A SIMPLIFIED PERSPECTIVE OF THE MARKOWITZ PORTFOLIO THEORY

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ABSTRACT

Noted economist, Harry Markowitz ("Markowitz) received a Nobel Prize for his pioneering theoretical contributions to financial economics and corporate finance. His innovative work established the underpinnings for Modern Portfolio Theory—an investment framework for the selection and construction of investment portfolios based on the maximization of expected portfolio returns and simultaneous minimization of investment risk. This paper presents a simplified perspective of Markowitz' contributions to Modern Portfolio Theory, foregoing in-depth presentation of the complex mathematical/statistical models typically associated with discussions of this theory, and suggesting efficient computer-based 'short-cuts' to these performing these intricate calculations.

JEL: G30, G32, G11, G00, G20

KEYWORDS: Markowitz Portfolio Theory, Modern Portfolio Theory, Portfolio Investing, Investment Risk

INTRODUCTION

Harry Markowitz ("Markowitz") is highly regarded as a pioneer for his theoretical contributions to financial economics and corporate finance. In 1990, Markowitz shared a Nobel Prize for his contributions to these fields, espoused in his "*Portfolio Selection*" (1952) essay first published in *The Journal of Finance*, and more extensively in his book, "*Portfolio Selection: Efficient Diversification* (1959). His groundbreaking work formed the foundation of what is now popularly known as 'Modern Portfolio Theory' (MPT). The foundation for this theory was substantially later expanded upon by Markowitz' fellow Nobel Prize co-winner, William Sharpe, who is widely known for his 1964 Capital Asset Pricing Model work on the theory of financial asset price formation.

The problem, with respect to MPT, is that the majority of investigations of the topic focus on the highly complex statistics-based mathematical modeling and formulas which support the concept's theoretical assumptions. Typically, these investigations present their findings utilizing unnecessarily complicated rhetoric and intricate formulaic expressions. In opposite, the less complicated treatments are generally overly simplified, non-comprehensive, and lack the rigor requisite of serious scholars and practitioners.

In response to the above issues, this analysis focuses on Markowtiz' contributions to MPT in context of the theoretical and technological advances that have occurred since his theory first came to light in 1952. Since then, the field of financial investing has undergone major evolutions that include significant advances in the financial concepts and tools available to investors and investment professionals. While a substantial part of MPT is devoted to statistics-based mathematical modeling and formulas which support its theoretical assumptions, this analysis expands upon this body of literature by focusing on a simplified perspective of its key theoretical assumptions. At the same time, examples are strategically included to demonstrate how modern computing technology (specifically Microsoft Excel) can be used as highly efficient 'short-cuts' to make the often complex calculations needed to support MPT, thus allowing for more attention to be placed on MPT's theoretical underpinnings.

Following a review of foundational and current literature, this essay includes an overview of Modern Portfolio Theory and a general discussion of its framework and key concepts, including risk & return, expected return, measures of risk and volatility, and diversification. Finally, it closes with concluding remarks including analysis limitations and a possible perspective for future research.

LITERATURE REVIEW

The foundation for Modern Portfolio Theory ("MPT") was established in 1952 by Harry Markowitz with the writing of his doctoral dissertation in statistics. The most important aspect of Markowitz' model was his description of the impact on portfolio diversification by the number of securities within a portfolio and their covariance relationships (Megginson, 1996, p. 325). His dissertation findings, entitled "Portfolio Selection" (1952), were first published in *The Journal of Finance*. Subsequently, these findings were significantly expanded with the publication of his book, *Portfolio Selection: Efficient Diversification* (1959). About thirty years later, Markowitz shared a Nobel Prize for his MPT contributions to the fields of economics and corporate finance.

In 1958, economist James Tobin in his essay, "Liquidity Preference as Behavior Toward Risk," in *Review of Economic Studies*, derived the 'Efficient Frontier' and 'Capital Market Line' concepts based on Markowitz' works. Tobin's model suggested that market investors, no matter their levels of risk tolerance, will maintain stock portfolios in the same proportions as long as they "maintain identical expectations regarding the future" (Megginson, 1996, citing Tobin, 1958). Consequently, concluded Tobin, their investment portfolios will differ only in their relative proportions of stocks and bonds.

Independently developed by William Sharpe, John Lintner, and Jan Mossin, another important capital markets theory evolved as an outgrowth of Markowitz' and Tobin's earlier works—The Capital Asset Pricing Model (CAPM) (Megginson, 1996, p. 325). The CAPM provided an important evolutionary step in the theory of capital markets equilibrium, better enabling investors to value securities as a function of systematic risk. Sharpe (1964) significantly advanced the Efficient Frontier and Capital Market Line concepts in his derivation of the CAPM. Sharpe would later win a Nobel Prize in Economics for his seminal contributions. A year later, Lintner (1965) derived the CAPM from the perspective of a corporation issuing shares of stock. Finally, in 1966, Mossin also independently derived the CAPM, explicitly specifying quadratic utility functions (Megginson, 1996, p. 327). Since the earlier works of Markowitz, and later, Sharpe, Lintner and Mossin, there have been various expansions and iterations of MPT. The remainder of this essay addresses a perceived "simplicity" gap in that literature, and suggests a systemic failure of theorists and practitioners to capitalize upon the tremendous advances in finance and technology. It also specifically extends the conceptual premises of Wharton professor, Dr. Simon Benniga, in his book, *Principles of Finance with Excel* (2006), wherein he argues for a more simplistic approach to understanding and calculating the various mathematical concepts underlying MPT.

Modern Portfolio Theory

Technically speaking Modern Portfolio Theory ("MPT") is comprised of Markowitz' Portfolio Selection theory, first introduced in 1952, and William Sharpe's contributions to the theory of financial asset price formation which was introduced in 1964, which came be known as the Capital Asset Pricing Model ("CAPM") (Veneeya, 2006). Essentially, MPT is an investment framework for the selection and construction of investment portfolios based on the maximization of expected returns of the portfolio and the simultaneous minimization of investment risk (Fabozzi, Gupta, & Markowitz, 2002).

Overall, the risk component of MPT can be measured, using various mathematical formulations, and reduced via the concept of diversification which aims to properly select a weighted collection of investment assets that together exhibit lower risk factors than investment in any individual asset or singular asset class. Diversification is, in fact, the core concept of MPT and directly relies on the conventional wisdom of "never putting all your eggs in one basket" (Fabozzi, Gupta, & Markowitz, 2002; McClure, 2010; Veneeya, 2006).

It is instructive to note here that Markowitz' portfolio selection theory is a 'normative theory.' Fabozzi, Gupta, & Markowitz (2002) define a normative theory as "one that describes a standard or norm of behavior that investors should pursue in constructing a portfolio…" (p. 7). Conversely, Sharpe's asset pricing theory (CAPM) is regarded as a 'positive theory'—one that hypothesizes how investors actually behave as opposed to how they should behave. Together, they provide a theoretical framework for the identification and measurement of investment risk and the development of relationships between expected return and risk. There remains a degree of debate as to whether or not MPT is interdependent upon the validity of asset pricing theory (Fabozzi, Gupta, & Markowitz, 2002). This analysis assumes that MPT is indeed independent of asset pricing theory, with the latter concept the subject of separate analysis.

Accordingly, for purposes of this writing, concentration is made on Markowitz' portfolio selection theory contributions. In that regard, these contributions will continue to be referred to as the collective MPT—also referred to the mean-variance analysis (with 'mean' used interchangeably with average or expected return, and 'variance' used to denote risk). Markowitz demonstrated that under certain conditions, an investor's portfolio selection can be reduced to balancing two critical dimensions: (1) the expected return of the portfolio, and (2) the risk or variance of the portfolio (Royal Swedish Academy of Sciences, 1990). Due to the risk reduction potential of diversification, portfolio investment risk, measured as its variance, depends upon both individual asset return variances as well as the 'covariances' of pairs of assets (McClure, 2010). In other words, Markowitz (1952) states that portfolio selection should be based on overall risk-reward characteristics, as opposed to simply compiling portfolios with securities with individually attractive risk-reward characteristics. These essential MPT terms are discussed below.

DISCUSSION

The framework for MPT includes numerous assumptions about markets and investors. Some of these assumptions are explicit, while others are implicit. Markowitz built his portfolio selection contributions to MPT on the following key assumptions (Bofah, n.d.; Wecker, n.d.; Markowitz, 1952): 1.) Investors are rational (they seek to maximize returns while minimizing risk), 2.) Investors are only willing to accept higher amounts of risk if they are compensated by higher expected returns, 3.) Investors timely receive all pertinent information related to their investment decision, 4.) Investors can borrow or lend an unlimited amount of capital at a risk free rate of interest, 5.) Markets are perfectly efficient, 6.) Markets do not include transaction costs or taxes, 7.) It is possible to select securities whose individual performance is independent of other portfolio investments. These foundational assumptions of MPT have been widely challenged. Many of the criticisms leveled at the theory are discussed later in this essay.

Risk & Return

Financial risk can be defined as deviation away from expected historical returns during a particular time period (Bofah, n.d.; McClure, 2010). However, Markowitz' portfolio selection theory maintains that "the essential aspect pertaining to the risk of an asset is not the risk of each asset in isolation, but the contribution of each asset to the risk of the aggregate portfolio" (Royal Swedish Academy of Sciences, 1990).Risk of a security can be analyzed in two ways: (1) stand-alone basis (asset is considered in isolation), and (2) portfolio basis (asset represents one of many assets). In context of a portfolio, the total risk of a security can be divided into two basic components: systematic risk (also known as market risk or common risk), and unsystematic risk (also known as diversifiable risk) (Lowering portfolio risk, 2011). MPT assumes that these two types of risk are common to all portfolios.

Systematic, risk is a macro-level form of risk—risk that affects a large number of assets to one degree or another (Ross, Westerfield, & Jaffe, 2002). General economic conditions, such as inflation, interest rates, unemployment levels, exchange rates or Gross National Product-levels are all examples of systematic risk factors. These types of economic conditions have an impact on virtually all securities to some degree. Accordingly, systemic risk cannot be eliminated.

Unsystematic risk, on the other hand, is a micro-level form of risk—risk factors that specifically affect a single asset or narrow group of assets (Ross, Westerfield, & Jaffe, 2002). It involves special risk that is unconnected to other risks and only impacts certain securities or assets. For example, the ill-received change in the announced consumer pricing structure of NetFlix resulted in extremely negative consumer response and defections, which resulted in lower earnings and lower stock prices for NetFlix. However, it did not impact the overall stock performance of the Dow Jones or S&P, or even that of entertainment and media industry companies for that matter—with the possible exception of its biggest rival Blockbuster Video, whose value increased significantly as a result of NetFlix' faltering market share. Other examples of unsystematic risk might include a firm's credit rating, negative press reports about a business, or a strike affecting a particular company (Helela, n.d.).

Unsystematic risk can be significantly reduced by the diversification of securities within a portfolio (McClure, 2010). Since, in practice, the returns on different assets are correlated to at least some degree, unsystematic risk can never truly be completely eliminated regardless of how many types of assets are aggregated in a portfolio (McClure, 2010; Royal Swedish Academy of Sciences, 1990).

Risk/Return Tradeoff

The concept of 'Risk and Return trade-off' relates to Markowitz' basic principle that the riskier the investment, the greater the required potential return. Generally speaking, investors will keep a risky security only if the expected return is sufficiently high enough to compensate them for assuming the risk (Ross, S. Westerfield, R., & Jaffe, J, 2002). The risk represents the chance that the actual return of an investment will be different than expected, which is technically measured by standard deviation (Risk-Return Tradeoff/Investopedia, n/d). A higher standard deviation translates into a greater risk and a requisite higher potential return.If investors are willing to bear risk, then they expect to earn a risk premium. Risk premium is "the return in excess of the risk-free rate of return that an investment is expected to yield" (Risk Premium/Investopedia, n/d). The greater the risk, the more investors require in terms of a risk premium. Some risks can be easily and cheaply avoided and, as such, bear no expected reward. "It is only those risks that cannot be easily avoided that are compensated (on average)" (Bradford, J. & Miller, T., 2009, p. 28). The risk-return tradeoff points only to the possibility of higher return of investments—not guarantees of a higher return. As such, riskier investments do not always pay more than a risk-free investment. This is what exactly makes them risky. However, historical analysis demonstrates that the only way for investors to earn higher returns is to make riskier investments (Bradford, J. & Miller, T., 2009).

In Markowitz' portfolio selection theory, risk is synonymous with volatility—the greater the portfolio volatility, the greater the risk. Volatility refers to the amount of risk or uncertainty related to the size of changes in the value of a security (Volatility/Investopedia, n/d). This volatility is measured by a number of portfolio tools including: (1) calculation of expected return, (2) the variance of an expected return; (3) the standard deviation from an expected return, (3) the covariance of a portfolio of securities, and (5) the correlation between investments (Wecker, n.d.; Ross, Westerfield, & Jaffe, 2002). Each of these measures of risk/volatility is discussed in the following sections.

Expected Return

In order to predict future returns (expected return) for a security or portfolio, the historical performance of returns are often examined. Expected return can be defined as "the average of a probability distribution of possible returns" (Expected Return, n.d.). Calculation of the expected return is the first step in Markowitz' portfolio selection model. Expected return, also commonly referred to as the mean or average return, can simply be viewed as the historic average of a stock's return over a given period of time (Benniga, 2006). Calculations for a portfolio of securities (two or more) simply involve calculating the weighted average of the expected individual returns (Ross, Westerfield & Jaffe, 2002). For a simplified methodology for calculating expected return see *Table 1*.

Table 1: Simplified Expected Return Calculations

Step #	Microsoft Excel Procedures and Functions
1	Calculate each individual periodic return (e.g. daily, monthly, annually) by dividing the adjusted close by the prior period's close, minus 1
2	Calculate the periodic portfolio return by multiplying each proportion of stock X, Y, etc., times the periodic average return
3	Add together the totals of the Periodic Portfolio Return
4	Factor in the periodic average (e.g. 1 year average) Portfolio Return by applying Microsoft Excel "*AVERAGE"* formula to the range of the periodic returns.

Table 1 demonstrates the simplified steps necessary to calculate the expected (Average) return of portfolio of stocks, utilizing Microsoft Excel. This expected return is also referred to as the Average or the mean return. Calculation formula basis information was provided by S. Benniga (2006).

A particularly glaring drawback of using the historical performance of returns to forecast expected returns is the uncertainty of the time-frame over which to sample (Fabozzi, Gupta, & Markowitz, 2002). Should the sample period include past performance over a five-year period; over a ten-year period; or over a longer period of time? The truth is that there is likely no correct answer because of the uncertainties and volatilities confronting markets. However, it is reasonable to assume that only after a market or security has experienced a lengthy and proven record of healthy and consistent performance, under varying economic and political conditions, that historical market performance can be deemed a fair barometer of future market performance (Fabozzi, Gupta, & Markowitz, 2002).

Portfolio Return Variance

As previously discussed, there are various ways to determine the volatility (risk) of a particular security's return. The two most common measures are variance and standard deviation. Variance is a "measure of the squared deviations of a stock's return from its expected return"—the average squared difference between the actual returns and the average return (Bradford, J. & Miller, T., 2009; Ross, Westerfield & Jaffe, 2002). The concept of standard deviation is discussed in the following section.

In context of a portfolio, variance measures the volatility of an asset or group of assets. Larger variance values indicate greater volatility. Similar to the formula for the expected return, the variance of more than two assets is also an extension of the two asset formula. When many assets are held together in a portfolio, assets decreasing in value are often offset by portfolio assets increasing in value, thereby minimizing risk. Therefore, the total variance of a portfolio of assets is always lower than a simple weighted average of the individual asset variances (Frantz & Payne, 2009). For a simplified methodology for calculating portfolio variance see Table 2.

Table 2: Simplified Portfolio Variance Calculations

Step #	Microsoft Excel Procedures and Functions
1	*Calculate Return of Individual Securities* - Calculate each individual periodic return (e.g. daily, monthly, annually) by dividing the adjusted close by the prior period's close, minus 1
2	*Calculate Percentage of Investment* – Calculate the percentage of investment represented by each security in the portfolio
3	*Calculate Portfolio Variance* – Calculate the variance of return for each respective security for the given period using Microsoft Excel formula VARP or DVARP (e.g. VARP(B:1:B10).

Table 2 demonstrates the simplified steps necessary to calculate the Variance of securities within a portfolio of stocks, utilizing Microsoft Excel. Calculation formula basis information was provided by S. Benniga (2006).

Analysts' observations indicate that the variance of a portfolio decreases as the number of portfolio assets increases (Frantz & Payne, 2009). According to Frantz & Payne (2009), increasing the number of portfolio assets significantly improves its Efficient Frontier (the efficient allocations of diversified assets for variable risks). To a degree, the returns on these types of assets tend to cancel each other out, suggesting that the portfolio variance return of these assets will be smaller than the corresponding weighted average of the individual asset variances (Frantz & Payne, 2009). Accordingly, maintaining portfolios comprised of a greater number of assets allows investors to more effectively reduce their risk.

In actuality, once the number of assets in a portfolio becomes large enough, the total variance is actually derived more from the covariances than from the variances of the assets (Schneeweis, Crowder, & Kazemi, 2010). The significance of this is that it reinforces the concept that it is more important how assets tend to move within a portfolio rather than how much each individual asset fluctuates in value.

Standard Deviation

Another common measure of volatility (risk) is the standard deviation of a security. Markowitz' portfolio selection model makes the general assumption that investors make their investment decisions based on returns and the risk spread. For most investors, the risk undertaken when purchasing a security is that they will receive returns that are lower than what was expected. As a result, it is a deviation from the expected (average) return. Put another way, each security presents its own standard deviation from the average (McClure, 2010). A higher standard deviation translates into a greater risk and a required higher potential return. The standard deviation of a return is the square root of the variance (Bradford, J. & Miller, T., 2009). The standard deviation of expected returns requires the statistical calculation of several factors which will help to measure the return's volatility. For a simplified methodology for calculating standard deviation see *Table 3*.

Table 3: Simplified Standard Deviation Return Calculations

Step #	Microsoft Excel Procedures and Functions
1	*Calculate Portfolio Return* – Calculate the percentage of investment represented by each security in the portfolio
2	*Calculate Portfolio Return* – Calculate the sum of securities from step 1 using Excel SUM formula (e.g., SUM(A1:A10)
3	*Calculate Standard Deviation* – Use Excel formula STDEVP or DSTDEVP to calculate the standard deviation of portfolio return (e.g. STDEVP (C1:C10).

Table 3 demonstrates the simplified steps necessary to calculate the Standard Deviation of Return for securities within a portfolio of stocks, utilizing Microsoft Excel. The Standard Deviation (equal to the square root of the variance), reduces the squared percentages of the variances back to a percent. Calculation formula basis information was provided by S. Benniga (2006).

Covariance of Return

Variance and standard deviation measure stock variability. However, if a measurement of the relationship between returns for one stock and returns on another is required, it is necessary to measure their *covariance* or *correlation*. These two concepts measure how two random variables are related (Ross, Westerfield & Jaffe, 2002). Correlation is addressed in the following section. Covariance is a statistical measure which addresses the interrelationship between the returns of two securities. If the returns are positively related to each other, their covariance will be positive; if negatively related, the covariance will be negative; and if they are unrelated, the covariance should be zero (Ross, Westerfield & Jaffe, 2002). Markowitz argues that, "It is necessary to avoid investing in securities with high covariances among themselves" (Markowitz, 1952, p. 89). For a simplified methodology for calculating covariance see *Table 4*.

Table 4: Simplified Covariance of Return Calculations

Step #	Microsoft Excel Procedures and Functions
1	*Calculate Individual Returns* - Calculate each individual periodic return (e.g. daily, monthly, annually) by dividing the adjusted close by the prior period's close, minus 1
2	*Calculate Covariance of Returns* – Calculate the covariance of returns between selected pairs of security returns for the respective period(s) using Excel formula COVARP or COVARIANCE.P (e.g. COVAR(D:1:D10, E1:E10).

Table 4 demonstrates the simplified steps necessary to calculate the Covariance of Return for securities within a portfolio of stocks, utilizing Microsoft Excel. Covariance relates the returns of two stocks to each other. Calculation formula basis information was provided by S. Benniga (2006).

Correlation Coefficient of Returns

Correlation coefficient (also referred to as correlation) is the final measure of risk/volatility examined here. It determines the degree to which two variables are related. Correlation coefficient addresses some of the difficulties of analyzing the squared deviation units presented by the covariance of return measure (Ross, Westerfield & Jaffe, 2002). For a simplified methodology for correlation coefficient see *Table 5*.

Table 5: Simplified Correlation Coefficient of Return Calculations

Step #	Microsoft Excel Procedures and Functions
1	*Calculate Individual Returns* - Calculate each individual periodic return (e.g. daily, monthly, annually) by dividing the adjusted close by the prior period's close, minus 1
2	*Calculate Correlation Coefficient* – Calculate the correlation coefficient of returns between selected pairs of security returns for the respective period(s) using Excel formula CORR or CORREL (e.g. CORR(F:1:F10, G1:G10).

Table 5 demonstrates the simplified steps necessary to calculate the Correlation Coefficient of Return for securities within a portfolio of stocks, utilizing Microsoft Excel. The Correlation Coefficient divides the Covariance by the product of the Standard Deviations. Calculation formula basis information was provided by S. Benniga (2006).

MPT attempts to analyze the interrelationship between different investments. It utilizes statistical measures such as correlation to quantify the diversification effect (discussed below) on portfolio performance (Veneeya, 2006). In that regard, the correlation coefficient simply divides the covariance by the standard deviations of a pair of securities. If the correlation between the securities is positive, then the variables are positively correlated; if it is negative, then they are negatively correlated; and if the correlation is zero, then the variables are determined to be uncorrelated (Ross, Westerfield & Jaffe, 2002).

The degree of risk reduction is dependent upon the variance of the different assets, particularly from the correlation between the investment asset and its weight in the portfolio (Wecker, n.d.). The greater the proportion of uncorrelated assets in a portfolio, the greater the risk reduction.

Correlation is an important measure of diversification effect as it effectively measures the covariance of the returns of asset pairs. While covariance is meaningful because it influences portfolio risk, portfolio correlation coefficients is more useful because it standardizes covariance (Gibson, 2004). The 'imperfect' correlations (between +1.00 and -1.00) generally indicate a reduction in portfolio risks. Portfolio pairs with smaller correlation coefficient values suggest less risk than pairs with larger values (Hight, 2010). In any event, these risk factors should be carefully selected because the correlation between assets and risk factors is not always obvious (Amu & Millegard, 2009). Moreover, correlation may exist even if the factor and asset are not in the business or industry.

Diversification

The terms 'diversification' and 'Diversification Effect' refer to the relationship between correlations and portfolio risk. Diversification, a cornerstone of Markowitz' portfolio selection theory and MPT, is a risk reduction concept that involves the allocation of investments among various financial instruments, industries and other investment categories (Importance of diversification, 2009). In more simplistic terms, it relates to the well-known adage "don't put all your eggs in one basket." If the basket is dropped, all eggs are broken; if placed in more than one basket, the risk that all eggs will be broken is dramatically reduced (Fabozzi, Gupta, & Markowitz, 2002). Diversification can be achieved by investing in different stocks, different asset classes (e.g. bonds, real estate, etc.) and/or commodities such as gold or oil.

The objective of diversification is to maximize returns and minimize risk by investing in different assets that would each react differently to the same event(s). For instance, negative news related to the European debt crisis generally causes the stock market to move significantly lower. At the same time, the same news has had a general positive impact on the price of certain commodities such as gold. Accordingly, it is important that portfolio diversification strategies not only include different stocks within the same industry and outside of that industry, but that they should also include different asset classes, e.g. bonds and commodities (Importance of diversification, 2009). Diversification Effect refers to the relationship between correlations and portfolios (Gibson, 1990). When the correlation between assets is imperfect (positive, negative), the result is the diversification effect. It is an important and effective risk reduction strategy since risk reduction can be achieved without compromising returns (Hight, 2010). Accordingly, any savvy investor who is 'risk averse' will diversify to some degree.

Markowitz (1952) argues that diversification cannot eliminate all risk. As discussed earlier, investors are confronted with two main types of risk: systematic risk and unsystematic risk. The latter, unsystematic risk is also commonly referred to as 'diversifiable risk' (Frantz & Payne, 2009). This type of risk is the part of the risk equation that can be reduced or, according to some theorists, eliminated (Frantz & Payne, 2009). The bases for these types of risk are events that are unique to a particular company. Systematic risk (market risk), on the other hand, cannot be eliminated or reduced by diversification since it stems from external factors such as recessions, high interest rates, war or inflation, which 'systematically' affect a majority of all companies (Importance of diversification, 2009).It is important to note that while a truly diversified portfolio can often improve returns and significantly reduce unsystematic risk, it is highly unlikely that any amount of diversification can effectively eliminate <u>all</u> risk—there are simply too many variables. Furthermore, no amount of diversification can eliminate or reduce systematic risk, which affects all or most companies and markets at the same time.

Efficient Frontier

Efficient Frontier, also referred to as Markowitz Efficient Frontier, is a key concept of MPT (Efficient frontier/Money Terms, n.d.). It represents the best combination of securities (those producing the maximum expected return for a given risk level) within an investment portfolio (Efficient Frontier, 2010). It describes the relationship between expected portfolio returns and the riskiness or volatility of the portfolio. It is usually depicted in graphic form as a curve on a graph comparing risk against the expected return of a portfolio. The optimal portfolios plotted along this curve represent the highest expected return on investment possible, for the given amount of risk (McClure, 2010). Portfolios lying on the 'Efficient Frontier' represent the best possible combination of expected return and investment risk.

The relationship between securities within a portfolio is an important part of the Efficient Frontier. For instance, the price of some securities in a portfolio moves in the same direction, while the price in others moves in opposite directions. The greater the covariance (the more they move in opposite), the smaller the standard deviation (the smaller the risk) within the portfolio. One of the major implications of

Markowitz' Efficient Frontier theory is its inferences of the benefits of diversification (Efficient frontier/Investing Answers, n.d.). Diversification, as discussed above, can increase expected portfolio returns without increasing risk. Markowitz' theory implies that rational investors seek out portfolios that generate the largest possible returns with the least amount of risk—portfolios on the Efficient Frontier.

Theoretical Limitations

Despite its momentous theoretical importance, there are numerous critics of MPT who argue that its underlying assumptions and modeling of financial markets are not in line with the real world in many ways. Beginning with the key MPT assumptions itemized at the beginning of this analysis, it can be argued that none of these assumptions are entirely true, and that each of them, to varying degrees, compromises MPT.Generally, some of the key criticisms include:

Investor 'Irrationality' – The assumption is that investors are rational and seek to maximize returns while minimizing risk. This is contradicted by the observation of market participants who get swept up in 'herd behavior' investment activity. Investors, for instance, routinely go for 'hot' sectors, and markets regularly boom or bust because of speculative excesses (Morien, n.d.).

Higher Risk = Higher Returns – The assumption that investors are only willing to accept higher amounts of risk if compensated by higher expected returns is frequently contradicted by investor's contrary actions. Often, investment strategies demand that investors take on a perceived risky investment (e.g., derivatives or futures) in order to reduce overall risk without any discernible increase in expected returns (McClure, 2010). Additionally, investors have certain utility functions that may outweigh distribution of returns concerns.

Perfect Information – MPT assumes the timely and complete receipt by investors of all information relevant to their investment. In reality, world markets comprise information asymmetry (one party has superior information), insider trading, and investors who are simply better informed than others (Bofah, n.d.). This might explain why stocks, business assets and businesses are often purchased well below book or market value.

Unlimited Access to Capital – Another key assumption cited earlier is that investors have virtually unlimited borrowing capacity at a risk free interest rate. In real world markets, every investor has credit limits. Moreover, only the federal government can consistently borrow at the interest free treasury-bill rate (Morien, n.d.).

Efficient Markets – Markowitz' theoretical contributions to MPT are built upon the assumption that markets are perfectly efficient (Markowitz, 1952). Conversely, MPT's reliance on asset prices make it vulnerable to various market vagaries such as environmental, personal, strategic, or social investment decision dimensions. Additionally, it does not take into account potential market failures such as externalities (costs or benefits not transmitted through prices), information asymmetry, and public goods (a good that is non-rival and non-excludable) (Morien, n.d.). From another perspective, hundreds of years of 'rushes', 'booms', 'busts', 'bubbles', and 'market crises' demonstrate that markets are far from efficient.

No Taxes or Transaction Costs – Markowitz' theoretical contributions to MPT do not include taxes or transactions costs. To the contrary, real investment products are subject to both taxes and transaction costs (e.g. broker fees, administrative costs, etc.), and factoring these costs may indeed alter optimum portfolio selection.

Investment Independence – MPT assumes that it is possible to select securities whose individual performance is independent of other portfolio investments. However, market histories have demonstrated that there are no such instruments (McClure, 2010). During periods of market stress and extreme uncertainty, for example, seemingly independent investments do, in fact, exhibit characteristics of correlation.

Other less vocal, but equally valid, criticisms include: 1.) There is no such thing as a "truly risk-free" asset (McClure, 2010), 2.) Historical 'expected value' assumptions often fail to factor newer circumstances which did not exist during the historical data period, 3.) MPT only seeks to maximize risk-adjusted returns while disregarding environmental, personal, strategic or social factors.

CONCLUDING REMARKS

The methodology for data assimilation of this analysis included an extensive literature review on the topic of MPT and related concepts. This review included comparative analysis of earlier MPT works to those of more current economic theorists. In particular, derived data was generated from the current literary works of Benniga (2006). His evolved suggestions of the application of Microsoft Excel to various statistical computations of MPT were modified, tested, and verified against respective proven mathematical models.In spite of its shortcomings, including overly complicated mathematical musings and a reliance on oft disproven theoretical assumptions, MPT has established itself as the gospel of modern financial theory and practice. The gist of MPT is that the market is difficult to beat and those who are successful in doing so are those who effectively diversify their portfolios and take above-average investment risks. In any event, Markowitz' portfolio selection contributions to the MPT model can be simplified (as attempted here) and can be solved more efficiently using modern financial tools such as Microsoft Excel. In that regard, Wharton's Dr. Benniga (2006) makes an excellent argument that "Excel is a great statistical toolbox—someday all business-school statistics courses will use it" (p. 338).

The important thing to remember is that the model is just a tool—albeit perhaps the biggest hammer in one's financial toolkit. It has been nearly sixty years since Markowitz first expounded on MPT and it is unlikely that its popularity will wane anytime in the near future. His theoretical conclusions have become the springboard for the development of other theoretical analysis in the field of portfolio theory. Even so, Markowitz' portfolio theory is subject to, and dependent upon, continued 'probabilistic' growth and expansion. Where this progression leads is unknown since one cannot reasonably divine the expansion of human knowledge, or accurately forecast the capacity for relevant technological advancement. "It is a story," stated Markowitz (1952), "of which I have read only the first page of the first chapter" (p. 91).

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