Downside Risk and Portfolio Optimization of Energy Stocks: A Study on the Extreme Value Theory and the Vine Copula Approach

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Energy price spikes hurt global economic growth. However, energy stocks benefit from higher energy prices. Thus, energy stocks are potentially a hedge against inflation and macroeconomic shocks. In recognition to these factors, a number of foundations and endowments in the US maintain a separate allocation to energy stocks. Many mutual funds also prefer to allocate a significant portion of their funds to energy stocks. Hence, a study on energy stocks portfolio management is indeed an important area of research in financial risk management as the research findings can provide potential implications not only for sophisticated investors such as energy fund managers, foundations and endowments, but also for individual investors and policymakers. This study aims to predict the portfolio VaR and CVaR, and comprehensively evaluate the relative performance of different models in the context of energy stock portfolio management.

Using 15 energy stocks from the US markets, we investigate the relative performance of proposed GARCH-EVT-vine copula models (hereafter vine copula models) under three different dimensions with other competing models. In our proposed vine copula models, we use static C- and D-vine copulas. We examine the relative performance of our proposed models with other competing models such as different GARCH-EVT-standard copula models (hereafter standard copula models) and the benchmark multivariate normal (MVN) model in forecasting VaR and CVaR of energy stock portfolio. The proposed model is expected to capture stylized facts of energy stock return series, such as negative skewness, excess kurtosis, volatility clustering, and nonlinear and asymmetric dependence among multiple stock returns. Although, this sophisticated model is expected to be more accurate in predicting VaR and CVaR, the benchmark MVN and standard copula models may be less costly. Hence, we use Data envelopment analysis (DEA) approach to measure the relative efficiency of all methods in predicting energy stock portfolio VaR and CVaR. In addition, the proposed advance vine copula model presents an important opportunity to address some intriguing questions in the modern portfolio management context. For instance, does the more sophisticated vine copula approach yield superior economic and statistical performance than the standard copula models? Does the vine copula model produce superior outcomes for a large portfolio than a small one? Can the vine copula model produce better results than the MVN model? Can the dynamic vine copula models yield superior economic and statistical performance than the static vine copula models? Since, investors are likely to prefer different levels of risk, we apply a plethora of risk-adjusted measures to investigate portfolio performance, and answer the above questions in a tactical asset allocation framework.

Our results show that for portfolios of three energy stocks and more, the proposed vine copula models forecast energy portfolio VaR and CVaR more accurately than the competing models. However, while examining the relative efficiency of different models, the overall efficiency results show that the proposed vine copula and benchmark MVN models are equally efficient with

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respect to the standard copula models for all sizes energy stock portfolios. The finding also reveals that across a range of economic and statistical metrics, the vine copula models produce higher rank outcomes than the remaining models. In fact, the relatively better performance of the vine copula models is even more prominent when the portfolio size increases. Further, when we directly compare the time-series performances of the equally efficient vine copula and MVN models, the former model produces superior outcomes. Finally, to provide the dynamics of portfolio performance, we also use the dynamic vine copula models, and investigate whether these models yield superior economic and statistical performance than their static counterparts. By comparing the time series performance of static models with dynamic models in a portfolio of fifteen stocks, we find that although no model clearly outperforms the other model in terms of risk adjusted performance measures, dynamic C-vine copula dominates its static counterpart in producing higher economic gain for four of the five years out-of-sample period consistently.

The findings of the study might be especially useful for energy fund managers, endowment fund managers and pension fund managers who seek to optimize energy stock portfolios using the CVaR minimization method. Since the proposed advance vine copula models yield superior statistical and economic outcomes compared to the standard copula and the MVN models, we may safely conclude that the proposed vine copula model is truly useful when constructing portfolios of high dimensions, as it captures the dependence structure more accurately than either the standard copula or the MVN models. When energy prices are expected to increase, individual investors can invest in energy stocks and manage downside risk of their energy stock portfolio following the proposed methodology. The optimal hedge ratio can be determined by identifying the portfolio weights appropriately based on the downside risk hedging strategy to minimize the portfolio downside risk using the proposed vine copula approach. Also, inflation sensitive pension fund managers and retired persons may buy and manage energy stocks and improve their portfolio performance by diversifying the portfolio downside risk based on the proposed model. Moreover, government and policy makers could make the energy stocks more attractive adjusting their returns by regulating environment taxes on fossil fuels. The policy makers may ask the energy fund managers and foundations and endowments which incorporate a separate portfolio allocation to energy stocks, to invest a part of their funds to risk-less government securities and maintain adequate capital. The required amount of investment to government securities should be estimated on the basis of portfolio VaR / CVaR calculated using the proposed model. Thus, the findings, in general, may be useful to all kinds of market participants such as portfolio managers, financial market analysts, hedgers and investors.