Title: Mean-Variance versus Mean-Expected Shortfall Models: An Application to Wheat Variety Selection

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Abstract:

It is alarming that recent climate changes could lead to severe reduction in wheat production and higher variability in wheat yields. Among a variety of risk management strategies and tools (including geographical diversification, enterprise diversification, crop diversification, crop insurance, and derivative instruments), varietal diversification seems to be the most cost-effective method for wheat producers to mitigate yield risk caused by diverse growing conditions and unpredictable climate. Then, the question is how to determine the optimal mix of wheat varieties. Previous studies on wheat variety selection, including the works by Barkley et al. (2010), Nalley and Barkley (2010), and Nalley et al. (2009), proposed the use of a mean-variance model as a tool to optimally select wheat varieties.

A major drawback of the standard mean-variance analysis is that it uses variance, which treats both upside and downside risk as the same, as the risk measure. Because the producers often consider the upside risk to be favorable, the use of variance seems to be inappropriate. The only case where upside and downside risk are the same and, thus, variance is a correct measure of risk is when crop yields or profits are normally distributed. However, in reality, agricultural yields have been shown to be non-normal (Atwood et al. 2002; Day 1965; Ramirez et al. 2003). Given that the producers are only concerned with the downside risk, some studies used Expected Shortfall (ES), which measures the risk of the actual yield being far below the expected yield (that is, the downside risk), as the risk measure (see, for example, Larsen et al. (2015), Strauss et al. (2011), and Zylstra et al. (2003) for applications of ES in agriculture). One could then use a mean-ES model, instead of the mean-variance model, to determine an optimal proportion of each crop variety to be planted.

Even though researchers are well aware that crop yields may not be normally distributed and that wheat producers are particularly concerned with the downside risk, to our best knowledge, none of the existing studies have applied the mean-ES model to the wheat variety selection problem. This study is, therefore, the first study to explore the potential benefits of the mean-ES approach as a technique to select wheat varieties. Particularly, we compare optimal wheat variety mixes obtained from the mean-variance framework with those from the mean-ES model, and then examine potential gains from applying the two portfolio optimization methods to wheat variety selection. In addition, our study adds to earlier studies on wheat variety selection by applying the methods to a different data set. While the previous studies applied portfolio theory to wheat variety selection decision in Kansas (Barkley et al. 2010), Colorado (Mortenson et al., 2012), Yaqui Valley of Northwestern Mexico (Nalley and Barkley, 2010), and Texas High Plains (Park et al., 2012), we consider the wheat selection problem in Texas Blacklands. The location is chosen based upon data availability and the lack of previous research. Last but not least, unlike previous studies that evaluate the performance of the optimization models on the period over which the model is estimated (that is, the optimization period), this study looks at how well the models perform the year after the estimation period. This is a better way to evaluate the performance of optimization strategies because in reality wheat producers must make decisions regarding which varieties to be planted next year before the next-year yield data exist.
Our results suggest that the mean-variance model may not be the best tool for choosing the optimal mix of wheat varieties to plant as suggested by the previous studies, and that portfolio optimization in a downside risk framework seems to be a better alternative. This research should provide useful information for agricultural producers who aim at improving variety selection and developing a new adaptation strategy to cope with the changing climate.

References