

Estimating optimal hedging ratio and hedging efficiency in China's stock market

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Abstract. This paper examines the risk spillover mechanism between China's stock market and international commodity markets using selected industry data series on soybean copper, gold, silver, sugar, and crude oil. Based on the results of this analysis, a DCC-GARCH model is used to describe the dynamic correlation, build a risk hedging model, calculate the risk hedging efficiency, and evaluate the risk hedging effect. According to the findings, the industrial and optional consumer industries are the primary risk receiving markets, while the energy and finance industries are the primary risk export markets. The stock market crash in 2015 and the COVID-19 epidemic in 2020 made the risk spillover between China's stock market and international commodity markets surge. On average, the commodity copper is the most efficient hedge, followed by silver, while commodities such as sugar, gold and soybeans are less effective, and copper will continue to be a good hedge for the Chinese stock market in the coming months.

Keywords: International commodity market; Stock market; Spillover index; Spillover effect; Risk hedging.

1 Introduction

Volatility spillover is an important part of portfolio allocation, portfolio strategy and hedging strategy design between assets [1-4]. There is a variety of hedging ratio, hedging efficiency and parameters estimation studies that use different methods. Ghosh [5] uses EMC method, whereas GARCH model is used in the works of [6-9]). Markov switching model is used in the works of Davtyan [10] and Bedin [11]. Furthermore, many academics combine the GARCH model with VaR, Copula, and other models to calculate stock market risk spillover. The dynamic conditional correlation coefficient multivariate GARCH model (dcc-GARCH) proposed by Engel [6] overcomes the shortcomings of more parameter estimation and the trend of asset return correlation coefficient changing with time and can better investigate the time variability of spillover. However, it is unable to provide a good description of the direction, contribution, and net spillover effect of a single market. Based

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on the VAR model, Diebold, Yilmaz [12-13] the DY spillover index model to analyze the spillover effect between stock markets in different countries. This method can describe the direction of volatility spillover and the size of spillover effect and can be combined with rolling window method to describe the time-varying characteristics of volatility spillover.

Risk hedging strategies in various markets, has been investigated in the works of Okulov [14]; Masko, [15]; and Pankov, [16]. In the Russian market, for instance, derivatives are largely used as instrument of hedging economic risks, rather than making profit [16]. In this paper, DCC-GARCH model is used to study the dynamic correlation between various industries in the stock market and commodities. Based on this, this paper quantifies the optimal portfolio weight and hedging ratio to design the optimal hedging strategy.

2 Materials and Methods

This paper uses a DCC-GARCH model to describe the dynamic correlation, build a risk hedging model, calculate the risk hedging efficiency and evaluate the risk hedging effect. With the improvement of the financialization of commodity futures, agricultural products are gradually included in risk hedging instruments by investors. The analysis uses six representative commodity indexes of CBOT soybean, COMEX gold, COMEX silver, ICE 11 sugar, LME copper and NYMEX crude oil in energy, basic raw materials and agricultural and sideline products. The sample interval is from January 2, 2006 to July 28, 2021. Excluding the missing observation values, a total of 3783 daily observation data are finally obtained, all of which are from WIND database.

3 Results

Based on DCC-GARCH model, this paper analyzes the risk hedging of each asset portfolio of 11 industries and international commodity futures in China's stock market, including the analysis of portfolio weight (w_t^{ES}), optimal hedging ratio (β_t^*) and hedging efficiency (HE). The results are shown in Table 1.

Table 1. Descriptive statistics of portfolio weight, hedging ratio and hedging efficiency

	Portfolio Material / soybean	w_t^{ES}			β_t^*			HE
		average value	minimum value	Maximum m	average value	minimum value	Maximum m	
Material Science	Material / gold	0.3877	0.0459	0.8996	0.1264	-1.0763	0.6438	0.023 4
	Material / Silver	0.2365	-0.0056	0.5710	0.2671	-0.5007	1.1993	0.014 6
	Material / sugar	0.5300	0.0557	0.9580	0.1732	-0.0056	0.3952	0.036 7
	Material / copper	0.5417	0.0993	0.8049	0.0283	0.0147	0.0845	-0.002 3
	Material / crude oil	0.3961	0.0283	0.8220	0.3508	0.1305	0.7786	0.060 6
	Utilities / soybeans	0.5867	0.1054	1.0165	0.1224	-0.0287	0.3210	0.007 4

public utility	Utilities / gold	0.5167	0.0772	0.9256	0.0843	-0.6879	0.4059	0.0094
	Utilities / Silver	0.3699	0.0145	0.7479	0.1506	0.0600	0.5027	0.0037
	Utilities / sugar	0.6486	0.0735	1.0520	0.0939	-0.0294	0.2107	0.0140
	Utilities / copper	0.6487	0.1154	0.9333	-0.0123	-0.7081	0.2064	0.0010
	Utilities / crude oil	0.5469	0.0093	0.9214	0.2157	0.0854	0.8549	0.0306
	Industrial / soybean	0.6940	0.0458	1.0100	0.0740	-0.0764	0.7056	0.0013
Industry	Industry / gold	0.4273	0.0409	0.9200	0.1047	-1.1090	0.7633	0.0231
	Industry / Silver	0.2810	0.0001	0.6007	0.1786	-0.7358	0.9957	0.0003
	Industrial / sugar	0.5644	0.0259	0.9760	0.1370	-0.2342	0.7363	0.0250
	Industrial / copper	0.5761	0.0929	0.8290	0.0157	0.0080	0.0527	-0.0023
	Industrial / crude oil	0.4496	0.0171	0.8563	0.2821	0.1032	0.6712	0.0380
	Telecommunications services / soybeans	0.6204	0.0153	1.0147	0.1001	-0.1344	0.8862	0.0056
	Telecom Services / gold	0.3618	0.0577	0.8541	0.0454	-0.1829	0.2310	-0.0003
	Telecom Services / Silver	0.2388	0.0211	0.7212	0.0789	0.0265	0.2473	0.0045
	Sugar / telecom services	0.4837	0.0651	0.9408	0.0842	0.0237	0.2647	0.0102
	Telecommunications services / copper	0.5044	0.1056	0.8597	0.0254	0.0099	0.0675	-0.0016
	Telecommunications services / crude oil	0.3744	0.0292	0.8785	0.1509	-0.0636	0.5398	0.0079
	Energy / soybean	0.5416	0.1033	0.9916	0.0895	-0.0467	0.2354	0.0025
Telecom-mun ication service	Energy / gold	0.4457	0.0761	0.9224	0.1379	0.0400	0.3342	0.0146
	Energy / Silver	0.3001	0.0216	0.7299	0.1854	-0.4585	0.7912	0.0194
	Energy / sugar	0.5810	0.0393	9.0000	0.1553	-0.1206	0.7120	0.0490
	Energy / copper	0.5994	0.1340	0.8769	0.0542	0.0253	0.1492	-0.0029
	Energy / crude oil	0.4716	0.0332	0.9608	0.3282	0.1538	0.6519	0.0712

	Information technology / soybean	0.6613	0.1812	1.0412	0.1639	-0.0318	0.4124	0.0340
energy	Information technology / gold	0.3490	0.0437	0.8734	0.0507	-0.9782	0.5319	0.0144
	It / Silver	0.2156	0.0148	0.5227	0.1612	0.0732	0.4630	0.0046
	Information technology / sugar	0.4739	0.0462	0.9019	0.1220	0.0399	0.3240	0.0155
	Information technology / copper	0.4927	0.0901	0.7784	0.0205	0.0104	0.0594	-0.0013
	Information technology / crude oil	0.3536	0.0160	0.7955	0.2602	0.1063	0.6562	0.0272
	Optional consumption / soybean	0.5294	0.0937	0.9785	0.1036	0.0218	0.2818	0.0042
information technology	Optional consumption / gold	0.4327	0.0607	0.9190	0.1039	-0.6628	0.5477	0.0166
	Optional consumption / Silver	0.2893	0.0025	0.6476	0.1662	-0.7412	0.9153	-0.0015
	Optional consumption / sugar	0.5672	0.0468	0.9504	0.1265	-0.0972	0.5582	0.0227
	Optional consumption / copper	0.5808	0.1044	0.8510	0.0262	0.0125	0.0820	-0.0029
	Optional consumption / crude oil	0.4537	0.0249	0.8564	0.2782	0.1017	0.6082	0.0386
	Finance / soybean	0.6234	0.0484	1.0093	0.0961	-0.0871	0.6772	0.0097
	Finance / gold	0.4438	0.0838	0.9250	0.1239	-0.1911	0.5378	0.0107
	Finance / Silver	0.3055	0.0390	0.7006	0.1266	-0.3911	0.5533	0.0046
	Finance / sugar	0.5767	0.1234	0.9782	0.1382	-0.2257	0.3776	0.0261
	Finance / copper	0.5908	0.2221	0.8612	0.0121	0.0056	0.0256	-0.0005
	Finance / crude oil	0.4692	0.0538	0.9254	0.3275	0.0507	0.6704	0.0757
Consumer Discretionary	Real estate / soybean	0.6436	0.2006	1.0237	0.0836	-0.1933	0.2239	0.0058
	Real estate / gold	0.3669	0.0589	0.9017	0.0906	-0.0074	0.2158	0.0017
	Real estate / Silver	0.2381	0.0102	0.6175	0.1388	-0.6935	0.8847	0.0020
	Real estate / sugar	0.4925	0.0546	0.9309	0.1360	-0.2821	0.5601	0.0289

	Real estate / copper	0.5148	0.1376	0.8174	0.0021	-0.2998	0.2286	-0.0007
	Real estate / crude oil	0.3709	0.0165	0.8632	0.3209	-0.1307	0.8676	0.0477
	Daily consumption / soybean	0.5525	0.0489	1.0351	0.0981	-0.3966	0.7275	0.0152
finance	Daily consumption / gold	0.4346	0.0644	0.9083	0.0969	0.0280	0.2615	0.0040
	Daily consumption / Silver	0.2830	0.0090	0.6509	0.2169	-0.2303	0.7486	0.0136
	Daily consumption / sugar	0.5711	0.0679	0.9712	0.1379	-0.0851	0.5236	0.0227
	Daily consumption / copper	0.5854	0.1176	0.8809	0.0313	0.0136	0.0931	-0.0028
	Daily consumption / crude oil	0.4526	0.0315	0.8508	0.2583	0.0937	0.5966	0.0349
	Healthcare / soy	0.6264	0.0565	1.0009	0.0973	-0.0657	0.6763	0.0104
	Healthcare / gold	0.4190	0.0808	0.8965	0.0361	-0.4409	0.2958	0.0087
	Healthcare / Silver	0.2701	0.0119	0.6504	0.2152	-0.3528	0.6877	0.0075
	Healthcare / sugar	0.5510	0.0623	0.9211	0.1171	-0.1536	0.5216	0.0144
	Healthcare / copper	0.5634	0.1378	0.8377	0.0062	0.0030	0.0166	-0.0004
	Healthcare / crude oil	0.4322	0.0304	0.8541	0.1998	0.0794	0.5983	0.0237
	Portfolio	0.6003	0.1057	0.9856	0.0724	-0.0424	0.4192	0.0060

The results in Table 1 show that from the perspective of portfolio weight, the portfolio weight of each commodity futures portfolio fluctuates between 28% and 65%. The average weight of the investment portfolio of the material industry and CBOT soybeans is about 0.39, which means that for the investment funds of investors, 39% should be invested in the material industry and the remaining 61% should be invested in CBOT soybeans for risk hedging, to reduce the investment risk while keeping the expected return unchanged. This explanation is used for all the investment portfolios calculated. From the perspective of optimal hedging ratio, its average value has positive and negative values. When the hedging ratio is positive, it indicates that investors should hold long positions in industry stocks and short positions in international commodity futures when hedging risks. The average value of the optimal hedge ratio of each portfolio shows that the optimal hedge ratio between stock index and LME copper in most industries is higher, and the optimal hedge ratio between each industry and LME copper is greater than 15%, followed by COMEX gold. Among commodity futures, ICE11 sugar and NYMEX crude oil have the lowest optimal hedging ratio with various industries.

Hedging efficiency (HE) can reflect the investment effectiveness of the portfolio. The higher the HE, the better the hedging effect of the portfolio. From the calculated hedging

efficiency results, the most effective commodity futures for risk hedging in various industries of China's stock market are LME copper, followed by COMEX silver, and the commodities ICE11 sugar, COMEX gold and CBOT soybean with low effectiveness of risk hedging. This result shows that although the Risk Spillover and Risk Spillover of ICE11 sugar and CBOT soybean are small, they are not the futures with the highest effectiveness in risk hedging.

4 Discussion

LME copper shows good risk hedging effect in six international bulk commodities. To further analyze the hedging effectiveness of LME copper, a hedging model based on DCC-GARCH model is constructed to estimate within the sample, and the method of rolling window outside the sample is used for prediction. The specific implementation process is as follows: the sample data is divided into two parts. The first part of the data estimates the optimal hedging ratio and uses the estimated hedging ratio to calculate the hedging effect on the next trading day until the rolling window uses all the sample data, that is, the estimation and prediction of off sample hedging are completed.

The situation on the stock market reflects the findings in order to more intuitively show the change in copper portfolio weight and the change in optimal hedging ratio. It is found that the portfolio weight (w_t^{ES}) of LME copper does not change much in value as a whole;

The average value of the optimal hedging ratio (β_t^*) of LME copper is still above 15%, but the value of the optimal hedging ratio has increased on the whole. According to the rolling prediction outside the sample, to hedge the risk, investors should increase the proportion of holding LME copper in the investment portfolio of Chinese stocks and LME copper in the next three months. The results of hedging efficiency (HE) show that the hedging efficiency of LME copper has been comprehensively improved, indicating that LME copper in commodity futures still shows good risk hedging effectiveness. Increasing the proportion of LME copper held in the portfolio can reduce the volatility of portfolio income and effectively reduce investment risk.

5 Conclusion

The optimal hedge ratio shows that except for the healthcare industry, the optimal hedge ratio between stock index and LME copper is the highest in other industries, followed by COMEX gold. Among commodity futures, ICE11 sugar and NYMEX crude oil have the lowest optimal hedging ratio with various industries. For risk hedging of various industries in China's stock market, LME copper is the most efficient, followed by COMEX silver. Commodity ICE11 sugar, COMEX gold and CBOT soybean are less effective in risk hedging, and LME copper will continue to play a good role in offsetting China's stock market in the coming months.

The above research conclusions have significant policy implications for the state to prevent systemic risks between primary industries in China's stock market and international commodity markets, and also provide risk aversion strategies for investment in the financial market. On the condition of uncertainty, investors should consider the portfolio weight of stocks and the optimal hedging ratio of portfolios, and reasonably allocate assets to hold positions in combination with their own preferences to reduce investment risks.

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