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Intra-day return modeling with the MGHyp distribution for portfolio optimization

Bachelor Thesis

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Executive Summary

The subject of this thesis is to enhance daily asset allocation by incorporating intra-day returns into the optimization process. For this purpose, we use the multivariate generalized hyperbolic [MGHyp] subclass of the variance gamma [VG] model to fit 30 minute [min] returns of ten stocks listed on the New York Stock Exchange [NYSE]. We derive daily return distributions from those estimates to minimize the Expected Shortfall [ES] of the portfolio, and compare its performance to the results based on fitting daily returns. By using the flexible VG model and the ES as a downside risk measure, we account for the skewness and heavy-tails of the return distributions, especially at the intra-day level (Figueroa-López et al. (2011)).

Furthermore, the optimization is conducted while assuming the returns to be independent and identically [iid] distributed, which lowers portfolio turnover compared to time-varying volatility models (Sheedy et al. (1999)). Most importantly, the iid framework is required for the convolution-invariant property of the VG model (Mattei (2017), Podgórski and Wallin (2016)), which makes it easy to derive daily parameter estimates calibrated on the 30min time scale. However, the assumption is also quite questionable for intra-day returns (Voev and Lunde (2006)), which stresses our focus on the practical benefit of the approach, rather than the statistical fit of the model.

We compare the estimation strategies based on different sample sizes. The benchmark strategy uses the last 1'000 daily returns for the VG calibration, whereas the contending 30min strategies estimate the model by using 1'000, 3'000 and 11'000 data points [dp], with the last sample size representing the same time frame as the daily return sample. Without transaction costs, all 30min strategies outperform the daily estimation method. The strategy with the 30min sample of 1'000dp reaches the highest Sharpe Ratio [SR], but exhibits an almost four times higher turnover rate compared to the daily approach. The seemingly negative relationship between the sample size and turnover rate hence limits the convolution method's ability to shorten sample periods. Fortunately, the 30min-11'000dp strategy achieves the second best SR with an improvement of over 25% compared to the daily model, while even reducing portfolio turnover. These results strongly indicate an efficiency gain of the 30min strategies with big enough estimation samples, which is further supported by their stable outperformance, which remains even under the simplification of using eleven times less parameter estimates for the model calibration. Further research is necessary to make broader statements about the universal validity of this approach, but is encouraged by the tracked outperformance of the 30min-11'000dp strategy for almost eight years.

Abstract

This thesis contributes to the growing literature of modeling financial returns at the intra-day level by considering its ability to predict the daily structure for asset allocation purposes. We test, whether the VG-iid model calibrated on the 30min time scale is beneficial for daily portfolio optimization by minimizing the next day ES. The VG-iid model lowers portfolio turnover, fits the return data quite well and allows for an easy derivation of daily parameter estimates based on intra-day returns (Podgórski and Wallin (2016)). However, the assumption of iid returns is quite questionable at the intra-day level (Voev and Lunde (2006)), which stresses our focus on the practical benefit of this approach. Without transaction costs, we present an outperformance of all our strategies using 30min data instead of daily returns. The benefits are quite stable and remain even under simplifying assumptions. One of the 30min strategies also reduces the turnover rate, which stresses the practical significance of our findings.