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Realized hedge ratio: Predictability and hedging performance☆

Chrysi E. Markopoulou [a], Vasiliki D. Skintzi [b,*], Apostolos-Paul N. Refenes [a]

[a] Department of Management Science and Technology, Athens University of Economics and Business, Athens, Greece
[b] Department of Economics, University of Peloponnese, Greece

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ABSTRACT

This study explores the dynamic properties and predictability of the Realized Minimum Variance Hedge Ratio (RMVHR), constructed from five-minute spot and future returns of two stock indices and two exchange rates. A number of econometric models are employed to forecast directly the RMVHR and the out-of-sample performance is evaluated. Results from statistical measures suggest that the evolution of the realized hedge ratio series is predictable. In terms of risk reduction, we conclude that realized hedge ratio forecasts dominate conventional methods that use daily data while the benefit is pronounced when economic gains are considered. The superior performance of RMVHR methods holds across different asset classes but is more conspicuous in the case of stock indices. Finally, this study assesses the effect of sampling frequency and transaction costs.

1. Introduction

The increased availability of high-frequency data has stimulated the interest of practitioners and academics, giving rise to a new area of research in financial modeling where multi-dimensional high-frequency data is utilized to estimate, model and forecast the second moments of asset returns. Andersen and Bollerslev (1998) introduced the notions of realized volatility and covariance as model-free estimators of the true latent process, computed from intraday return data. Andersen, Bollerslev, Diebold, and Labys (2001b), Andersen, Bollerslev, Diebold, and Ebens (2001a) and Barndorff-Nielsen and Shephard (2002) proved that, according to the theory of quadratic variation, by allowing the sampling frequency to tend to zero, the realized measures are unbiased and efficient estimators of the integrated processes, which essentially become observable, thus enabling direct estimation. In the forecasting context, Koopman, Jungbacker, and Hol (2005) and Blair, Poon, and Taylor (2010) amongst others have provided evidence of superior informational content of the realized measures when compared to estimators derived from daily closing prices.

Andersen, Bollerslev, Diebold, and Wu (2006) extended their previous work on realized volatility and correlation, and defined realized beta as the ratio of realized covariance between asset and market returns to market variance. Under continuous-time stochastic volatility diffusion process of the price, the realized beta is a consistent estimator of the true integrated beta. Additionally, they advocate that any common persistence trait of the covariance and variance processes could be neutralized when forming the beta ratio. In addition, the study assesses the comparative predictability of realized beta versus the (co)variance predictability and finds that the former is much smaller. Notably, the predictability of the short-run beta, modeled through a simple autoregressive process, is much higher than the predictability of the long-run beta estimated from an ARFIMA specification.

In a similar context, the Realized Minimum Variance Hedge Ratio (RMVHR, hereafter) is defined as the ratio of the realized covariance of futures and spot returns divided by the futures realized variance. This study is motivated by the findings of Andersen et al. (2006) on the differential distribution properties of the realized (co)variance and beta, and the additive value of utilizing intraday information in dynamic hedging. More specifically, we address the question whether forecasting the dynamics of the RMVHR per se results in substantial benefit to the hedger in terms of risk reduction and economic value while the results are compared with those obtained from conventional models that use daily data. Our methodology is in contrast to previous studies that employ econometric specifications on daily returns to model the variance–covariance matrix, construct out-of-sample forecasts and ultimately, calculate the hedge ratio.

Only a limited number of studies have examined the information content of intraday data in a dynamic hedging context. Yeh, Huang, and Hsu (2008) provide evidence of superior hedging performance of ARMA(1,1) forecasts of realized hedge ratio for the S&P 500 index. Based on intraday data on currency futures, Harris, Shen, and Stoja

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* Corresponding author at: Department of Economics, University of Peloponnese, Thesi Sehi, GR22100, Tripolis, Greece.
E-mail address: vikiski@uop.gr (V.D. Skintzi).

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(2010) indicate that, when compared to the RMVHR used as benchmark, the parametric variance–covariance models based on daily data perform poorly in terms of hedging effectiveness. The the low hedging performance of the conditional daily models is attributed to the low persistence and, hence, the unpredictability of the RMVHR. Lastly, McMillan and Quiroga Garcia (2010), using data on the Spanish IBEX 35 Index, advocate that the portfolio variance is minimized when the hedge ratio is estimated from daily returns while the realized hedge ratio yields superior Sharpe ratio.

This study makes four contributions to the ongoing discussion about the value of employing high-frequency data to the estimation of the hedge ratio. First, a thorough evaluation of the time-series characteristics of the realized volatility, realized covariance and RMVHR is performed and the differential properties of the distributions are assessed. Second, we perform a horse race amongst alternative model specifications and evaluate the statistical significance of the predictability of the RMVHR series per se. Third, we produce one-step-ahead forecasts of the RMVHR under various econometric processes and examine the improvement in hedging performance against conventional modeling and forecasting techniques. Finally, an extensive dataset of equity indices and foreign exchange rates is used and differentiated patterns across asset classes are examined.

Overall, empirical results from alternative time-series specifications suggest the presence of predictable pattern in the evolution of the RMVHR series per se. Statistical evaluation criteria suggest that the time-varying weighted combination forecasts and forecasts based on the Heterogeneous Autoregressive model (HAR) are the best performing forecasts for the stock indices and exchange rates, respectively. In addition, alternative econometric specifications predict successfully the directional change of the series approximately 70% of the times throughout the out-of-sample period while results do not vary significantly across models.

Importantly, the direct forecast of the RMVHR series, based on intraday data, improves hedging portfolio performance in terms of risk reduction, Sharpe ratio and mostly in terms of economic gains. In specific, results from the percentage risk reduction metric suggest that, the improvement, when switching from daily to intraday returns, ranges within 0.1% and 0.6%. Notably, the hedger's benefit is substantial when taking into account both the average return and the variance of the hedge portfolio. In the majority of cases, the use of intraday returns and direct forecasting of the series results in substantial improvement of the Sharpe ratio and economic gains. The results hold across the different asset classes, although the benefits are lower in the case of exchange rates. Lastly, our main results are relatively robust for a range of sampling frequencies and with the inclusion of transaction costs.

The remaining paper is organized as follows. Section 2 presents the methodology for the derivation of the Realized Minimum Variance Hedge Ratio and the econometric models employed to forecast the hedge ratio. Section 3 describes the dataset used in the study along with the descriptive statistics of realized variance, covariance and hedge ratio. Sections 4 and 5 present the in-sample estimation results and the out-of-sample forecast evaluation under statistical and economic metrics, respectively. At Section 6, we assess the effect of alternative sampling frequencies and transaction costs to the out-of-sample economic significance of employed models. We conclude at Section 7.

2. Methodology

2.1. Realized Minimum Variance Hedge Ratio

Consider an investor with a long (short) position in the spot market. The hedge ratio denotes the number of futures contracts that the investor is willing to sell (buy) in order to offset the risk deriving from fluctuations of the spot market. The return of the hedged portfolio at time t is given by:

$$r_{p,t} = r_{s,t} - \beta_t r_{f,t} \tag{1}$$

where $r_{s,t}$ and $r_{f,t}$ are the logarithmic returns, from $t-1$ to t, of the cash position in the spot and the futures market, respectively, and β_t is the hedge ratio. The optimal hedge ratio is obtained by minimizing the variance of the portfolio and equals to:

$$\beta^*_{t|\Omega_{t-1}} = \frac{\sigma_{sf,t|\Omega_{t-1}}}{\sigma^2_{f,t|\Omega_{t-1}}} \tag{2}$$

where $\sigma_{sf,t}$ and $\sigma_{f,t}$ are the spot and futures returns covariance and futures variance, respectively, conditional on the information set Ω, available at time $t-1$.

The vast majority of previous studies estimate the variance–covariance matrix using daily closing prices. Andersen and Bollerslev (1998) show that the Realized Volatility (RV), defined as the sum of squared intraday returns, sampled at non-overlapping intervals of frequency Δ, is a consistent and efficient estimator of the true latent volatility. In essence, RV is defined as follows:

$$RV_{i,t} = \sum_{m=1}^{1/\Delta} r^2_{i,t-1+m\cdot\Delta,\Delta} \tag{3}$$

where $i = s,f$ for the spot and futures returns, respectively and $1/\Delta$ is the number of intraday intervals. Similarly, the Realized Covariance (RC) can be defined as the cross-product of squared intraday returns.

$$RC_{ij,t} = \sum_{m=1}^{1/\Delta} r_{i,t-1+m\cdot\Delta,\Delta} \cdot r_{j,t-1+m\cdot\Delta,\Delta} \tag{4}$$

Andersen, Bollerslev, Diebold, and Wu (2006) introduced the notion of realized beta, while Harris, Shen, and Stoja (2010) defined the Minimum Variance Hedge Ratio as the optimal hedge ratio calculated from intraday data. For the purposes of this study, the Realized Minimum Variance Hedge Ratio (RMVHR) is defined as follows:

$$RMVHR_t = \frac{RC_{sf,t}}{RV_{f,t}} \tag{5}$$

2.2. Forecasting models

Vast majority of existing literature supports the presence of intraweek and seasonality patterns in the dynamics of the return distribution from daily prices. With the main purpose of our paper laying in the predictability of the daily RMVHR, the impact of such regularities on the evolution of the series is assessed. First, we examine the presence of the day-of-the week effect through the specification:

$$y_t = \sum_{i=1}^{5} \alpha_i D_{i,t} + \gamma D_{roll} + \delta y_{t-1} + \varepsilon_t \tag{6}$$

where y is the RMVHR and D_i are the dummy variables corresponding to the five days of the week (i.e. D_1 equals 1 if Monday and 0 otherwise, D_2 equals 1 if Tuesday and 0 otherwise, etc). A dummy variable, D_{roll}, taking a value of 1 at the day the futures series is rolled to the next contract and 0 otherwise, is added to the specification to control for the possible effects of futures contract rollover.