

classes are utilized and a more diversified portfolio is achieved.

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model obtains the highest minimum five-year return of the all the models. Based on these results it would seem that a more risk averse investor would select the  $M_0$  model

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to determine if a more prescriptive form of investment exists. The study is on short-term government bonds, long term government stocks, small cap growth, small cap value, large cap growth, large cap value and commodities. These asset classes are measured by the Merrill Lynch three to five year government bonds, Merrill Lynch government bonds, MSCI EAFE Equity Index, Russell 2000 Growth, S&P 500/BARRA Growth, S&P 500/BARRA Value, NAREIT-REIT Index and Goldman Sachs Commodity Index. Based on these asset classes, a set of optimal portfolios will be generated by the mean-variance minimax rule. These two techniques will be compared to determine if one set of future market conditions will be simulated to determine if one set is better than the other.

## 2. Literature Review

Research in the area of portfolio management can really be broken into two sectors: asset allocation and portfolio theory. The main topics of asset allocation look at active versus passive asset allocation performance. The works that deal with portfolio theory take a new idea of constructing an optimal portfolio and compare it to the benchmark mean-variance portfolio theory created by Markowitz.

Harry Markowitz is the father of portfolio management theory. Markowitz developed an efficient frontier generated by the multi-objective function to minimize risk while maximizing return characterized by:

$$\text{Min } z_1 = x^T Q x \quad (2.1)$$

$$\text{Max } z_2 = \mu^T x \quad (2.2)$$

where  $Q$  denotes the symmetric variance-covariance matrix of the assets,  $\mu$  is the matrix of returns corresponding to the assets and  $x$  denotes the amount invested in the asset. A portfolio on the efficient frontier has the highest expected return for a given level of risk and the lowest level of risk for a given expected return. His key insight to mean-variance framework is that the covariances between and among assets, not just the variance of the asset themselves, play a role in determining the overall risk in the portfolio. The problem with this theory is that it exists in a prescriptive form. There are no guidelines for investors to follow to assess their attitudes about the trade-off of expected returns and risk.

There has been some work to improve this methodology by Schirripa and Tecotzky [2000]. Their approach constructs an optimal frontier portfolio. In this case, a group of investors pool their money together and an efficient portfolio is based on the

combination of the individual's risk-return goals. In this instance, the whole is greater than the sum of the parts. For this method to be successful, it is not only important to have a diverse portfolio but diverse investors as well. Each investor is paid based on his weighted investment contribution in the portfolio. Some important findings for the optimal frontier portfolio are that the degree of curvature on the portion of the efficient frontier where investors have selected risk points will impact the return enhancement and the distribution of investor dollars among the risk points also impacts the return enhancement.

Other portfolio theories tend to depart from this methodology. Sheffrin and Statman [2000] developed a positive behavioral portfolio theory and explored the consequential implications for portfolio construction and security design. Behavioral portfolio theory is one in which investors choose portfolios by considering expected wealth, desire for security and potential, aspiration levels, and the probabilities of achieving these aspiration levels. The type of investor depicted in this theory deviates from the textbook investor in that this investor lacks self-control. Self-control is enforced by penalty charges for an early sale or a tax write-off for the investment. Their portfolios resemble a combination of bonds and lottery tickets. There are two types of behavioral portfolio theories. Behavioral portfolio theory- single mental account (BPT-SA) investors resemble mean-variance investors in that they integrate their portfolios into a single mental account by considering covariance. When compared with the mean-variance framework, they found that some BPT-SA portfolios are on the mean-variance efficient frontier but not all of the BPT portfolios are identical to the mean-variance portfolios. Behavioral portfolio theory - multiple mental accounts portfolio resembles a layered