Proceedings of the 2nd International Conference on Management Research and Economic Development
DOI: 10.54254/2754-1169/95/2024MUR0075

Research on Hedging Ratio of Stock Index Futures to ETF Fund

Jiahao Wu[1,a,*]

[1]*College of Finance and Statistics, Hunan University, Changsha, Hunan, 410006, China*
a. 202218110105@hnu.edu.cn
**corresponding author*

Abstract: Exchange Traded Funds (ETF) can largely avoid non-systematic risk, but investors often cannot avoid systemic risk, and the hedging function of stock index futures can do this. Therefore, hedging ETF with stock index futures has become a good investment strategy. Based on the trading data of the China Securities Index (CSI) 300 stock index futures and CSI 300 Exchange-Traded Fund (ETF), this paper analyzes the optimal hedging ratio of CSI 300 stock index futures by Ordinary Least Squares (OLS) and dynamic Error Correction Model - Generalized Autoregressive Conditional Heteroskedasticity (ECM-GARCH) model and compares the hedging performance predicted by the model to avoid the systematic risk of ETF. The results show that the hedging effect of the dynamic hedging model is better than that of the static model, and the ability to avoid systemic risk is also better. The predictions of both models show that stock index futures hedge ETFs very well. The dynamic model is more able to reduce the heteroscedasticity of the transaction data.

Keywords: CSI 300 stock index futures, hedging ratio, ETF, ECM-GARCH

1. Introduction

Exchange-traded funds (ETFs), use a completely passive indexation investment strategy to track and fit a representative underlying index. Because ETFs sell portfolios, fluctuations in individual bonds have less impact on bond ETFs. At the same time, the fund invests in bonds with excellent qualifications and good liquidity, so the returns of bond ETFs are relatively stable. Therefore, the fund can effectively avoid the non-systematic risk of individual stocks, to obtain a rate of return similar to the index. However, the huge systemic risk in the stock market brings unavoidable risks to investors. Stock index futures are a hedging tool for investors, and shorting stock index futures can achieve the purpose of avoiding systemic risks.

When investors invest in financial assets, to ensure considerable returns and avoid market risks, they usually hedge through hedging [1]. Nowadays, a large number of investors participating in ETF trading will use stock index futures, a financial derivative, to hedge, avoid systemic risks and improve returns. Therefore, how to hedge ETF through stock index futures has research significance.

The hedge ratio refers to the mathematical relationship that exists between the amount of assets used for hedging and the amount of assets being hedged. Among them, the optimal hedging ratio refers to the hedging ratio in which the combination of hedging can eliminate the risk caused by the change in spot value [2]. To maximize the realization of asset hedging, it is very necessary to study the optimal hedging ratio. The more commonly used method is the minimum variance hedge ratio,

DOI: 10.54254/2754-1169/95/2024MUR0075

whose goal is to minimize the fluctuation of the entire hedging portfolio return, which is specifically manifested as the minimization of the hedging return.

At present, there are many models for hedging ratio research, the time series model is the most extensive prediction, and there are also many studies on the hedging ability of China Securities Regulatory Commission (CSI) 300. For the static hedging model, that is, the hedging ratio does not change with time, the Ordinary Least Square (OLS) is better than other models in terms of prediction accuracy and operation difficulty [3]. When the hedging ratio changes in the long-term financial time series, the dynamic hedging model is used. The univariate Generalized AutoRegressive Conditional Heteroskedasticity (GARCH) model cannot estimate the covariance between variables or carry out error correction, while the Error Correction Model-Generalized AutoRegressive Conditional Heteroskedasticity (ECM-GARCH) model not only considers the cointegration relationship between futures price and spot price but also considers the heteroscedasticity problem existing in the price series fluctuations of the two prices [4]. So consider estimating and forecasting with these two models.

However, there are not many studies on the hedging effect of combining CSI 300 stock index futures and ETF funds with real-time data.

This paper selects the recent data of CSI 300 stock index futures and Harvest 300ETF and analyzes the effect of using stock index futures on ETF hedging by constructing static and dynamic hedging models.

Based on the static and dynamic hedging models, this paper discusses the necessity of avoiding the systemic risk of the market through the literature research and analysis of ETF risk and finds that the investment choice of stock index futures can reduce the systemic risk. Then taking CSI 300 stock index futures and Harvest 300ETF as an example, the optimal hedging ratio and hedging performance of stock index futures on ETF are predicted, the hedging effect of the two models is compared, and the hedging effect of stock index futures on ETF is studied.

2. Research Review

In recent years, there have been many precedents for the hedging of stock index futures. Wang Jing used the simple portfolio hedging model to conclude that ETFs in the rising channel need not be hedged for temporary periodic adjustment because the transaction cost of hedging transaction is not necessarily lower than the adjustment loss [5]. Gu uses OLS, Bayesian-Vector Autoregressive(B-VAR), Error Correction Model (ECM), and ECM-GARCH models to determine the hedging ratio of CSI 300 index futures and spot data, and finds that hedging technology has a great impact on hedging performance under daily data. Under 5 min frequency data, increasing information efficiency can make up for the defect of technical efficiency [6]. Zhong took Harvest 300ETF and CSI 300 stock index futures as sample data and found that the VAR model had the best hedging performance through the OLS model, vector autoregression model, and error correction model [7]. Sun Yanhong et al. established the exponential weighted moving average model (EWMA model) and GARCH model combined with volatility under the principle of minimum VAR. Among them, the method combining EWMA and Cornish-Fisher expansion achieves the best hedging effect [8].

Ederington studied the hedging effect of US Treasury bond futures based on Makowitz's portfolio theory and found that the optimal hedging ratio calculated was due to the hedging ratio of 1, and the hedging method was a special case of portfolio theory [9]. Ghosh considered the cointegration relationship between the two time variables, and based on this, used the ECM model to study the stock hedging ratio and effect, and found that the effect was better than the hedging ratio obtained by ordinary OLS [10]. Hsu proposed a series of estimation models of optimal hedging ratio based on

DOI: 10.54254/2754-1169/95/2024MUR0075

GARCH, including traditional static GARCH, constant conditional correlation GARCH, and dynamic conditional correlation GARCH [11].

According to a large number of hedging examples and the empirical work of Fama et al., except for very few futures commodities, the basis volatility of most commodities is quite violent, and the basis risk is sometimes no less than the price risk. In addition, the model assumes either full or no hedging of spot positions, ignoring the ability of many hedgers to anticipate price fluctuations and the feasibility of flexibly adjusting hedging decisions based on expectations.

3. Algorithm Principle and Research Method

3.1. Description of ETF Systemic Risk

According to the Capital Asset Pricing Model (CAPM), the value of assets in inefficient markets can be assessed as follows:

$$R_j = \alpha_j + \beta_j R_m + \varepsilon_j \tag{1}$$

R_j is the return rate of the JTH asset, R_m is the market return rate, and the variance relationship can be obtained:

$$\sigma_j^2 = \beta_j^2 \sigma_m^2 + \sigma_\varepsilon^2 \tag{2}$$

Consider variance as a measure of risk, total risk, $\beta_j^2 \sigma_m^2$ is systematic risk, and unsystematic risk determined only by the asset or firm is σ_ε^2. Then the proportion of systemic risk θ_j is:

$$\theta_j = \frac{\beta_j^2 \sigma_m^2}{\sigma_j^2} \tag{3}$$

Here, $\beta_j = \frac{Cov(R_j, R_m)}{Var(R_m)} = \frac{\sigma_{jm}}{\sigma_m^2}$.

If I plug in, $\theta_j = \frac{\beta_j^2 \sigma_m^2}{\sigma_j^2} = \frac{\sigma_{jm}^2}{\sigma_j^2 \sigma_m^2}$.

3.2. Determination of Hedging Ratio

3.2.1. Static Hedging Model (The Hedging Ratio is Fixed)

The OLS hedging model:

The least squares regression model is established to estimate the hedging ratio, and the model is as follows: $\triangle S_t = \alpha + \beta \triangle F_t + \varepsilon_t$.

Variance of spot portfolio returns $Var(R_p) = Var(\Delta S_t) + h^2 Var(\Delta F_t) - 2hCov(\Delta S_t, \Delta F_t)$,The hedging efficiency is the highest when the variance of the spot portfolio return rate is the smallest, take the derivative concerning h, let the derivative be zero, and get $\beta = h^* = Cov(\triangle S_t, \triangle F_t) / Var(\triangle F_t)$.

Where, ΔS_t and ΔF_t are the return rate of spot price and the return rate of futures price respectively, and ε_t is the random disturbance term. The slope β is the optimal hedging ratio, $\beta = h^* = Cov(\triangle S_t, \triangle F_t) / Var(\triangle F_t)$.

3.2.2. Dynamic Hedging Model

The estimation model of the static hedge ratio is established, and the estimated optimal hedge ratio does not change with time. However, time series data often have heteroscedasticity. When the risk level of the futures market and the spot market changes over time, the hedging ratio changes over time [4].

The ECM-GARCH model:

For financial time series with high volatility, it is necessary to introduce a GARCH model that the variation of spot price variance over time. Due to the possible ARCH effect of the ECM model, the obtained residual may have heteroscedasticity, thus affecting the estimation of the hedging ratio, which can be overcome by the ECM-GARCH model:

Establish the mean equation:

$$\Delta S_t = C_s + \beta_s Z_{t-1} + \varepsilon_{st} \tag{4}$$

$$\Delta F_t = C_s + \beta_f Z_{t-1} + \varepsilon_{ft} \tag{5}$$

$Z_{t-1} = S_{t-1} - \beta F_{t-1}$. is the residual term in the long run, and here is the error correction term.

And $\varepsilon_{st}, \varepsilon_{ft} \sim N(0, H_t)$, $H_t = \begin{pmatrix} h_{ss,t} & h_{sf,t} \\ h_{sf,t} & h_{ff,t} \end{pmatrix}$, h_{ss}, h_{ff} is the conditional variance of the random error term and h_{sf} is the covariance of ε_{st}, and ε_{ft}.

The conditional variance equation is:

$$H_t = \begin{pmatrix} C_{ss} & 0 \\ 0 & C_{ff} \end{pmatrix} + \begin{pmatrix} \alpha_{ss} & \alpha_{sf} \\ \alpha_{sf} & \alpha_{ff} \end{pmatrix} \begin{pmatrix} \varepsilon_{s,t-1}^2 & \varepsilon_{s,t-1}\varepsilon_{f,t-1} \\ \varepsilon_{s,t-1}\varepsilon_{f,t-1} & \varepsilon_{f,t-1}^2 \end{pmatrix} + \begin{pmatrix} \lambda_{ss} & \lambda_{sf} \\ \alpha\lambda_{sf} & \lambda_{ff} \end{pmatrix} \begin{pmatrix} h_{ss,t-1} & h_{sf,t-1} \\ h_{sf,t-1} & h_{ff,t-1} \end{pmatrix} \tag{6}$$

It is estimated that the optimal hedge ratio:

$$h^* = \frac{Cov(\varepsilon_{st}, \varepsilon_{ft})}{Var(\varepsilon_{ft})} = \frac{h_{sf,t}}{h_{ff,t}} \tag{7}$$

3.3. Hedging Performance

For the hedging effect under all optimal hedging ratios, some index is applied to measure the hedging effect. In this paper, HP is the proportion of portfolio return variance reduction before and after hedging to measure the hedging effect:

$$HP = \frac{Var(U) - Var(H)}{Var(U)} = \frac{X_s^2 \sigma_s^2 - (X_s^2 \sigma_s^2 + X_f^2 \sigma_f^2 + 2 X_s X_f \sigma_{sf})}{X_s^2 \sigma_s^2} \tag{8}$$

DOI: 10.54254/2754-1169/95/2024MUR0075

HP minimum, $HP_{\min} = \frac{\sigma_{sf}^2}{\sigma_s^2 \sigma_f^2}$.

(Xs is the spot holding position, Xf is the stock index futures holding position, Var(U) is the variance of spot return before hedging, and Var(H) is the variance of portfolio return after hedging.)

4. Empirical Analysis

4.1. Hedge Ratio

Harvest 300 ETF is selected as the spot for hedging CSI 300 stock index futures. The data of the two are selected because Harvest 300 ETF was listed earlier and has a large market share. CSI 300 stock index futures have sufficient data, low risk, and high return, which are similar to stock market operations and easy for investors to understand. The experimental data range from January 2, 2022, to July 2, 2023, 355 trading days of Harvest 300ETF and CSI 300 stock index futures contract closing prices. The data are obtained from the Choice financial terminal. The regression analysis of the above model is done on the sample data through MATLAB.

(1) OLS Model

Table 1: Parameter estimates from the OLS model

α	β	R^2	P value (F-test)
-6.164073	0.894320	0.9836	0

It can be seen from Table 1 that $\Delta S_t = -6.164073 + 0.894320\Delta F_t, R^2 = 0.9836$ the model has a high degree of fit and the regression effect is significant. The hedging ratio is 0.894320. Under F test, the P value is 0<0.5, and the regression fitting degree is good.

(2) ECM-GARCH Model

The ECM-GARCH model was established by MATLAB programming according to the formula $h^* = \frac{Cov(\varepsilon_{st}, \varepsilon_{ft})}{Var(\varepsilon_{ft})} = \frac{h_{sf,t}}{h_{ff,t}}$ The dynamic hedge ratio is derived.

Table 2: Predicted results of the ECM-GARCH model

model	Mean value	Maximum	Minimum	Standard deviation
ECM-GARCH	0.9123	0.9564	0.7543	0.0340

It can be seen from Table 2 that the hedge ratio under this model is stable at 0.9123. Among them, $R^2 = 0.9263$, the regression effect is better.

4.2. Hedging Performance

Based on, $HP = \frac{Var(U) - Var(H)}{Var(U)} = \frac{X_s^2\sigma_s^2 - (X_s^2\sigma_s^2 + X_f^2\sigma_f^2 + 2X_sX_f\sigma_{sf})}{X_s^2\sigma_s^2}$.

The HP of the two models is calculated and the following results are obtained (Table 3).

Table 3: Hedging performance of the two models

model	Hedging performance(%)
OLS	90.6448
ECM-GARCH	91.2689

It can be seen that the hedging efficiency of the two models is 90.64% and 91.27% respectively, and the hedging effect is relatively high, and both models can avoid more than 90% of the risk of spot ETF portfolio. However the dynamic ECM-GARCH model performs a little better in risk aversion than the static OLS model.

After this study, the dynamic ECM-GARCH model studies long-term financial series, which can better overcome the large volatility of data series, prevent some data from being too high and some data from being too low, and make the hedging ratio more stable and better [4]. Therefore, it also shows that the hedging ratio is dynamically adjusted. For investors holding ETFs in the future, the OLS model with simple operation can be used to operate, and the hedging strategy of stock index futures can be used to reduce systemic risk as much as possible. However, the study also shows that the hedging ratio is dynamically adjusted, and investors should adjust the optimal hedging ratio. To get more revenue. In addition, the recent data of Harvest 300ETF are selected in this study, but the data of some funds with long sample periods, such as Shanghai and Shenzhen 300ETF, are not selected, so the prediction effect is not too universal. The hedging ratio of the same model is dynamically adjusted, which may cause a high cost of position adjustment [3]. Therefore, it is necessary to comprehensively examine the hedging effect of static and dynamic hedging ratio models from the perspective of cost, to make stock index futures fully play the role of risk aversion.

5. Conclusion

This paper puts the hedging of stock index futures into ETF to study and summarize and selects a static and dynamic hedging model. This can reduce the systematic risk of ETF for investors, and it is of great significance to learn from domestic and foreign literature to study the hedging of stock index futures under ETF. The results show that stock index futures have high hedging ability, and the hedging effect reflected by the dynamic hedging model is better than that of the static model. When constructing the spot investment strategy, investors can determine the optimal hedging strategy according to the trading volume data of spot and stock index futures, and obtain the optimal number of futures contracts. However, it should be clear that investors can only reduce part of the risk with stock index futures, not achieve complete hedging, but also combine the actual situation, the optimal hedging and investment.

References

[1] *Xiao, C. (2014). Research on the hedging ratio of Shenzhen 100ETF based on CSI 300 Stock index Futures. Xi 'an: Northwest University.*
[2] *Zheng, Z. Chen, R. (2020). Financial Engineering.5 Ed. Beijing: Higher Education Press.*
[3] *Chen, Q. (2020). Research on the hedging efficiency of stock index futures in China. Forum on Industry and Technology, 19(1): 90-91.*
[4] *Wang, J. Y., Zheng, Y. W. (2014). Hedging efficiency measurement of CSI 300 stock index futures. Journal of Chengdu University of Technology (Social Science Edition), 22(6).*
[5] *Wang, J., Xianmin, C., Lexin, Z. (2007). Hedging research of stock index futures in ETF investment management. Journal of Dalian University of Technology (Social Science Edition), 28(1).*
[6] *Gu, C. Lyu, W. (2021). Research on Optimal hedging ratio of CSI 300 Stock Index Futures based on High Frequency data. Journal of Natural Science of Harbin Normal University, 37(5): 8-16.*

DOI: 10.54254/2754-1169/95/2024MUR0075

[7] *Zhong, C. Y. (2023). Hedging ratio between CSI 300 stock index futures and ETF funds. China market, 23.*
[8] *Yanhong, S., Guangping, F. (2015). Research on hedging ratio of stock index futures with VaR minimization. Journal of Mathematical Statistics and Management, 34(04): 750-760.*
[9] *Ederington, L. H. (1979). The Hedging Performance of the New Futures Markets. Journal of France, (34): 157-170.*
[10] *Ghosh, A. (1993). Hedging with stock index futures: estimation and forecasting with error correction model. The Journal of Futures Markets, 13(7), 743-752.*
[11] *Chihchiang, H., Chihping, T., Yawhuei, W. (2018). Dynamic hedging with futures: A couple-based GARCH model. Journal of Futures Markets, 28(11): 1095-1116.*