding significance for rubber farmers and investors in planting and investment to ensure natural rubber production capacity, achieve targeted poverty alleviation, and promote the sustainable development of China's natural rubber industry.

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