Analysis of the Dynamic Correlation between Currency, Futures, and Economic Indicators in China and Australia Based on VAR Model

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Abstract: Under the background of global economic integration, exchange rate, as a bridge connecting domestic and foreign markets, has a profound impact on national economy. As the world's second-largest economy and a significant consumer of commodities like iron ore, China's exchange rate fluctuations not only impact the domestic price level but also exert influences on international trade, industrial production, and financial markets via the transmission mechanism. Particularly, iron ore, being an essential raw material for steel production, its price variations are directly associated with the costs and profits of downstream industries and subsequently affect the overall economic operation. The intricate interplay among exchange rates, commodity costs, and inflation holds significant implications for the formulation of monetary stance. This paper employs a Vector Autoregression (VAR) model to analyze the relationships among the AUD/CNY exchange rate, Chinese iron ore futures, China's Consumer Price Index (CPI), and the yield on China's 10-year government bonds. By examining the interactions between these variables, the paper aims to reveal the impact of exchange rate fluctuations on Chinese iron ore futures prices and other key economic indicators, thereby providing insights into broader economic effects.

Keywords: Iron Ore Futures; Exchange Rate; Interest Rate; Macroeconomics Performance Indicator; Inflation; CPI

1. Introduction

The intricate connections between currency values, the cost of commodities, and the rate of inflation are pivotal for economists and policymakers in charge of fiscal strategies. Understanding these interactions is essential for making informed decisions regarding monetary policy, as fluctuations in exchange rates can significantly influence a country's economic stability and growth. This paper delves into these complexities by employing a Vector Autoregression (VAR) model to analyze the relationships among the AUD/CNY exchange rate, Chinese iron ore futures, China's Consumer Price Index (CPI), and the yield on China's 10-year government bonds.

The choice of the AUD/CNY exchange rate is particularly relevant due to the substantial trade relationship between Australia and China, with iron ore being a major export commodity from Australia to China. Iron ore prices are crucial not only for the economies of these two countries but also for global markets, as they influence industrial production costs and overall economic performance. Additionally, the AUD/CNY exchange rate serves as an indicator of economic conditions and trade dynamics between these two significant economies.

China's CPI and the yield on its 10-year government bonds are integral components of the country's macroeconomic performance. The CPI reflects the inflation rate, which is a key measure of economic health, influencing consumer purchasing power and living standards. Government bond yields, on the other hand, indicate investor confidence and the cost of borrowing for the government. These yields are influenced by monetary policy and economic expectations, making them a vital part of the analysis.

In this research, the paper seeks to reveal the repercussions of exchange rate volatility on the pricing of Chinese iron ore futures and other significant economic indicators by scrutinizing the interactions of these variables. The VAR model provides a robust framework for capturing the dynamic interdependencies among these time series data, allowing for a comprehensive analysis of how changes in one variable propagate through the system to affect others.

This study contributes to the broader literature on exchange rate economics and commodity price dynamics by providing empirical evidence on the specific case of the AUD/CNY exchange rate and its implications for the Chinese economy. The findings have significant implications for policymakers, market participants, and researchers, offering insights into how exchange rate movements can affect commodity prices, inflation, and interest rates. These insights can help in formulating more effective monetary policies and economic strategies to mitigate adverse impacts and leverage positive outcomes in the face of exchange rate volatility.

2. Literature Review

Dees et al.[1] pointed out that exchange rate shocks significantly affect domestic prices in various countries, highlighting the importance of exchange rate dynamics in global economic interactions. Chen and Rogoff [2] demonstrated that the exchange rates of commodity-exporting countries are strongly influenced by commodity price fluctuations, indicating that the AUD/CNY exchange rate is affected by Australia's iron ore exports to China, playing a crucial role in shaping the economic outcomes of both countries.

Guo and Huang [3] revealed that Chinese metal prices are susceptible to external financial shocks, underscoring the potential impact of exchange rate fluctuations on China's iron ore market. Zhou and Zhang [4] concluded that external commodity price shocks significantly affect domestic prices, aligning with our focus on the impact of the AUD/CNY exchange rate on Chinese iron ore prices and CPI.

In the academic literature, the price discovery mechanism of futures market has been widely discussed. The price discovery function of the futures market has been extensively discussed in the literature. Tang and Xiong[5] pointed out that the futures market plays a role in price discovery by reflecting market expectations of future prices. This is closely related to our study, as the iron ore futures prices we analyze reflect market expectations of future supply and demand conditions. The research found significant interactions between exchange rates and iron ore futures prices, supporting the importance of the futures market in price discovery.

Based on TVP-VAR model study the time-varying relationship between international commodity prices, RMB exchange rate, interest rate and inflation, and use the wavelet coherence model to analyze the impact of each variable on inflation. The results show that commodity prices and exchange rates have a significant positive impact on inflation, and the interest rate has a lag effect on inflation[6]

Through the construction of MS-DSGE model, the changes in monetary policy transmission efficiency after the launch of the new LPR mechanism in 2019 were tested from both macro and micro levels, and further empirical analysis was conducted based on the TVP-VAR model. The research results show that the new LPR mechanism effectively improves the transmission efficiency of monetary policy, and significantly reduces the financing cost of enterprises in the downward stage of interest rates, but at the same time, it will narrow the interest rate spread of commercial banks and increase the interest rate risk of commercial banks[7].

Based on the SV-TVP-VAR model, this paper explores the impact of global value chain participation on China's balance of payments. It is found that the increase of global value chain participation will increase the balance of current account and non-reserve financial account, and the transmission mechanism is as follows: Global value chain participation → Trade surplus → Inflation → current account balance; global value chain participation → financial development level → actual use of foreign capital → non-reserve financial account balance[8].

Based on the TVP-SV-VAR model, the dynamic impact effects of exchange rate and interest rate on commodity price fluctuations are reflected. The results show that the exchange rate and commodity price, interest rate and commodity price all have a bottom tail dependency structure, which is non-linear and thick tail dependency. The impact effect of exchange rate and interest rate on commodity prices is non-linear, time-varying and asymmetrical. Exchange rate has a positive impact on commodity prices, while interest rate has a negative impact on commodity prices, and the impact effect of exchange rate on commodity prices is greater than that of interest rate on commodity prices [9].

The VAR model is constructed by using the international general commodity price index and its four sub-indexes and the domestic price index respectively. The results show that :(1) the impact of different commodities on PPI and CPI is different. The international commodity index and the international Industrial product Price index have the biggest influence on PPI [10].

3. Model Introduction

The VAR model is a statistical model that describes the joint behavior of multiple time series variables based on variables' lagged values. It is powerful to capture complex interactions between variables. The expression shows below as formula(1):

$$Y_t = \beta 0 + \sum_{i=1}^{k} \beta i Yt - i + ut \qquad (1)$$

Where Yt is Variables determined by k lags of all variables in the system, β0 is constant term, and βi is the coefficients on the ith lag of Y.

4. Descriptive Analysis

As we can see from Figure 1， this article adopted the monthly closing price of iron ore futures, monthly AUD/CNY exchange rate, monthly yields of Chinese ten-years government bonds, and the monthly CPI of China as 4 variables in VAR model. The investigated period is selected from 1st November 2013 to 1st May 2024. The data are obtained from the website Investment.com.

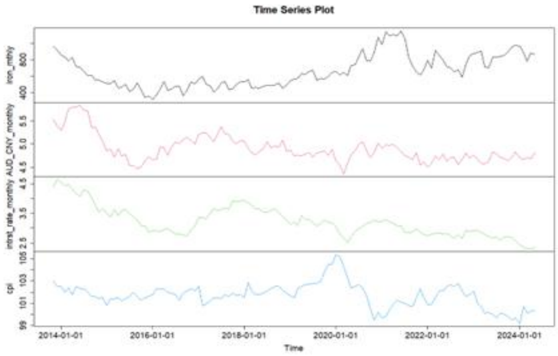

Figure 1. Time Series Plot of China Iron Ore Futures, AUD/CNY Exchange Rate, Yields of Chinese Ten-years Government Bonds, and China's CPI

5. Empirical Analysis

5.1 Stability Test and Determination of Lag Order

To make sure the model regression is unbiased, the ADF test is required to test the stability of the four variables. The result is showed in Table 1.

Table 1. Stability Test Results Before 1st Order Difference

	Intrst rate	CPI	AUD/CNY	Iron ore
ADF test	-2.7759	-2.5563	-3.4095	-3.4033
	(0.254)	(0.3453)	(0.0562)	(0.0572)
Result	non-stationary	non-stationary	non-stationary	non-stationary

China Monthly Interest rate—Intrst rate; China Monthly CPI—CPI; AUD/CNY exchange rate—AUD/CNY; China Monthly Iron Ore Future—Iron ore;

All four variables don't pass the adf stability test. The null hypothesis, which is the variable doesn't show stability, will not be rejected under the normal 5% significant level. Since the alternative hypothesis, which is the variable is stable, are favored, I difference all four variables by one order and did the ADF test again. Table 2 illustrated the stability of all four variables crucially improved.

Table 2. Stability Test Results After 1st Order Difference

	Intrst rate	CPI	AUD/ CNY	Iron ore
ADF test	-4.9241	-5.3166	-5.6597	-6.6115
	(0.01)	(0.01)	(0.01)	(0.01)
Result	non-stationary	non-stationary	non-stationary	non-stationary

5.2 Modeling

The VAR model estimation results for the monthly interest rate, iron ore futures prices, AUD/CNY exchange rate, and CPI reveal significant interactions among these variables. This paper evaluates the lag order by adopting AIC, HQ, SC, and FPE criteria. The HQ and

SC results in 1st order as the optimal lag order. The AIC and FPE points to 2nd order as the optimal order. This paper decides to comply with the AIC criteria, setting the lag order to be 2nd.

China Iron Ore Futures Monthly Price Equation

Table 3. Estimation results for Equation China Iron Ore futures

	Estimate	P-value
Iron ore. l1	-0.1031	0.2750
AUD/CNY.l1	140.6291	0.0092**
Intrst rate. l1	98.8264	0.0760.
CPI.l1	-16.4182	0.2074
Iron ore. l2	-0.0024	0.9791
AUD/CNY. l2	-85.3269	0.1290
Intrst rate. l2	37.3511	0.4862
CPI. l2	11.3080	0.3867
R-squared	0.1226	
F statistics	2.026	

From Table 3, one of the significant variables that influence China Iron Ore Futures Price is AUD_CNY exchange rate in lag 1 period. The coefficient is strongly positive, which can by explained as when Chinese Yuan depreciated more compared to last month, which means a strong AUD compare to CNY, the Chinese Iron Ore Futures Price rise violently. The reason is that as Australia is the largest import source of China's iron ore resources, so a stronger AUD makes Australian iron ore more expensive for Chinese importers, potentially driving up the futures price in China as domestic buyers anticipate higher costs.

The other variable that affects China Iron Ore Future Monthly Price is Chinese interest rate. Although the p-value of this variable is 0.07598, which means the variable is unsignificant under the normal 95% confidence interval, it shows marginally significant positive effect on China iron ore future price. The intuition behind is to regard interest rate as an economic indicator. When interest rate increase, it normally reflects a rising economic condition in the country. The other way to think about it is to treat interest rate as a tool to relieve inflation. In this way, demand for commodities such as iron ore could increase, leading to higher prices.

Table 4 demonstrated that in the Equation of AUD/CHY exchange rate, the negative coefficient seems to be hard to explained in economic sense. As we all know, higher CPI indicates higher inflation in China, leading a depreciation of the CNY relative to the AUD, which shows as an increase in AUD/CNY in the model. However, when we take the act of central bank into account, this negative relationship could be explained by the People's Bank of China's (PBOC) intervention in the foreign exchange market. If the PBOC anticipates inflation, it will take actions to strengthen the CNY to counteract inflationary pressures. This intervention could involve using foreign reserves to buy CNY, thereby reducing the exchange rate (making CNY stronger).

AUD_CNY Monthly Exchange rate Equation

Table 4. Estimation results for Equation AUD/CNY Exchange Rate

	Estimate	p-value
Iron ore.l1	-0.0001	0.4665
AUD/CNY.l1	140.6291	0.1751
Intrst rate.l1	98.8264	0.4989
CPI.l1	-16.4182	0.1232
Iron ore.l2	-0.0024	0.2438
AUD/CNY.l2	-85.3269	0.3972
Intrst rate.l2	37.3511	0.0798.
CPI.l2	11.3080	0.0449*
R-squared	0.0938	
F statistics	1.5	

China 10 years government bond Interest rate Equation

Table 5. Estimation results for Equation China 10 years government bond Interest rate

	Estimate	p
Iron ore. l1	-1.686e-4	0.2890
AUD/CNY. l1	0.2540	0.0053**
Intrst rate. l1	0.0050	0.5929
CPI.l1	-0.0121	0.5804
Iron ore. l2	-2.797e-5	0.8570
AUD/CNY. l2	0.0667	0.4796
Intrst rate. l2	0.1423	0.1163
CPI. l2	-0.0155	0.4793
R-squared	0.0979	
F statistics	1.573	

As shown in Table 5, an increase in the AUD/CNY exchange rate leads to higher interest rates in China. This could be due to the People's Bank of China adjusting rates in response to currency fluctuations to manage inflationary pressures or stabilize the economy.

In Table 6, the equation of China Monthly CPI demonstrates that the AUD_CNY exchange rate affects the inflation level in China. This may occur because a stronger AUD increases the cost of imported goods from Australia, contributing to overall price increases in China. Notably, the variable that is statistically significant is the exchange rate in lag 2 period. The impact on import prices typically doesn't reflect immediately in the CPI. Instead, it takes some time for higher import costs to be passed through the supply chain to final consumer prices.

China Monthly CPI Equation

Table 6. Estimation results for Equation China Monthly CPI

	Estimate	p
Iron ore.l1	-0.0005	0.4721
AUD/CNY.l1	0.3938	0.2868
Intrst rate.l1	-0.0141	0.9706
CPI.l1	-0.0264	0.7691
Iron ore.l2	-0.0007	0.3072
AUD/CNY.l2	1.0470	0.0079**
Intrst rate.l2	0.0271	0.9420
CPI.l2	0.0711	0.4325
R-squared	0.0721	
F statistics	1.127	

5.3 Granger Cause test

The Granger causality tests provide insights into the directional relationships between the variables in our VAR model. It reveals whether past values of one variable help predict future values of another.

Table 7. Results of Granger Causality Test of China Monthly Interest Rate and Monthly CPI

original hypothesis	hysteresis order (math.)	F-Test	p	reach averdict
Intrst rate do not Granger-cause Iron ore, AUD/CNY, CPI	1	1.1135	0.338	acceptance
CPI do not Granger-cause intrst rate, Iron ore, AUD/CNY	1	1.6834	0.148	acceptance

From Table 7, the absence of significant Granger causality from China monthly interest rate and monthly CPI to the others suggests that, although they may have contemporaneous and lagged effects within the VAR regression model, their past values do not provide additional predictive power for future values of the other variables in this model.

Table 8. Results of Granger Causality Test of China Iron Ore Future and AUD/CNY Exchange Rate

original hypothesis	hysteresis order (math.)	F-Test	p	reach averdict
Iron ore do not Granger-cause Intrst rate, AUD/CNY, CPI	1	0.6997	0.552	acceptance
AUD/CNY do not Granger-cause Intrst rate, Iron ore, CPI	1	4.104	<2.2e-16	reject

In table 8, the Granger-cause test demonstrates that there is strong evidence that the AUD/CNY exchange rate Granger-causes all the other variables. The significant Granger causality from the AUD/CNY exchange rate to the other variables highlights the critical role of exchange rate fluctuations in influencing economic dynamics in China.

Initially, the significant causal relationship indicates that past values of the AUD/CNY exchange rate help predict future values of Chinese iron ore futures prices. This relationship could be due to the fact that changes in the exchange rate directly affect the cost of imported iron ore, which in turn influences the futures prices as market participants adjust their expectations based on anticipated costs.

Additionally, the strong causality suggests that exchange rate fluctuations are considered by policymakers when setting interest rates. For instance, a depreciation of the CNY, which means an increase in AUD/CNY, might prompt the PBOC to raise interest rates to restrain the potential inflationary pressures from more expensive imports.

Finally, the significant causality aligns with the understanding that exchange rate changes affect the prices of imported goods and services, which are components of the CPI. A higher AUD/CNY exchange rate makes imports more expensive, potentially leading to higher inflation.

Instantaneous causality tests examine whether changes in one variable are contemporaneously associated with changes in another variable within the same time period. In this case, the null hypothesis (H0) is that there is no instantaneous causality between Chinese iron ore futures prices and the AUD/CNY exchange rate, China's interest rate, and China's CPI. The p-value is 0.0383, which less than the commonly used significance level of 0.05. This indicates that there is evidence of contemporaneous association between Chinese iron ore futures prices and the other variables within the same period.

A significant p-value suggests that changes in Chinese iron ore futures prices are contemporaneously related to changes in the

AUD/CNY exchange rate, China's interest rate, and China's CPI. This means that fluctuations in iron ore futures prices might be immediately reflected in or driven by changes in the other variables within the same period.

Firstly, Immediate changes in the exchange rate can directly affect the cost of imported iron ore, influencing futures prices within the same month. Secondly, changes in interest rates might immediately impact investor sentiment and expectations, leading to contemporaneous adjustments in futures prices. Thirdly, Immediate shifts in CPI can reflect rapid changes in inflation expectations, which can influence commodity prices, including iron ore.

5.4 Impulse Response

As we can see from Figure 2, the perturbation of China's CPI gradually increased and reached its maximum in period 3, and then it dropped to zero and became slightly negative. Then it hovered around and converged to zero. In Figure 3, the Chinese interest rate' perturbation exhibits roughly the same pattern as China's CPI, but it reached its maximum in period 2.

Demonstrated by Figure 4, The perturbation of Chinese iron ore future gradually raised and reached its maximum in period 2, then it decreased and became negative and reached its minimum in period 3. Then, it increased again and started to hover around to zero from period 4 and finally converged to zero.

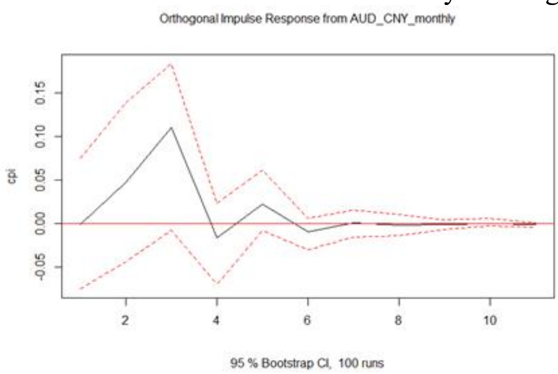

Figure 2. Orthogonal impulse response from AUD/CNY Exchange Rate to CPI

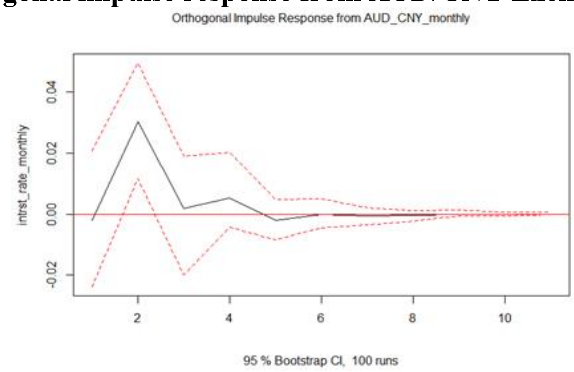

Figure 3. Orthogonal impulse response from AUD/CNY Exchange Rate to Chinese Monthly Interest Rate

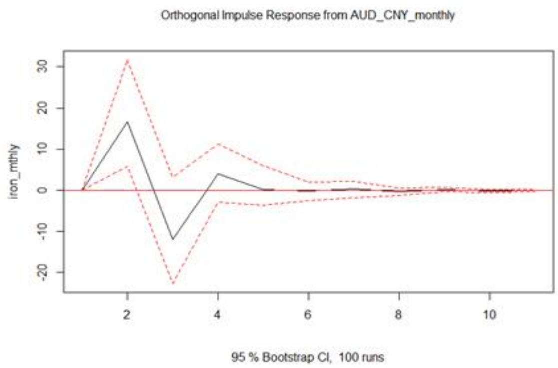

Figure 4. Orthogonal impulse response from AUD/CNY Exchange Rate to Chinese Iron Ore Future

5.5 Smoothness Test and Prediction

By adopting OLS-CUSUM stability test, the trend of China's CPI is the smoothest variable as shown in Figure 5. The closing price of China iron ore future and AUD/CNY exchange rate are relatively smooth, within 0.5% and no major fluctuations or deviations from the mean. The OLS-CUSUM stability test of China interest rate captures relatively different result. The trend of China interest rate results in negative index of all time, within 1.5% and some outliers almost deviating from the mean more than 1.5%, indicating the model of interest rate is less stable compare to the model of China Iron Ore Future, AUD/CNY Exchange Rate, and China's CPI. Nonetheless, all four models fall inside the 1.5% interval in the OLS-CUSUM stability test and stability of models can be assured.

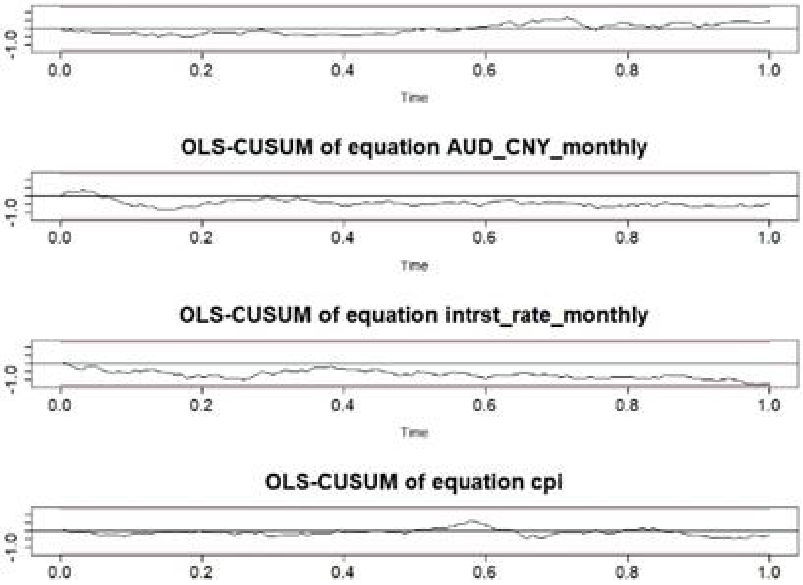

Figure 5. OLS-CUSUM of equation China Iron Ore Future, AUD/CNY Exchange Rate, Chinese Interest Rate, and China's CPI

6. Conclusion

This study utilized a Vector Autoregression (VAR) model to explore the intricate relationships between the AUD/CNY exchange rate, Chinese iron ore futures prices, China's Consumer Price Index (CPI), and the yield on China's 10-year government bonds. Our findings highlight the significant influence of exchange rate fluctuations on key economic indicators in China.

The empirical results reveal that the AUD/CNY exchange rate has a pronounced effect on Chinese iron ore futures prices. Specifically, a stronger AUD relative to the CNY leads to higher iron ore futures prices in China, driven by increased costs of Australian iron ore imports. This relationship underscores the critical role of exchange rate dynamics in commodity pricing.

Additionally, the study shows that changes in the AUD/CNY exchange rate also impact China's CPI and interest rates. A stronger AUD, resulting in higher import costs, contributes to inflationary pressures in China. This effect, however, is moderated by the People's Bank of China's interventions, which aim to stabilize the exchange rate and manage inflation through monetary policy adjustments. The Granger causality tests further support the significant role of the AUD/CNY exchange rate in predicting future values of Chinese iron ore futures prices, CPI, and interest rates. This indicates that past exchange rate movements are crucial for anticipating future economic conditions in China.

Overall, this research contributes to a better understanding of the complex interplay between exchange rates, commodity prices, and macroeconomic variables in China. The insights gained from this study can inform policymakers and market participants about the broader economic impacts of exchange rate fluctuations, aiding in more effective decision-making and economic planning.

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