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Joint Non-Gaussian Cholesky-GARCH Modeling of Asset Returns and Factors with Applications in Portfolio Optimization

Master's Thesis

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Executive Summary

It is well established that daily or higher frequency financial asset returns exhibit volatility clustering and non-Gaussian behavior, notably so-called heavy tails. These features have enormous implications for both passive risk management (such as measuring the value at risk of a given portfolio) and active risk management (portfolio optimization). While many models have been proposed in a univariate setting to address these features, far fewer constructs are available in the large-scale multivariate case. Among such multivariate constructs, most are based on Gaussianity, and are inappropriate for accurate risk assessment. In this work, not only is the Gaussianity assumption relaxed, but each asset is allowed to have its own tail behavior, allowing more accurate modeling and portfolio risk assessment.

A further, independent development in financial economics and empirical asset pricing is the use of so-called factors, or exogenous variables, that are assumed to have predictive ability for the asset returns. Research in this area, and search for new factors, continues unabated, since the seminal work of Eugene Fama and Kenneth French in the early 1990s. Such models are an extension of the famous CAPM construction, and its use for portfolio construction differs completely from the alternative approach of using a multivariate predictive distribution of the returns and application of a Markowitz-type of optimization.

This work combines the two strands of literature by proposing a mathematically elegant stochastic process that allows the joint time series modeling of financial asset returns and factors. Such a construction appears to be new in the academic literature, and subsumes numerous previously proposed approaches. It allows for volatility clustering and heterogeneous tail behavior among the assets. In doing so, the effect of including factors can influence both the mean prediction of returns, as well as their covariance structure, and thus influence also risk prediction. The mathematical overhead required for its implementation needs to go beyond basic regressions and other simple statistical procedures. For example, it entails use of more sophisticated time series filtering mechanisms, use of distribution inversion theorems, and deeper concepts in optimization, though it is still computationally feasible. Importantly, the methodology is applicable in reasonably high dimensions, as is necessary in a realistic investment environment.

A limited empirical example using five daily value-weighted industry portfolio returns, along with the classic three Fama-French factors is conducted, in a long-only investment setting, comparing the performance with and without conditioning on the factors. Future research will expand upon the model and, crucially, conduct extensive backtesting exercises with various and larger data sets.