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INVESTMENT COUNSEL

Asset Allocation, Diversification, and Correlation

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June 2010

Preface

Prior to the 1960's, both institutional and personal investors tended to approach the portfolio construction problem from a similar perspective. Investment portfolios were, of course, built by combining various securities. Securities, in turn, were selected based on return expectations and on some rudimentary assessment of their underlying risk. While investors intuitively accepted the implied relationship between risk and return—truly low risk investments could not rationally be expected to generate consistently high returns—they lacked both the theoretical rationale and the necessary data to evaluate comprehensively the risk and return implications of complex interactions between securities. In the 1930's, humorist and social commentator Will Rogers summarized the prevailing wisdom regarding investment selection:

"Don't gamble; take all your savings and buy some good stock and hold it 'till it goes up, then sell it. If it don't go up, don't buy it."

Given the uncertain nature of the Rogers approach, we refer to it as "hopeful" investing. All investors who do not maintain short positions—bets against the market--buy stocks hoping that they will go up in value.

While his advice was obviously facetious, he neatly summarized the nature of the investment problem. Since investors could not know how a stock would perform after they purchased it, many observers compared stock investing to gambling because both appear to be speculative ventures. Will Rogers' comment encapsulated prevailing investor sentiment during the Great Depression of the 1930's; similar opinions seem prevalent today following the market collapse of 2008.

During the 1950's the emerging science of financial economics sought a better understanding of capital market behavior. Building on sights derived from applied mathematics and statistics, as well as on reams of newly available performance data for individual securities and aggregate markets, researchers endeavored to explain why markets performed as they did. The goal was to develop a more rational approach to solving the portfolio construction problem. Over time, this research developed into a body of work that we know today as Modern Portfolio Theory [MPT]. Using MPT, investors could develop a rational portfolio construction approach, in contrast to the prior hopeful portfolio construction approach.

Rational vs. Hopeful Investing

Although this essay outlines a spectrum of investment approaches ranging from *Hopeful* to *Rational*, the reader should not infer that one approach is, in every case, better than the other. Indeed, in many respects, the approaches are not mutually exclusive. The hopeful approach selects securities in anticipation of future price appreciation or future interest and dividend yield. The approach relies on close attention to a security's *fundamentals*. For example, a stock with attractive fundamentals may exhibit a trend of increasing earnings and profits from continuing operational activities—*quality of earnings*, from

payoffs to its R&D activities—*competitive advantage*, from flexibility in its debt/equity structuring, and so forth. Superior security valuation skills are prerequisites for investment success under the hopeful approach.

To a great extent, the hopeful investor does not distinguish between prospects for a stock and for a firm. A stock is primarily a share of legal ownership in the firm and—here is the key point—the prospects for making a good return from owning the stock closely parallel the earnings and profit prospects faced by the firm. If a firm's equity price is not overvalued, then its stock should be a good buy. In short, a good investment is an investment in a good company. At the far end of the spectrum, the hopeful investor is the owner/entrepreneur of a successful closely-held business. The majority of wealth is held in the form of single non-marketable stock and, for this investor, diversification away from such extreme asset concentration is not an attractive strategy because investment success directly parallels commercial success.

To the rational investor, a stock is primarily a set of investment characteristics. The prospects for economic success through stock ownership are evaluated from the portfolio context rather than from examining the stock—business venture--in isolation. The question shifts from "is this a good business to own" to "what is the contribution of this stock to the portfolio's risk and reward."

Investors accumulate and spend dollars—not rates of return. Dollar wealth is the product of compounding returns over time. A shorthand mathematical expression for wealth accumulation is:

Compound Wealth = Initial Principal x [(average return – ½(variance of return)]

This equation suggests that spendable dollars are increasing in positive returns—no surprise here—and decreasing in a risk term known as variance. The rational investor understands that there is a point where dollar wealth can increase more by risk control activities than by seeking higher investment returns. This insight is invaluable and lies at the heart of the rational investing approach.

Initially, the rational approach tended to be adopted by institutional investors, such as foundations, endowments, and pension plans, while individual investors continued to apply the traditional hopeful approach. Institutional investors' greater scale and access to more sophisticated advisors made it easier for them to migrate towards the rational approach. Over time, however, many individuals also adopted the rational approach, partially due to the broad acceptance of MPT among the investment advisory community.

While they have much in common, the hopeful investor differs from the rational investor in at least one key respect: when confronting the task of acquiring investments the hopeful investor asks, "What should I own?" while the rational investor asks, "How can I succeed?" For the hopeful investor investment issues often devolve into product-oriented solutions. What investments (stocks, bonds, annuities, mutual funds, partnerships, hedge funds, etc.) will contribute to my economic prosperity? The decision process of the

hopeful investor seeking to accumulate wealth generally unfolds along the following lines:

- I have $x of money that I can currently invest;
- My investment goal is to have enough money in the future to accomplish one or more economic objectives;
- To accomplish the objective(s), I will need to increase the value of my current investment fund—that is to say, I need more money;
- More money is always better than less, therefore, my investment policy is to make money;
- The more quickly I increase my investment fund, the more likely it is that I will be able to achieve my economic objective(s);
- The more money I make, the safer my economic position because the greater my investment "cushion;"
- Therefore, the investment problem reduces itself to a search for investments that will make a lot of money. If I want to create a performance-seeking portfolio, what investments should I own?

For the hopeful investor in the wealth decumulation stage (i.e., drawing on a portfolio for periodic income), the process often becomes a quest to maximize safety of principal rather than return on principal. Both approaches--maximize the probability for maximum gain / maximize the probability for minimal loss--are, however, simply two sides of the same coin.

What is wrong with the hopeful investor approach? There is nothing wrong with it if, after careful consideration of all economic consequences, the investor decides that the approach is well suited to his goals and economic circumstances. Before, charging ahead with buying the ten best stocks according to your favorite investment guru, however, it may be wise to pause and consider the rational investor's approach.

As soon as the rational investor poses the question "How can I succeed?" two follow-up questions, "Succeed at what?" and "How can I fail?" present themselves. The implications of these questions are profound. They move the discussion away from a single dimensional quest for asset growth to at least a two-dimensional discussion of how to calibrate asset growth to both the costs and risks of funding future economic objectives. The difference between rational investing and hopeful investing is best illustrated in a balance sheet context. Hopeful investing concentrates on the left-hand side of the balance sheet because it seeks to grow assets as quickly as possible. If the pace of asset growth outstrips the future costs of economic goals, then the hopeful investing strategy will have been successful. This type of investment program is also known as an "Asset Only" approach. It succeeds or fails based primarily on a Profit & Loss [P&L] metric—did I make a sufficient amount of money to achieve my objective?

By contrast, the rational investment strategy takes into account both the Asset side of the balance sheet as well as the Liability side; and considers any investment surplus or

'cushion' as comparable to "owner's equity." In many cases, the liability is not a legal obligation; but, for personal investors, is a demand for funds sufficient to finance retirement consumption over a life span, to finance college costs for children, to finance gifting or bequest objectives, and the like. For institutional investors, it is a demand for funds sufficient to support operating expenses, provide grants, fund pension obligations, and the like. **The rational investor starts the portfolio design process primarily from the liability side** by quantifying the present value costs of funding future economic objectives. The decision process of the rational investor in the wealth accumulation stage often unfolds along the following lines:

- Make a reasonable estimate of the future amount of money that I must have on hand to make my economic objectives feasible;
- Compare the present value of this future sum with the current value of my investible resources;
- Determine the required return—that is, the rate at which my current assets must grow in order to fund future goals;
- Estimate the risk associated with trying to generate the required return (the more risk, the greater the probability of a future dollar shortfall);
- Make sure that the portfolio has a reasonable expectation of generating the required return;
- Make sure that the portfolio has reasonable risk bounds—sufficient risk to generate the required return, but not so much excess risk that return outcomes blur into a cloud of uncertainty;
- Compare different portfolio designs to arrive at a prudent and suitable asset allocation.

What is a prudent and suitable asset allocation? It is easy to see that a portfolio that suffers from a "return gap" (i.e., is not expected to produce enough return to fund future goals) is not well designed. For example, a portfolio consisting of 100% short-term T-Bills is not suitable for funding a future objective requiring substantial growth above the risk-free rate. However, in addition to avoiding a return gap, the asset allocation also should avoid a "risk gap." Just as a portfolio whose return expectations are mismatched to the required return may be considered imprudent, so also, a portfolio that takes on more (or, less) risk than necessary may also be considered imprudent. The larger the risk gap, the more likely that the portfolio will fail to attain its critical objectives.

Of course, most institutional investors never fully migrated to the rational approach, while most individual investors never fully relied on the hopeful approach. Rather, we should think of the two approaches representing a spectrum, with investors using elements of both to formulate their portfolios. If the hopeful investor asks "How can I make money," the rational investor asks "How much money do I need to make?" At the far end of the spectrum, the hopeful investor engages in a single dimensional treasure hunt. By contrast, the rational investor acknowledges risk, estimates risk, and manages risk to improve the likelihood of achieving long-term economic success. The hopeful investor may equate success with beating the market (or, in the case of a passive investor,

with matching the market). The rational investor realizes that the goal is to generate returns sufficient to achieve an investment goal. At the limit, the hopeful investor conflates the portfolio construction and asset management process with the return generating process; the intention is to make money by seeking out high return investments--if an investment does not provide the expectation of an attractive return, why would you want to own it? The rational investor recognizes that returns are uncertain and seeks both required performance and appropriate protections against dollar shortfall risk if the bets on expected returns go sour. The hopeful investor assembles a collection of good investments ('good' can mean safe, high yield, high growth, etc., depending on the investor's perspective); the rational investor allocates a portfolio across a broad range of investments exhibiting differing risk & return characteristics. The hopeful investor creates a focused portfolio; the rational investor creates a diversified portfolio.

As stated, neither the hopeful investment strategy nor the rational investment strategy is inherently best under all circumstances. There may well be circumstances in which the investment goal requires the portfolio to beat the market; or, in many cases, institutions such a defined benefit pension plans require focused portfolios to match the cash flows of their contractual liabilities. Ultimately, the choice of an appropriate portfolio approach depends on risk tolerance, economic circumstances, portfolio objectives, family needs, and other preferences and constraints.

One great advantage of the hopeful investing approach is that it is easy to judge success or failure. This is primarily due to the fact that the investment activity stands or falls based solely on a P&L evaluation metric. For example, you can set up a bought-and-sold spreadsheet to determine, over a reasonable time, whether the securities that have left the portfolio have, in fact, underperformed the new additions. This will provide much information on your—or your broker's—security valuation and selection skills. Alternately, you can use more advanced performance evaluation metrics to compare the focused portfolio's approach (after adjusting for risk) to the results of an index fund investing in comparable securities. For the rational investor performance evaluation may be more difficult. For example, a portfolio asset allocation designed to provide a measure of safety in bear markets might generate returns that seem anemic in a bull market. This was certainly the case during the great bull market at the end of the 1990s when portfolios of tech stocks were generating 40%+ yearly returns while diversified portfolios allocated over a broad range of asset classes were limping along at well under 10%. Based solely on a P&L metric, diversified asset allocation appeared to be synonymous with mediocrity.

Part I: Asset Allocation

Asset Allocation and Asset Class Investing

If you are inclined towards the rational investing approach, it is important to be familiar with several topics:

1. What is the definition of asset allocation?
2. What is purpose of asset allocation?
3. What is the relationship between asset allocation and risk control?

Asset allocation is the process of combining various asset classes into a portfolio so that its risk and reward characteristics are suitable for the investor's risk tolerance and investment objectives. Asset classes—rather than individual securities—are the building blocks of the portfolio. An *asset class* is a group of securities that share common legal, economic and statistical characteristics. For example, the asset class of U.S. small stocks differs from the class of U.S. large stocks in several respects, including fundamental characteristics, such as market capitalization, and statistical characteristics such as expected volatility of return.

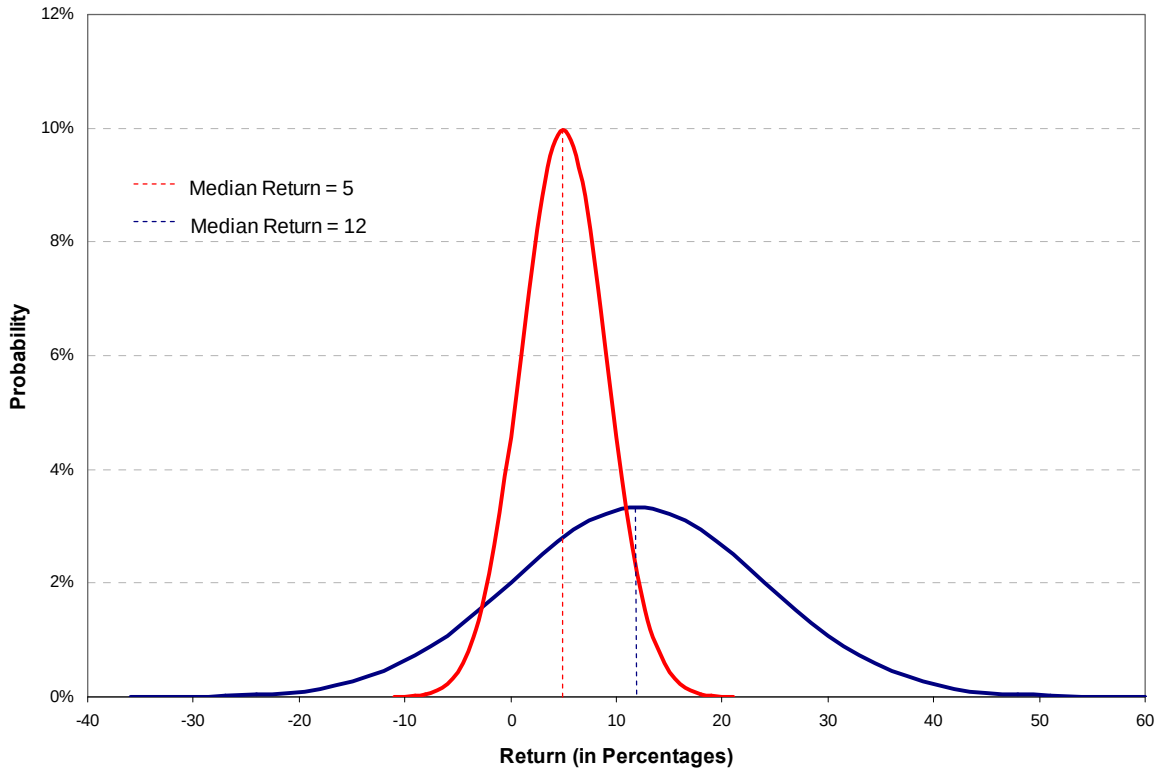
Rational investing prefers asset class building blocks, such as the S&P 500, to individual securities primarily because a single security may be a poor representative of the class. Enron, for example, was not a typical energy stock. All securities carry *systematic risk* (also known as market risk). They are affected by the same economic forces that influence the prices of all similar securities. But individual securities also exhibit unique (or, *unsystematic*) risks that affect only one company. For example, the price of Union Carbide changed dramatically as a sudden result of the horrible industrial accident in Bhopal, India; the price of British Petroleum plummeted following the Gulf of Mexico oil disaster. The unique risk of individual securities stands in contrast to the tendency of relatively homogeneous groups of securities--asset classes--to exhibit predictably common exposures to similar sets of risk factors. Airline stocks differ from energy stocks, for example, because the two sectors react differently to sudden changes in the price of oil. Over the long run, a diversified portfolio's returns are primarily associated with exposures to systematic risk factors. Thus, **the primary purpose of asset allocation is to set the investor's exposure to systematic risks**.

A Graphical Approach to Understanding Risk and Asset Allocation

The phrase 'setting exposures to systematic risks' sounds complicated, but graphically, it is easier to understand. Intuitively, most investors agree that the price volatility of a government-guaranteed, short-term T-Bill is considerably less than the price volatility of the S&P 500. At least in the short run, T-Bills are a safer asset than stocks.

Additionally, the expected behavior of a portfolio allocated 20% to T-Bills and 80% to stock should differ greatly from that of a portfolio allocated 80% to T-Bills and 20% to

stock. The following chart illustrates a hypothetical range of annual returns generated by each portfolio. The red curve traces returns from the portfolio allocated 80% to T-Bills, the blue curve traces returns from the portfolio allocated 80% to stocks.



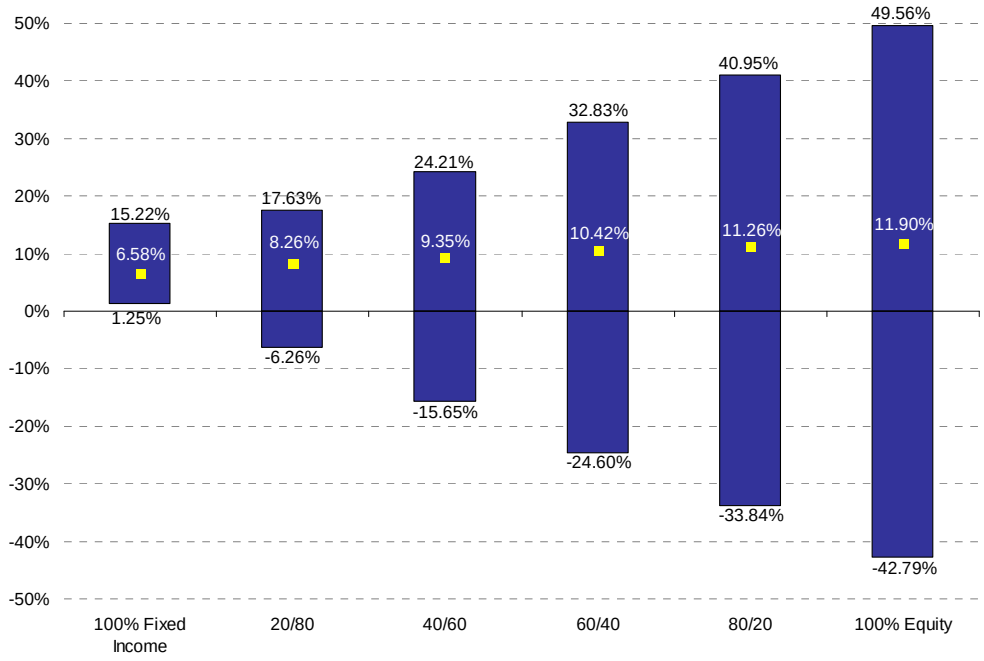
The graph depicts risk as the shape of the return curve. The more narrow the shape, the more certain the final outcome; the wider the shape, the greater the range of possible returns and, therefore, the less certain the final outcome. Narrower shapes exhibit lower expected returns and wider shapes exhibit higher expected returns because investors expect to be compensated for risk. Asset allocation determines the shape of portfolio returns and, as such, is a primary risk control mechanism.

Asset Allocation and the Risk/Return Tradeoff

Although investors cannot control returns, they can pick an allocation that produces a shape that is appropriate in terms of both required return and risk. Here is the important part—a basic tenet of modern portfolio theory is that there is an approximately linear relationship between systematic risk and expected long-term return. Simply put, if you diversify the portfolio so that it reflects market risk rather than unique company risk, then the risk and reward should line up over the long run. In any particular stretch of time, you may be getting returns from the left side of the distribution range—a bear market—or from the right side—a bull market. However, both bull and bear returns are in the distribution; and, if you maintain your asset allocation, ultimately you can expect to receive a return close to the long-term average. It is the logic underlying the advice to "stay the course" if you are a long-term investor. It is also the logic that suggests that focused portfolios consisting of only a few securities are not safe. The unique risk of

each position overwhelms the systematic risk of the aggregate portfolio making both the short-term and long-term risk/return alignment dangerously unpredictable.

The following graph illustrates the historical risk/reward tradeoff of various asset allocations. It depicts the best, worst and average annual returns from different allocations. An allocation to 100% T-bills generated the lowest realized return over the period 1973 through 2008. As risk (uncertainty of return) increases, long term reward becomes greater. A 100% equity allocation (before expenses) generated an annual return of 11.90% compared to the all T-Bill return of 6.58%.



Asset Allocation and Portfolio Preferencing Criteria

If the asset allocation decision focuses only on return expectations, it begins to look like nothing more than a sophisticated version of the hopeful approach in that asset allocation is used primarily to generate a high rate of return. But the rational approach does not define the best portfolio allocation as the one with the highest expected long-term return. Rather, it selects portfolios based on a lengthy list of preferencing criteria.

Let's suppose that you are evaluating six portfolios. The first criterion is to eliminate all portfolios that aren't expected to generate the required return. These portfolios might be very "safe" but they are hardly prudent choices because they are likely to fall short of the dollar amounts required to fund investment goals. Let's assume that the required return preferencing criterion eliminates three of the six candidate portfolios.

The second preferencing criterion is risk—you don't want to take more risk than is needed for long-term success. In other words, you do not wish to create a "risk gap." In this case, we can define risk in terms of the magnitude and likelihood of a shortfall in

actual future dollar wealth despite the fact that the *expected* future dollar wealth satisfies the funding requirements. For example, if you cannot accept more than a 20% risk a probable future shortfall, you would apply this criterion to the three remaining portfolios and eliminate any that violate your risk tolerance guidelines.

Assume that two portfolios pass your return and risk preference tests. Of the remaining candidates, one consists of eight asset class building blocks; the other of ten. Candidate one exposes 25% of wealth to the risks and returns of a single asset class; while candidate two's maximum exposure to a single asset class is 21%. Both portfolios have equal liquidity and marketability. Consequently, you may wish to select the second candidate based on a diversification preferencing criterion.

By rational application of preferencing criteria you have arrived at a portfolio that is appropriate for your economic objectives and personal preferences. Asset allocation has controlled risk and provided you with the best opportunity for a successful long-term outcome. This is the good news. The bad news is:

1. The allocation is completely myopic; and,
2. It is statistically valid only if there are no cash flows into or out of the portfolio.

Dynamic Asset Allocation

Operating a strict stay-the-course asset allocation on a period-by-period basis is like an automobile driver who moves towards a destination by making directional decisions one street at a time. By contrast, a dynamic allocation is like an automobile driver who sees the interconnection of streets throughout the entire trip and plots a course accordingly. This driver will avoid dead ends, traffic lights, and other detriments to efficient travel that could plague the myopic driver.

The right asset allocation suggests that "on average" you should succeed in creating sufficient dollar wealth. However, whenever cash enters or leaves the portfolio, the concept of "average" disappears. This topic is important because it highlights **the most injurious mistake made by investors**. Let's say that an investor wants to design a portfolio to provide a yearly income of $120,000. The current investment portfolio is worth $3,000,000. The investor makes the following calculations:

- The portfolio should be able to earn 8% after costs over the long term.
- Inflation should average 3% over the long term.
- I need to withdraw 4% ($120,000 ÷ $3,000,000) for income.
- 4% + 3% = 7%
- 7% is less than 8%.
- The portfolio should be sufficient to fund the target income on an inflation-adjusted basis in perpetuity.

Unfortunately, the investor's conclusion is correct only under the improbable conditions that the portfolio earns exactly 8% each and every year under an inflationary environment of exactly 3% each and every year.

The investor failed to consider the variability of future inflation, future investment returns, and the complex interactions between these factors. Withdrawals during periods when returns are below average compound their deleterious effects on dollar wealth. But withdrawals during periods when returns are above average vitiate their positive effects on dollar wealth. Constantly compounding the negative consequences of bad returns and limiting the positive consequences of good returns renders the concept of "average" return meaningless.

This suggests that asset allocation is a critical component of prudent portfolio design; but it is not the final step in the path towards investment success. In general the prudent investor cannot simply set an asset allocation and blindly stay the course. The missing ingredient is asset management which includes the process of periodically evaluating whether current assets are likely to be sufficient to fund anticipated liabilities. Substantial changes in wealth—positive or negative—require a rethinking of goals and strategies. One challenge to effective rational asset management is to move from a single-period asset allocation structure to a dynamic multiperiod structure that acknowledges changes in wealth and risk aversion. The asset allocation decision remains an important step in the rational investment process; but, if it is a necessary condition, it should not also be viewed as a sufficient condition for maximizing the probability of long-term economic success. A strategy for long-term success requires familiarity with other topics including "diversification" and "correlation."

Part II: Diversification

Hopeful investing bases portfolio design on an asset-only perspective, and selects investments based primarily on a P&L forecast. Rational investing often starts the portfolio design process from the liability side, and selects investments based on their contributions to overall portfolio return requirements and risk constraints. Hopeful investing moves the investor towards creation of focused, performance-seeking portfolios designed to maximize potential returns; rational investing moves the investor towards diversified portfolios designed to create a suitable return at the appropriate level of systematic risk. In large part, the hopeful investing approach asks "how much money can I earn;" while the rational approach asks "how much money do I need to earn / how much risk do I need to take."

Asset classes are broadly diversified investments in distinct capital markets. Asset class investments generally "wash out" some major risks associated with ownership of just a few securities. By contrast, focused, performance-seeking portfolios often jump from security to security (or from sector to sector) with only a passing nod to risk control on a macro portfolio level. Rather, a portfolio is deemed to be safe either if its securities are low risk—government guaranteed—or if its securities are fairly valued and represent ownership in solid companies. After all, how risky can it be to own a portfolio of seasoned, blue-chip, well-admired S&P 500 companies like Enron, GM, Lehman Brothers, Kodak, and Citibank?

The Performance Seeking Portfolio: A Case against Diversification

We continue the discussion by considering the topic of Diversification. The concept of investment diversification is frequently misunderstood and diversification strategies are sometimes maligned. Buying a broad cross-section of stocks and bonds in capital markets seems like a foolish and speculative strategy. The portfolio is packed with securities of firms about which the investor knows little or nothing. Many non-U.S. securities trade on exchanges that are open only during hours in which the U.S. investor is asleep. Inevitably, the investor ends up owning worthless securities in some portion of the portfolio as companies succumb inevitably to competitive pressures. Owning small positions in dozens of securities contributes to a failure to pay attention to important developments within each firm. The investor, fooling himself into believing that small losses do not matter in the context of his overall wealth, may develop habits of neglect and inattention that undermine long-term goals. Conversely, real fortunes are built by concentrating intellectual focus and capital resources. In the words of Andrew Carnegie:

"Put all your eggs into one basket and then watch that basket, do not scatter your shot."

Even worse, ownership of small companies with uncertain dividend payments is a speculative venture. Protection of principal and security of income has, for generations, formed the core principles in American trust law. Consider, for example, the prohibition

on speculative investments by trustees upheld in a famous 1869 New York Court of Appeals ruling:

"This necessarily excludes all speculation, all investments for an uncertain and doubtful rise in the market…..the preservation of the fund, and the procurement of a just income therefrom, are primary objects of the creation of the trust itself, and are to be primarily regarded."

If speculation is imprudent, then purchase of speculative investments such as raw land, securities of unseasoned companies, or any other undervalued or untried venture is also inappropriate. For several generations, investment commentators viewed broad-scope diversification across capital markets unfavorably. Conventional wisdom told investors to avoid unsafe investment categories. Ultimately, even purchase of "blue chip" stocks became questionable. Investment and Speculation, a book co-authored by L. Chamberlain and William Wren Hay in 1931, provides a post-1929 stock market crash point of view:

"Common stocks, as such, are not superior to bonds as long-term investments, because primarily they are not investments at all. They are speculations."

As late as 1983, a court ruled against a bank trust department (First Alabama Bank of Montgomery, N.A. v. Martin) because the bank purchased "…undervalued stocks instead of the higher priced, more established ones."

The sentiment against diversification, and in favor of a concentrated portfolio, echoes forcefully today. Many investors hire star investment managers to locate undervalued firms that are diamonds in the rough. One need only consider Warren Buffett's investment philosophy wherein he recommends a value-investing style characterized by a portfolio of carefully selected, undervalued companies offering superior opportunity for above average future growth. The tenets of Buffettology, however, exist somewhat uncomfortably with the alternative advanced by Vanguard's John Bogle:

"The winning formula for success in investing is owning the entire stock market through an index fund, and then doing nothing. Just stay the course."

How did this modern-day divergence of opinion come about? Which opinion is correct? Is it possible to reconcile the competing points of view? We consider these questions next.

The Most Important Investment Book Ever Written

If a time machine transported you back to 1938, you may notice a book entitled The Theory of Investment Value written, originally, as a Ph.D. thesis at Harvard by John Burr Williams. This book is perhaps the most important and influential investment text ever published. Not only does it establish the foundation for much of the mathematics currently employed by bond analysts, it is the first book to develop fully the theory of discounted cash flow analysis which underpins much of the hopeful investor's valuation

modeling and stock price forecasting methods. Discounted cash flow analysis holds that the justified price of a stock reflects the present value of dividends paid from a company's projected future earnings and profits.

To some extent, Burr Williams sought to counter certain investment strategies advocated by the prominent economist John Maynard Keynes. Keynes recognized that proper analysis of a stock's prospects should also incorporate an analysis of political, military, and macro-economic trends. The astute stock analyst considers industry-by-industry developments, a firm's competitive position within its industry, management capabilities, and other important factors that influence how the marketplace assesses the firm's future prospects. The degree of care and skill required to select and monitor securities demands full-time effort and attention. At best, even the most diligent portfolio manager quickly faces limits on the number of securities that can be safely included in the portfolio. Keynes was a powerful voice articulating the merits of a focused portfolio owning securities of a few companies exhibiting good future prospects for share-price appreciation. The Janus Twenty mutual fund or the Merrill Lynch "top investment ideas" stock lists reflect a Keynesian investment approach in today's market place.

The Keynesian approach disturbed John Burr Williams because, in part, he recognized that a portfolio owning only a few securities was vulnerable to catastrophic losses. Irrespective of how closely the manager monitors macro-trends, industry developments, and individual firm management, unforeseeable events could wreak havoc on one or more stocks. Today, this phenomenon is well known to investors in Enron, the Madoff proprietary fund, and such infamous investments as Executive Life (a casualty of Milken's junk-bond manipulations), ZZZ-Best (a high-flying stock of a mob-owned company), and others. Burr Williams offered an alternative strategy based on the concept of diversification. Rather than owning just a handful of stocks, the savvy investor should buy a broad cross-section of securities from economic sectors that seem most promising. For example, if trends appeared favorable for railroads, an investor in the late 1930s may wish to own positions across the entire railroad industry. Railroads in the Midwest generate profits transporting agricultural products (grains), Southern railroads transport cotton and fruits, Northeastern railroads transport industrial products, Mid-Atlantic railroads transport coal and steel, and so forth. A portfolio owning just a few railroad securities from a single region may be devastated by bad weather, labor conflicts, or other unanticipated surprises. Owning a cross-section of railroad securities, however, protects the portfolio from unacceptable downside loss. Sector fund offerings reflect the Burr Williams investment view in today's market place. In many ways, Burr Williams is the intellectual grandfather of the Fidelity Select Funds.

In 1952, a University of Chicago graduate student, working under economist and statistician Professor L.J. Savage, read John Burr William's book. The student, Harry Markowitz—a future Nobel Prize winner in Economics—agreed with Burr Williams that focused or concentrated portfolios subject investors to a risk of a catastrophic loss. However, Markowitz was not in agreement with Burr Williams' alternative strategy. Although the concept of diversification appealed to Markowitz, he recognized that owning 100 railroad stocks was not the same as owning 100 stocks across all industry

groups. Rather than a portfolio having 100 independent earnings events (trials) from 100 unrelated firms, the Burr Williams' portfolio is the statistical equivalent of a single trial. In statistical terms, although the Burr Williams' portfolio owns many securities, their price paths are highly correlated. There is a tendency for all investments to move in lockstep—which is wonderful if forecasted profits are realized, but disastrous if they are not. In a nutshell, Burr Williams' solution exacerbates the risk of focused portfolios rather than mitigating it.

Markowitz's "scientific diversification"[1] solution to the fundamental problem of portfolio design, however, was slow to catch on because it is based on two "unobservable" statistical factors: volatility and correlation. Investors can only know the historical series of realized investment returns. Volatility and correlation values depend on measurement intervals and sampling periods. Annualized volatility—also known as annual standard deviation—differs according to whether price changes are measured on a daily, weekly or monthly basis. Correlation, in turn, is a function of volatility. Eventually, however, Markowitz's revised and expanded doctoral thesis, published in 1959, became a cornerstone of Modern Portfolio Theory.

Investments 101: A Pop Quiz

Most every modern introductory investment textbook starts a discussion of diversification by asking students to select investments for a simple and stylized portfolio. This essay follows this tradition by presenting data on the following three investments:

- Investment X has an expected return of 6% and volatility of 15%
- Investment Y has an expected return of 7% and volatility of 20%
- Investment Z has an expected return of 4% and volatility of 25%.

The student is given the assignment of designing a portfolio with an expected return of 6% over the forthcoming period. The challenge is to pick the most efficient combination of assets investments for the portfolio. Many beginning students eliminate investment Z immediately for at least two reasons:

1. The return prospects for Z are relatively poor; and, including Z within the portfolio puts a drag on investment returns; and,
2. The volatility of Z is higher than the alternatives; and, including Z within the portfolio will increase the risk of unfavorable outcomes.

When considered in isolation, investment Z seems like a poor choice. It is unlikely that a TV investment guru would recommend purchase of this investment because it seems difficult to justify owning an investment that exhibits both high risk and mediocre return.

[1] The essay defines Scientific Diversification below.

Considering investments in isolation, however, characterizes the hopeful investment approach.[2] In the above example, the student may decide to allocate 100% to investment X. Investment X meets the target return (6%) at the lowest level of volatility. Alternatively, investment Y might seem to be a better choice because its expected return of 7% provides a cushion (margin of safety) despite the fact that it may be more volatile. Perhaps, after some consideration, the student may opt for a combination of X and Y.

The Quiz Answer

The key input that the beginning student lacks is asset return correlation values. On a preliminary basis, we define ***correlation*** as a measure of the linear association between two investments. If the return of investment A tends to be higher than its long-term average at the same time that the return of investment B tends to be higher than its long-term average, then the two investments are positively correlated. If the return of one investment tends to be lower than its long-term average while that of the other investment tends to be higher, then the two investments are negatively correlated. Finally, if the returns of each investment exhibit no linear association, the returns are not correlated. Uncorrelated returns have a correlation value of 0; returns that are perfectly correlated have a correlation value of +1; and returns that are perfectly negatively correlated have a correlation value of -1. Correlation can assume any value within the ±1 interval.

When considered individually, each investment is risky. Given an expected return of 6% and a standard deviation of 15%, for example, creates an approximately 95% chance of a realized return in the forthcoming period between -24% and +36% for investment X assuming a normal return distribution. However, if investments Y and Z are less than perfectly correlated with X, there may be an opportunity to use one or both to offset a portion of X's downside risk while preserving the feasibility of the 6% return target. Let's suppose that the correlations are 0.7 for X and Y, -0.4 for X and Z, and 0.8 for Y and Z. Some matrix algebra indicates that the investor prefers to own the follow portfolio:

- Investment X: 71.3% of wealth
- Investment Y: 19.1% of wealth
- Investment Z: 9.6% of wealth.

This portfolio achieves an expected return of 6% at a standard deviation of 13.65%. It is a more efficient asset allocation because it incorporates both correlation values and volatility values in addition to expected returns. The hopeful investor's P&L preferences give way to the rational investor's asset allocation decisions. The most efficient asset allocation weightings, in turn, suggest the wisdom of what Markowitz termed "scientific diversification." This is diversification based not on a higgledy-piggledy collection of many investments; but, rather, based on combining investments to generate return at an efficient level of risk. In this example, the best portfolio contained a positive weighting of the worst investment.

[2] Many 401(k) participants, for example, convince themselves that they should own only five-star mutual fund investments because the "best" investments make the "best" portfolio.

Just as the rational investor begins the asset allocation decision from the *liability* side of the balance sheet, so, also, he allocates assets to maintain an appropriate degree of *risk*. Once the investor determines the portfolio's required return, attention turns towards calibrating the return target with the investor's risk tolerance. In this context, owning just a few stocks seems to be a foolish investment strategy that amounts to mere speculation. Modern Portfolio Theory often runs counter to traditional investment wisdom.

The Periodic Table of Investment Returns

A common method for illustrating the value of diversification is the use of a "periodic table" of investment returns. We create such a table for the twenty-year period 1989 through 2008.

1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
Emerging Markets 61.51%	Citi WGBI 11.98%	CRSP 9-10 50.05%	CRSP 9-10 28.14%	Emerging Markets 79.61%	Int'l Small 14.77%	S&P 500 37.43%	NAREIT Equity 35.27%	S&P 500 33.36%	S&P 500 28.58%	Emerging Markets 67.11%	NAREIT Equity 26.37%	CRSP 9-10 33.99%	Citi WGBI 19.49%	CRSP 9-10 77.86%	Int'l Small 32.11%	Emerging Markets 35.19%	Emerging Markets 35.11%	Emerging Markets 40.28%	Citi WGBI 10.89%
S&P 500 31.49%	BC IT Gov't/Crd 9.16%	CRSP 6-8 48.65%	CRSP 6-8 17.38%	Int'l Small 34.39%	MSCI EAFE 8.06%	CRSP 9-10 33.20%	S&P 500 23.07%	CRSP 6-8 28.04%	MSCI EAFE 20.33%	CRSP 6-8 32.90%	BC IT Gov't/Crd 10.12%	NAREIT Equity 13.93%	BC IT Gov't/Crd 9.84%	Int'l Small 60.25%	NAREIT Equity 31.58%	Int'l Small 22.63%	NAREIT Equity 35.06%	MSCI EAFE 11.63%	BC IT Gov't/Crd 5.07%
Int'l Small 30.77%	1 Year T-Bill 8.05%	Emerging Markets 39.54%	NAREIT Equity 14.59%	MSCI EAFE 32.94%	1 Year T-Bill 5.23%	CRSP 6-8 29.47%	CRSP 9-10 19.26%	CRSP 9-10 24.02%	Citi WGBI 15.30%	CRSP 9-10 31.65%	1 Year T-Bill 6.27%	CRSP 6-8 13.24%	NAREIT Equity 3.82%	Emerging Markets 57.16%	Emerging Markets 28.12%	MSCI EAFE 14.02%	MSCI EAFE 26.86%	Citi WGBI 10.95%	1 Year T-Bill 2.01%
CRSP 6-8 19.23%	Emerging Markets -2.20%	NAREIT Equity 35.7%	S&P 500 7.67%	CRSP 9-10 20.10%	NAREIT Equity 3.17%	Citi WGBI 19.03%	CRSP 6-8 18.04%	NAREIT Equity 20.26%	Int'l Small 10.24%	Int'l Small 30.16%	Citi WGBI 1.59%	BC IT Gov't/Crd 8.96%	1 Year T-Bill 2.02%	CRSP 6-8 51.73%	CRSP 6-8 21.10%	NAREIT Equity 12.16%	Int'l Small 26.32%	Int'l Small 8.04%	S&P 500 -37.00%
BC IT Gov't/Crd 12.77%	S&P 500 -3.17%	S&P 500 30.55%	BC IT Gov't/Crd 7.17%	NAREIT Equity 19.65%	Citi WGBI 2.34%	BC IT Gov't/Crd 15.33%	Emerging Markets 9.37%	BC IT Gov't/Crd 7.87%	BC IT Gov't/Crd 8.44%	MSCI EAFE 27.30%	S&P 500 -9.11%	1 Year T-Bill 3.63%	Int'l Small -2.85%	MSCI EAFE 39.17%	MSCI EAFE 20.70%	CRSP 6-8 6.77%	CRSP 9-10 18.10%	BC IT Gov't/Crd 7.39%	CRSP 6-8 -37.59%
MSCI EAFE 10.80%	NAREIT Equity -15.35%	Citi WGBI 15.81%	Citi WGBI 5.53%	CRSP 6-8 18.24%	S&P 500 1.31%	NAREIT Equity 15.27%	MSCI EAFE 6.36%	1 Year T-Bill 5.70%	1 Year T-Bill 5.17%	S&P 500 21.04%	CRSP 6-8 -11.00%	Emerging Markets 1.77%	Emerging Markets -3.94%	NAREIT Equity 37.13%	CRSP 9-10 16.70%	S&P 500 4.91%	CRSP 6-8 16.17%	S&P 500 5.49%	NAREIT Equity -37.73%
NAREIT Equity 8.84%	CRSP 6-8 -17.79%	BC IT Gov't/Crd 14.62%	1 Year T-Bill 3.99%	Citi WGBI 13.27%	CRSP 6-8 -1.52%	MSCI EAFE 11.55%	1 Year T-Bill 5.61%	MSCI EAFE 2.06%	CRSP 6-8 0.51%	1 Year T-Bill 5.07%	Int'l Small -12.26%	Citi WGBI -0.99%	CRSP 9-10 -13.86%	S&P 500 28.70%	S&P 500 10.87%	CRSP 9-10 3.66%	S&P 500 15.80%	1 Year T-Bill 4.61%	CRSP 9-10 -41.48%
1 Year T-Bill 8.76%	Int'l Small -17.94%	MSCI EAFE 12.50%	Emerging Markets 3.28%	S&P 500 9.99%	BC IT Gov't/Crd -1.93%	1 Year T-Bill 6.13%	BC IT Gov't/Crd 4.05%	Citi WGBI 0.23%	CRSP 9-10 -8.17%	BC IT Gov't/Crd 0.39%	CRSP 9-10 -13.02%	S&P 500 -11.88%	MSCI EAFE -15.66%	Citi WGBI 14.91%	Citi WGBI 10.35%	1 Year T-Bill 3.59%	Citi WGBI 6.12%	CRSP 6-8 -0.12%	MSCI EAFE -43.06%
CRSP 9-10 8.15%	MSCI EAFE -23.2%	1 Year T-Bill 6.05%	MSCI EAFE -11.85%	BC IT Gov't/Crd 8.79%	CRSP 9-10 -3.14%	Int'l Small 0.99%	Citi WGBI 3.62%	Int'l Small -14.55%	NAREIT Equity -17.50%	Citi WGBI -4.27%	MSCI EAFE -13.96%	Int'l Small -16.75%	CRSP 6-8 -21.58%	BC IT Gov't/Crd 4.31%	BC IT Gov't/Crd 3.04%	BC IT Gov't/Crd 1.58%	1 Year T-Bill 4.94%	CRSP 9-10 -7.94%	Int'l Small -47.05%
Citi WGBI 4.33%	CRSP 9-10 -27.44%	Int'l Small 5.83%	Int'l Small -20.59%	1 Year T-Bill 3.49%	Emerging Markets -12.01%	Emerging Markets -8.41%	Int'l Small 2.80%	Emerging Markets -14.74%	Emerging Markets -22.01%	NAREIT Equity -4.62%	Emerging Markets -31.76%	MSCI EAFE -21.21%	S&P 500 -22.10%	1 Year T-Bill 1.25%	1 Year T-Bill 1.82%	Citi WGBI -6.88%	BC IT Gov't/Crd 4.08%	NAREIT Equity -15.69%	Emerging Markets -53.74%

The table depicts ten asset class "building blocks" from which investors can design portfolios. The color coding is as follows: Red = U.S. Large Company Stocks; Green = U.S. Small Company Stocks; Brown = U.S. Micro Cap Stocks; Yellow = Foreign Large Company Stocks; Purple = Foreign Small Company Stock; Gray = Emerging Markets Stock; Pink = Securitized Real Estate; Orange = 1-Year T-Bills; Periwinkle = U.S. Intermediate-term Bonds; and, Blue = World Government Bonds.

As the above table illustrates, the relative performance of asset classes can shift dramatically year-to-year. Investors have a choice as to whether they will attempt to predict the winning asset classes for the forthcoming year (a focused portfolio approach), or will maintain exposures to all asset classes to avoid the possibility of extreme performance results (a balanced, diversified approach). It is difficult to identify any exploitable investment pattern from the above table. Winners seem not to persist; and, conversely, a strict contrarian approach—investing in the previous year's losers—also seems not to assure long-term profitability. The lack of predictability is a source of frustration for the focused portfolio approach; but, is a potential benefit for a diversified portfolio approach. A later section of this essay examines the nature of this benefit as well as limitations and pitfalls that may arise when designing a diversified portfolio. It will revisit the above table from a very different perspective.

An Investment Tag Team Match: Warren Buffett & Andrew Carnegie vs. John Bogle & Harry Markowitz

Is there a way to reconcile Warren Buffett/Andrew Carnegie with John Bogle/Harry Markowitz? One often encounters a phrase like "when you buy a share of stock, you are investing in a company." However, the phrase's vocabulary may unwittingly serve to confuse as much as enlighten. When an entrepreneur invests in a company, he or she seeks control of company assets, and, by extension, control of the company's business strategies, with an ultimate goal of *commercial* success. When an investor buys a share of stock in a company, he or she probably does not demand operating control of the firm. Rather, the investor desires a reasonable return on the stock purchase with an ultimate goal of *investment* success. Carnegie wishes to control U.S. Steel, Buffett wishes to control Berkshire Hathaway, and Bogle wishes to achieve an attractive return for a wide population of mutual fund shareholders. The strategies required to attain commercial success are very different from those required to attain investment success. Unfortunately, to the great confusion of many investors, a common vocabulary is used for each endeavor.

We can take a second look at the phrase: "when you buy a share of stock, you are investing in a company." The force and effect of the vocabulary inevitably directs our attention to the fact that each share of stock represents a pro-rata right to share in the future dividends and profits of the company. Again, a good portfolio should only own the stocks of good companies—right? Who would want to own the stock of a company that may have poor future dividends and profits? The portfolio design process reduces itself to a hunt for good stocks with asset allocation concerns slipping far into the background—"***my investment policy is to make money***." We are faced with compelling examples of commercial success, and remain confused by the vocabulary in common use. But Warren Buffett doesn't manage *money*; he runs *businesses*. There is no such thing as the Buffett Mutual Fund. The financial analyst looking for a good business investment concerns himself with the fundamentals The analyst looking to design a good portfolio concerns himself with both fundamentals—a security seen as a bundle of forecasted monetary payoffs in each economic environment—as well as with a security's statistical aspects—a vector of returns that is a bundle of quantitative characteristics including its correlation values with other securities. In short, don't place all your bets on NASDAQ stocks because many of them share the same statistical characteristics.

When is it prudent not to diversify?

Briefly, it may be prudent to limit diversification under one or more of the following circumstances:

- Proven skill in selecting securities that can beat the market after taxes and fees (are investment managers like the children living at Lake Woebegone—all above average?);
- The need to match investment cash flows to future contractual obligations;
- The need to hedge specifically identified risk exposures;
- The need to limit "doubling-down" on certain risks especially in the face of pre-existing illiquid investment positions and labor income sources (a stock broker would probably not wish to overweight his retirement plan with stocks because the value of his labor income would be highly correlated to the value of his investment account);
- The desire to acquire or maintain voting control of a commercial enterprise;
- The need to avoid or defer tax liabilities, or an opportunity to take advantage of revenue code options like a deathtime step up in tax basis;
- The need to comply with regulatory reserving requirements or investment constraints; or,
- Strong economic "state preferences" for investment payoffs (hypersensitivity to decreases in investment wealth beyond a critical threshold).

Undoubtedly, the list can be expanded to encompass other circumstances where diversification may prove to be a sub-optimal strategy. Theoretically, for example, if a highly risk-tolerant investor does not care about changes in portfolio values, the case for diversification may not seem compelling. The point is that broad-scope diversification may not be the best portfolio design alternative given a wide variety of investor preferences and constraints. Rather, in most circumstances, it should be considered as a first option.[3]

Finally, it is interesting to consider the limits of diversification. It is not surprising to see a resurgence in post-1929 rhetoric given the recent downside volatility in many capital markets. Some investors now view stocks as mere speculations that should be avoided for portfolios tasked with funding critical economic objectives. Some investors suggest that critical goals should be scrupulously matched to and exclusively funded with low-risk fixed income investments. Under this view, equity investing is merely a residual activity that, if you are lucky, gives you a chance of becoming rich. The higher expected return of stocks is a siren's song that, sooner or later, will lead you to crash the financial ship. Principal guarantees take the place of portfolio diversification.

On the other hand, some investment gurus suggest that prudent asset management must involve dynamic market-timing shifts to avoid vulnerable sectors of the domestic and world economies. Other gurus tout that this is a "traders'" or "stock pickers" market. Still others recommend a large allocation to commodities like silver and gold. The process of portfolio design through broad-scope diversification takes a back seat to a strict P&L metric; diversification merely means

[3] The Prudent Investor Rule, promulgated in the latest restatement of American trust law, states: "In making and implementing investment decisions, the trustee has a duty to diversify the investments of the trust unless, under the circumstances, ***it is prudent not to do so***." [emphasis added]

that, without the guidance of an experienced guru, wealth disappears down ten drains at once instead of just one. Diversification seems ineffective and Modern Portfolio Theory is a fraud.

Part III: Correlation and the Portfolio Design Process

An efficient combination of investments with *differing* statistical characteristics optimizes a portfolio's risk/reward tradeoffs. This statistical-based method of portfolio construction stands in contrast to a technique that bundles investments sharing *common* statistical characteristics—safety of principal, forecasted capital appreciation, high current dividend or interest income—into a portfolio. In brief, the example provided above illustrates how a combination of three securities generates a portfolio that achieves the target return at a level of risk lower than any individual security. The pedagogical message of the admittedly stylized example is that the most favorable combination of securities includes an investment that, when viewed in isolation, promises comparatively low returns and high risk. The "best" portfolio includes the "worst" investment.

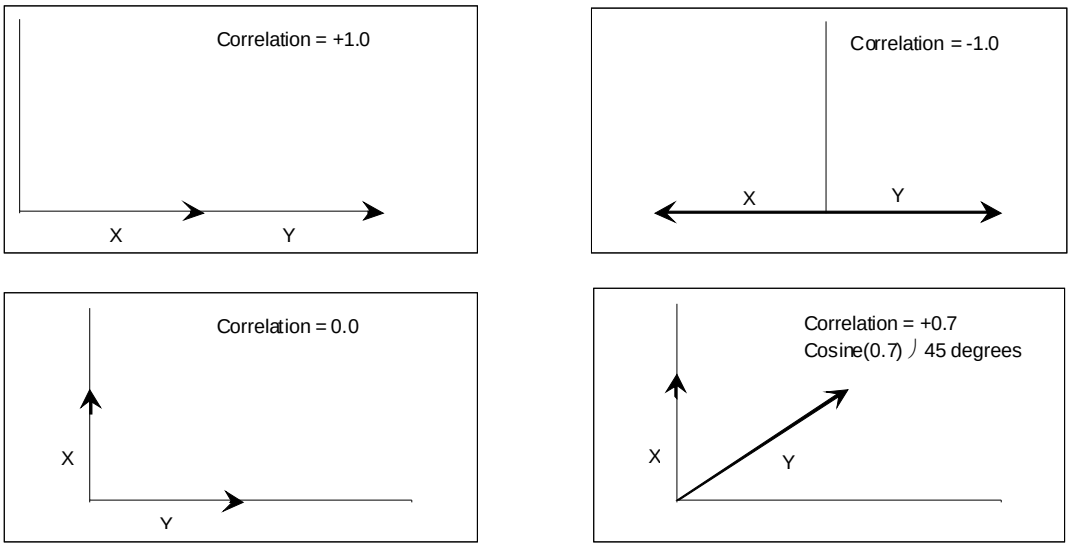
A key concept for understanding the principles of efficient portfolio diversification is the *correlation* statistic. At the outset, it may be important to clarify why we are inviting you on a soporific journey by asking you to read about a statistical concept. The central question that we wish to address is whether the recent bear market forces us to reassess the risk/reward benefits of portfolio diversification. Is diversification an effective strategy for controlling portfolio risk; or, should it be relegated to the scrap heap? Understanding the concept of correlation is a prerequisite to understanding the limits of diversification.

There is one more benefit to slogging through this material. Once you grasp the limits of diversification, you are in a better position to formulate a coherent asset management strategy that fits your risk/return preferences. However, you need only have an intuitive understanding of correlation—don't worry if you do not grasp each and every mathematical nuance. Even finance students find this stuff hard.

The Geometry of Correlation

As stated, *correlation* is a measure of the linear association between two investments. If the return of investment A tends to be higher than its long-term average at the same time that the return of investment B tends to be higher than its long-term average, then the two investments are positively correlated. If the return of one investment tends to be lower than its long-term average while that of the other investment tends to be higher, then the two investments are negatively correlated. Finally, if the returns of each investment exhibit no linear association, the returns are not correlated.

Geometrically, we can think of correlation as the interaction of return vectors. Working in a simplified two-dimensional coordinate plane, each return vector is a line through the origin if we set the initial period t – 1 return to zero. Geometrically, if returns are perfectly positively correlated they must point in the same direction; if perfectly negatively correlated they must point in opposite directions. Here are pictures of return vectors (arrows) in two-space for different values of the correlation statistic:



It is apparent that correlation depends on the angle formed by the two return vectors.[4] Our explanation stresses that correlation is a measure of a linear dependence relationship only. Two results flow from this observation:

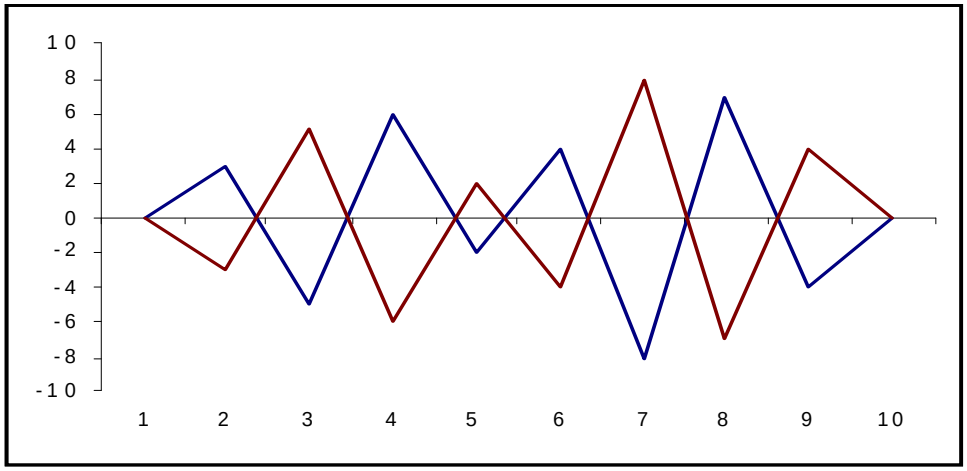
1. Some linear relationships result in spurious correlations. A well-known example is the correlation between ability in mathematics and children's shoe-size. This correlation is spurious because older children are typically better in math than younger children; and, older children tend to have larger feet. Buying your youngster an ill-fitting pair of large shoes will not increase his or her scores on an arithmetic test![5]
2. Two data series can have a zero value for the correlation statistic and, yet, exhibit a strong dependence structure because of a non-linear relationship. If, for example, X is distributed symmetrically around the origin and Y equals X^2, then their correlation equals zero despite their perfect dependence: the X return vector equals (-2, -1, 0, 1, 2) and the Y return vector equals (4, 1, 0, 1, 4). The correlation between X and Y = 0 despite the strong non-linear dependence relationship.

Each of these observations has important consequences for portfolio design and management.

We present this technical explanation because some people think that positive correlation means that two assets tend to increase in value at the same time, while negative correlation means that two assets tend to exhibit offsetting returns. This *incorrect* view is expressed graphically as follows:

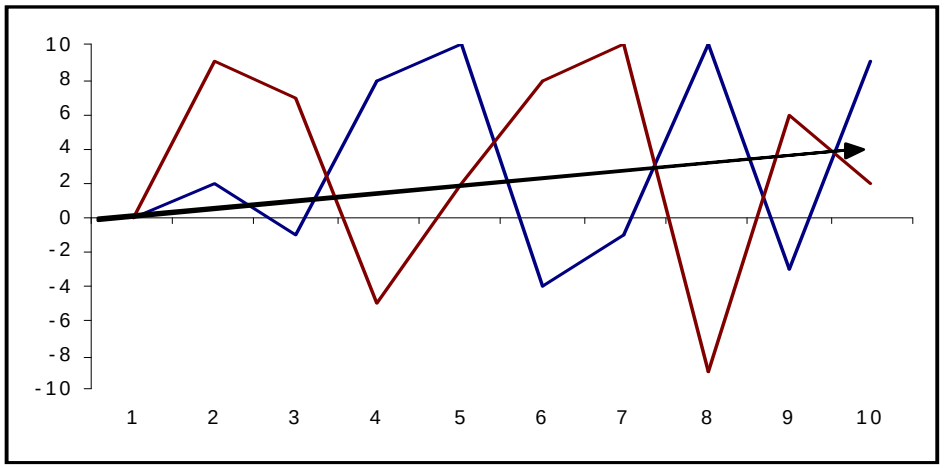
[4] More formally, for standardized returns [subtract the mean and divide by the standard deviation], correlation is associated with the cosine of the angle formed by the corresponding vectors. In linear algebra terms, for vectors X and Y, the cosine equals the inner product of the two vectors [X·Y] divided by the product of the norm of vector X and the norm of vector Y, where norm is a measure of distance according to the Pythagorean Theorem: distance = $[(A)^2 + (B)^2]^{1/2}$.

[5] Courses in advanced statistics often discuss difficulties encountered when estimating correlations between data series that cannot pass tests for stationarity (infinite variance series). This is important in finance because random walk price evolutions are, by definition, non-stationary.



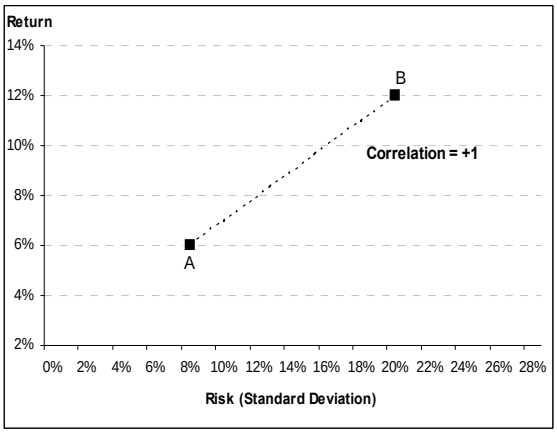
If this, in fact, were the case, combining assets with perfect negative correlation would take the portfolio nowhere fast—any gains made by investment X (blue) would be exactly offset by investment Y (brown). Combining two such investments into an equally-weighted portfolio guarantees no growth whatsoever! This incorrect view of correlation causes some commentators to observe that focused portfolios seeking high period-by-period performance are superior to portfolios formed by combining assets with low or negative correlation. This argument, although it sounds compelling, is specious.

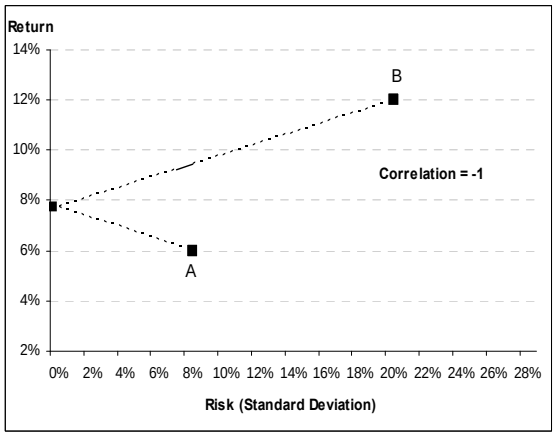
The following chart depicts the alternative, *correct*, view of negative correlation:

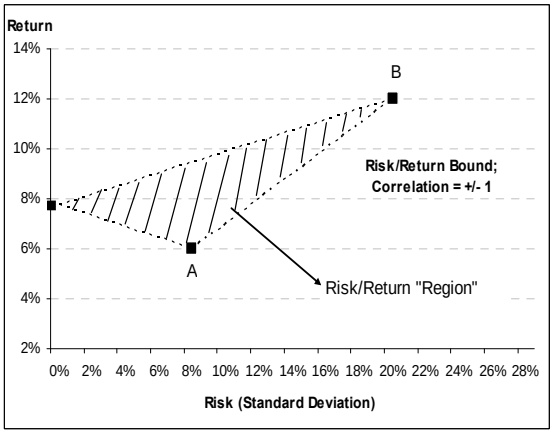


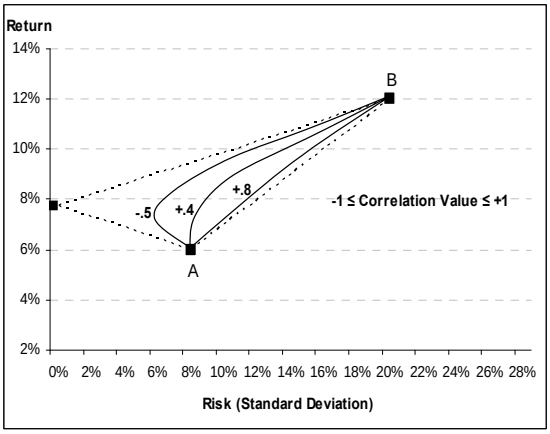
The graph shows negative correlation (when asset X is above its mean return of 3%, asset Y is below its mean return of 3%, and vice-versa). However, there is a positive long-term rate of growth as evidenced by the upwardly sloping arrow. For example, X and Y are negatively correlated in period t if asset X earns 4% and asset Y earns 2%. Both assets increase in value but exhibit perfect negative correlation for the period because the returns fall on the opposite side of their respective means.

During the classical period of Modern Portfolio Theory from the 1960s through the 1980s, knowledge of asset correlations was valued in so far as it provided a guide to designing portfolios at an appropriate level of risk. The promise of Modern Portfolio Theory [MPT] is centered in its belief that the correlation structure of securities provides the key to controlling risk without sacrificing return. Portfolios built on MPT risk-control principles differ from portfolios that accept low returns in exchange for principal guarantees. By forming portfolios of assets exhibiting differing pair-wise correlation values, overall risk is measured and controlled from the "portfolio context" rather than by merely aggregating low earning, stable-value assets. Let's work through some examples to illustrate how MPT uses correlation as a "risk-control" input for portfolios.









Each of the above charts depicts the consequences of forming a portfolio from two assets: asset A has an expected return of 6% with a volatility of 8% as measured by its annualized standard deviation; asset B has an expected return of 12% with a volatility of 20%. If we choose to form a portfolio consisting of 100% asset A, all of the portfolio weight will fall on the point labeled 'A.' If we begin to blend A with investment B, the economic consequences differ depending on the value of the correlation statistic. The upper left chart indicates that as we move from a 100% investment in A to a 100% investment in B, the investment results trace out a straight line because the correlation value is a perfect +1. However, if the correlation value is at the opposite

extreme—i.e., negative 1—then the upper right chart indicates that by blending the two investments the risk of A offsets the risk of B. Risk reduction continues until we arrive at a minimum risk portfolio. As the portfolio moves away from the minimum risk blend, the portfolio tracks either A or B more closely.

The bottom left chart depicts the region of feasible investment combinations over the complete range of correlation values—i.e., ±1. The upper and lower correlation bounds carve out a risk/return region into which any two investments with known returns and standard deviations must fall. The riskiest spot in the region is located at the point where the portfolio consists of 100% B and 0% A. This point has an expected return of 12% with a standard deviation of 20%. The location of the least risky spot in the region is at the point where A and B combine for 0% risk—the minimum risk blend. This point has an expected return of slightly less than 8% with a standard deviation of zero.[6] The bottom right chart indicates that a combination of asset weightings and correlation values between ±1 determine the portfolio's location within the feasible region's risk/return space. Given a positive weighting of any asset, the portfolio is likely to be improved by combining the first asset with a second asset with a low correlation value. The bottom right chart illustrates the risk/return profiles when asset correlations are -0.5, +0.4, and +0.8. The higher the value, the closer the portfolio tracks to the straight line (correlation = +1.0) at the edge of the region.

The Optimal Combination

Mixing assets with different pair-wise correlations can create an aggregate portfolio with a more favorable risk/reward tradeoff. In general, a portfolio benefits more by adding assets with lower correlation values than with higher values, all else equal. Knowledge of correlation enables investments to be evaluated in a portfolio context rather than in isolation because it provides a clue to how investments interact over time. This observation gives rise to a classic problem in Modern Portfolio Theory—what is the optimal combination of assets given an investor's return preferences and risk constraints. Harry Markowitz shared the 1990 Nobel Prize in Economics, in large part, because he provided a solution to this problem.

Please recall the "periodic table" of returns presented earlier. We can summarize asset class returns--the vectors of historically realized returns--into a more compact table of correlations (average pair-wise values of the correlation statistic):

[6] You can tell that this is a highly stylized example because today's risk-free rate is only about 1%. Current investors would love to earn a risk-free 8%.

	# Years	U.S. Large Company Stock	U.S. Small Company Stock	U.S. Micro Cap Stock	Securitized Real Estate	Foreign Large Company Stock	Foreign Small Company Stock	Emerging Markets Stock	U.S. 1-Year T-Bill	U.S. Intermediate Bonds	World Government Bonds
U.S. Large Company Stock	20	1.00	0.82	0.65	0.47	0.73	0.55	0.45	0.40	0.20	0.05
U.S. Small Company Stock	20	0.82	1.00	0.95	0.69	0.72	0.61	0.63	0.05	0.09	-0.04
U.S. Micro Cap Stock	20	0.65	0.95	1.00	0.72	0.61	0.55	0.55	-0.15	0.07	0.00
Securitized Real Estate	20	0.47	0.69	0.72	1.00	0.48	0.46	0.38	-0.04	0.07	-0.08
Foreign Large Company Stock	20	0.73	0.72	0.61	0.48	1.00	0.92	0.74	-0.05	-0.20	0.04
Foreign Small Company Stock	20	0.55	0.61	0.55	0.46	0.92	1.00	0.80	-0.13	-0.27	0.02
Emerging Markets Stock	20	0.45	0.63	0.55	0.38	0.74	0.80	1.00	-0.01	-0.08	-0.07
U.S. 1-Year T-Bill	20	0.40	0.05	-0.15	-0.04	-0.05	-0.13	-0.01	1.00	0.40	-0.17
U.S. Intermediate Bonds	20	0.20	0.09	0.07	0.07	-0.20	-0.27	-0.08	0.40	1.00	0.53
World Government Bonds	20	0.05	-0.04	0.00	-0.08	0.04	0.02	-0.07	-0.17	0.53	1.00

The classic definition of the portfolio design process entails the optimal combination of investments based, in part, on the correlation values like those exhibited in the above table. If certain simplifying assumptions are allowed, it can be demonstrated that there is a unique combination of assets that generates the highest expected returns for a given risk; and, the lowest level of expected risk for a given expected return. When the portfolio exactly matches the investor's risk/return preferences, financial economists term this unique asset combination the 'optimal portfolio.' Furthermore, investing in any portfolio other than the set of optimal portfolios along the risk/return spectrum results in an unnecessary destruction of wealth in the sense that a non-optimal portfolio has expected returns insufficient to compensate the investor for risk. Correlation values seem to be the key to creating investment portfolios.

The Dynamics of Asset Price Change

During the period that roughly spans the late 1980s through the present, probably no other area of academic research in finance has proved more fruitful than the study of how asset prices "behave." Finance professors investigating the properties of financial time series developed a rich set of theories on the topic of dynamic asset pricing. Central to this research is a re-examination of the nature of correlation. Recent advances in econometrics—the application of statistical techniques to finance problems—motivate, in some cases, substantial modifications of the classic principles of Modern Portfolio Theory. The scope of the literature on financial econometrics is vast, and we can only provide a brief discussion of a few basic points.

The first thing to recognize is that the classic definition of correlation relies on the central limit theorem. Although there is only a finite sample of returns, nevertheless, as the sample grows larger, the values of the return distribution's key statistical parameters will converge to their true values. According to this point of view, there is a long-term average expected return which represents the central tendency for the growth of wealth under specific asset allocations. In any period, realized returns may be either above or below this central tendency; but, such deviations

represent only temporary diversions from the true—but unknowable—central mean (called "the first moment"). Likewise, depending on the method of measurement, by the central limit theorem, there is a constant long-term parameter value for volatility (called "the second moment"). Risk-averse investors have a positive preference for a high first moment (average return) and a negative preference for a high second moment (volatility)—they like return and dislike risk.[7] Although this economic world view allows for period-by-period variations in realized risks and returns, such variations are merely temporary perturbations from fixed long-term constant parameter values. Ultimately, this is a static, equilibrium-oriented system. Volatility differs from period-to-period; but, its long-term value is a constant—i.e., not time varying. Correlation—as the "byproduct" of asset returns and volatility—also converges to an average or theoretical steady-state value. Econometricians call this constant value *unconditional correlation*. Under the central limit theorem, the larger the sample (i.e., the longer the history of returns), the more confident the investor can be in the "true" (i.e., unconditional) value of asset correlations.

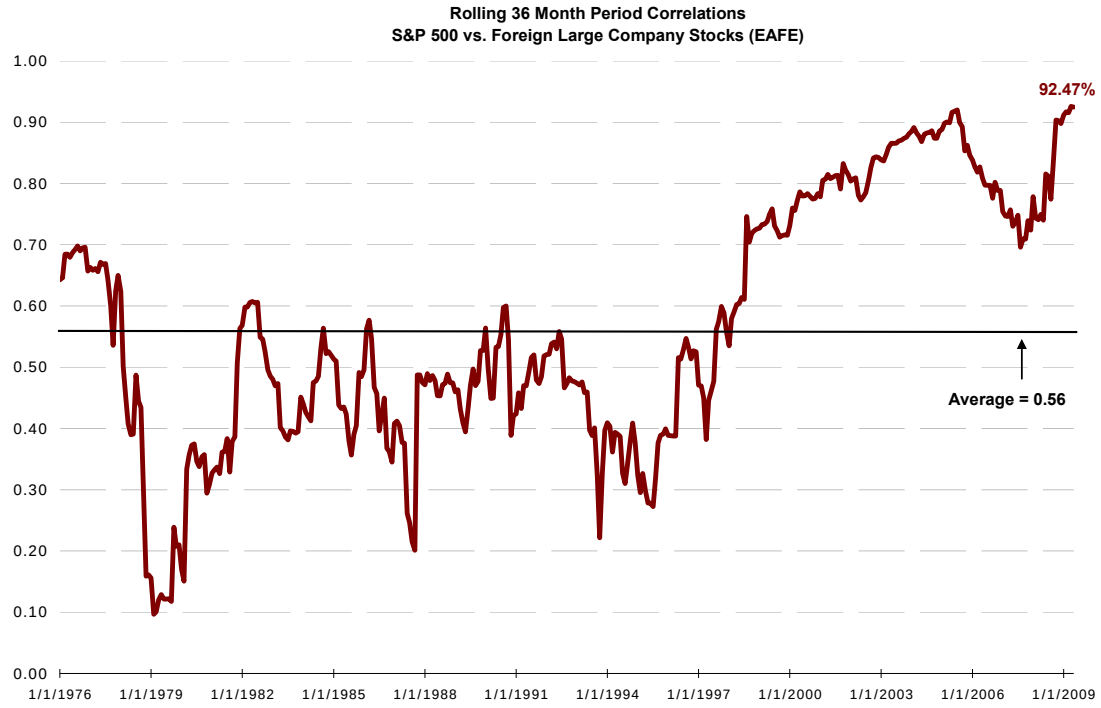
Beginning in the late 1980s more powerful computers allowed economists to build asset price models in which volatility became volatile—time varying volatility—and correlations became dynamic—*conditional correlation v. unconditional correlation*. By the mid 1990s certain large institutional investment houses like J. P. Morgan and consulting firms like BARRA developed more sophisticated "risk metrics" capable of producing advanced computer-driven asset return models. Recent econometric research has, to some extent, turned certain elements of classic Modern Portfolio Theory upside down. In the Fall of 2005, for example, Markowitz published an essay arguing that the market portfolio is not efficient and that there is probably no linear relationship between an asset's Beta [(correlation with the market) x (volatility relative to the market)] and its expected return.

Some current asset pricing theories now view return distribution parameters—mean and volatility—not as parameters that necessarily converge towards a theoretical steady-state constant value, but, rather, as dynamic values that must be adjusted both within and across differing regimes. There may not be a true overall unconditional average like the central limit theorem suggests; rather, volatility and correlation values are conditional on the particular market regime: "bull" or "bear" market.

A Graphical View: Conditional v. Unconditional Correlation

Consider, for example the following graph of rolling three-year correlation between large capitalization U.S. stocks (the S&P 500) and large capitalization foreign stocks (the EAFE index) over the period 1976 through 2008.

[7] See, for example, the mathematical expression for compound growth in wealth presented at the beginning of the essay.



A correlation table fixes the value of the correlation statistic at 0.56 which is the average for the period. However, the actual three-year rolling correlation values range from a low of approximately 0.10 to a high of 0.92. Building a portfolio on the assumption that the average is a reliable parameter estimate seems not to be a particularly good idea.

The above graph suggests two important facts about correlation:

1. It is an average taken over many years; and, like all averages, may not be representative of actual year-by-year values.
2. It is dynamic. Rather than forcing the correlation value to "fit" the entire period by assuming that it converges to a constant value, it may be more appropriate to split the time period into two or more regimes—e.g., a bull market regime and a bear market regime. If the correlation values shift dramatically from regime to regime, then building a portfolio based on an overall average may yield suboptimal results.

The second of the two facts leads some econometricians to argue that the most useful statistic is *conditional correlation* rather than absolute or *unconditional correlation*. Estimating a value for conditional correlation involves the following question: if the economy is currently in regime X, what is the likely linear association between one or more assets in *this* regime. This question is, of course, different from calculating the correlation values over *all* regimes within the sample period. Asset pricing models using conditional correlation values appear to produce models that better replicate the real world behavior of investment returns.

Diversification Meltdowns

Conditional correlation calculations highlight the dynamic nature of correlation. In severe down markets, volatility tends to increase. A higher standard deviation signifies that investment returns are more uncertain and, most importantly, **correlation values tend to increase**. This observation has profound consequences for portfolio management. During bear markets, when downside volatility increases, increases in asset correlations make it less likely that the portfolio can emerge unscathed. If correlation is the key to efficient diversification, then bear-market correlation value increases erode the benefits of diversification when it is most needed.

During the last several years, a flood of research has appeared on the topic of "diversification meltdowns" during periods of severe downside risk. Here is a brief recap of two important topics:

1. Correlation is only one measure of the possible dependence structures of financial return time series. It is a good dependence measure if the return series are multivariate normal (bell-curves) but a misleading measure for non-normal time series. Unfortunately, stocks and bonds as well as baskets of securities such as index funds flunk statistical tests for normality. Although they may flunk for a variety of reasons, the bad news is that financial returns are often leptokurtic. This means that they are "fat-tailed" and exhibit a propensity to manifest extreme results--both positive and negative--at a probability far greater than that found in normal distributions. This is not good news for investors. Extreme downside volatility increases pair-wise correlation values so that many asset combinations appear to be headed into a death spiral simultaneously. This can be very scary.

2. Financial return series exhibit a variety of extremely interesting non-linear associations. Cutting edge research is moving beyond correlation metrics into analysis of asset *co-integration* and portfolio *copula structures*. This research contains both good and bad news for investors.

The Strange World of Co-Integration and Copula Structures

Let's spend a moment on co-integration. The question to be entertained is this—if an asset price series is a random walk, where random walk is defined as "unpredictable" Readers of the famous book "A Random Walk Down Wall Street" by the economist Burton Malkiel know that Modern Portfolio Theory deems financial asset price changes to follow a random walk, can two random-walk asset price time series exhibit joint predictability?[8]

According to classical statistics, a financial time series is "stationary" if the series has a constant mean, a constant variance, and a constant autocovariance. Autocovariance is the correlation structure of an asset's current value and its values in previous time periods—i.e., "lagged values". A random walk *price* series is not stationary but, fortunately for investors, can be transformed easily into a stationary series by using a logarithmic transform of periodic *returns*

[8] Readers of A Random Walk Down Wall Street by the economist Burton Malkiel know that financial asset price changes follow a random walk according to Modern Portfolio Theory.

[ln(asset price period 1 - asset price period 2) ÷ ln(asset price period 1)]. This means that financial asset prices can wander a long way from their average values and may only rarely cross the moving average. For example, the Dow Jones Index price level at the end of 1930 was $164, and wandered to $12,463 by the end of 2006. Asset prices follow a random walk, and therefore, are unpredictable. If this sounds a lot like the Efficient Market Hypothesis, it should—because both points of view give expression to the same underlying mathematical concepts. Financial asset return series, however, are stationary and are more tractable to computer modeling. A model of future returns can then be applied to asset prices at a point in time--an "initial value condition"--to model the evolution of the price series.

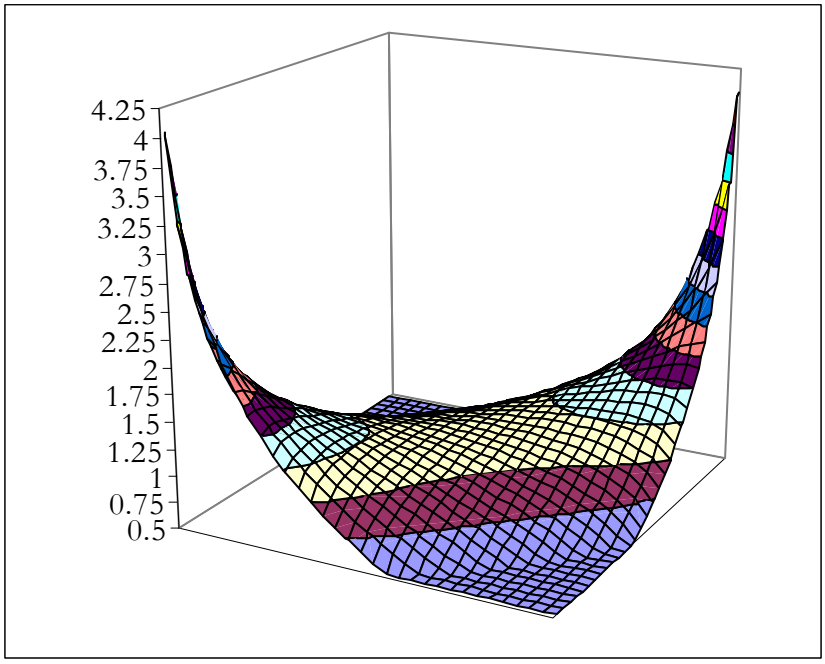
In classical statistics, by definition, two random walk prices series have zero correlation. You don't have a clue as to how series B will behave even if you know exactly what series A will do. As a matter of fact, you also don't have a clue about series A's future behavior but this is a different problem. Each series is random, exhibits no trend, and the pair-wise correlation must be zero. No association, no predictability—right? Wrong. Here is an example of a co-integrating relationship. Consider a dog that is wandering about a field. Its movements seem completely random—moving from spot to spot with no discernable purpose—except perhaps to another dog. However, an inebriated man is also wandering about the field. His movements seem completely random—moving from place to place with no discernable purpose. Although there should be no "dependency structures" to be found in uncorrelated vectors of motion, nevertheless, if the man is the owner of the dog, it is unlikely that the dog will wander too far away from its master. Uncorrelated random walks can exhibit a formal dependency structure—i.e., they can be co-integrated. Robert Engle and Clive Granger shared the 2003 Nobel Prize in economics, in part, for their studies of financial asset price behaviors including common trends such as co-integrating relationships and autocorrelation values.

Copula structures provide very good news for investors because they offer new ways of looking at how the "marginal distributions" of individual assets (the return distributions of assets considered in isolation) relate to the "joint distributions" of portfolio components as they dynamically interact.[9] Although the mathematical complexities of copula structures make it unlikely that they will appear any time soon at your local financial planner's office, nevertheless, as the underlying mathematics become better understood, the "dangers" of using only an unconditional correlation metric in portfolio design and asset management should also become apparent. We illustrate how copula functions can capture risk characteristics of financial asset returns that correlations miss. Correlation is a valid risk-control metric only when distributions manifest a symmetric, linear dependence structure. Copulas, by contrast, capture asymmetric tail dependence.

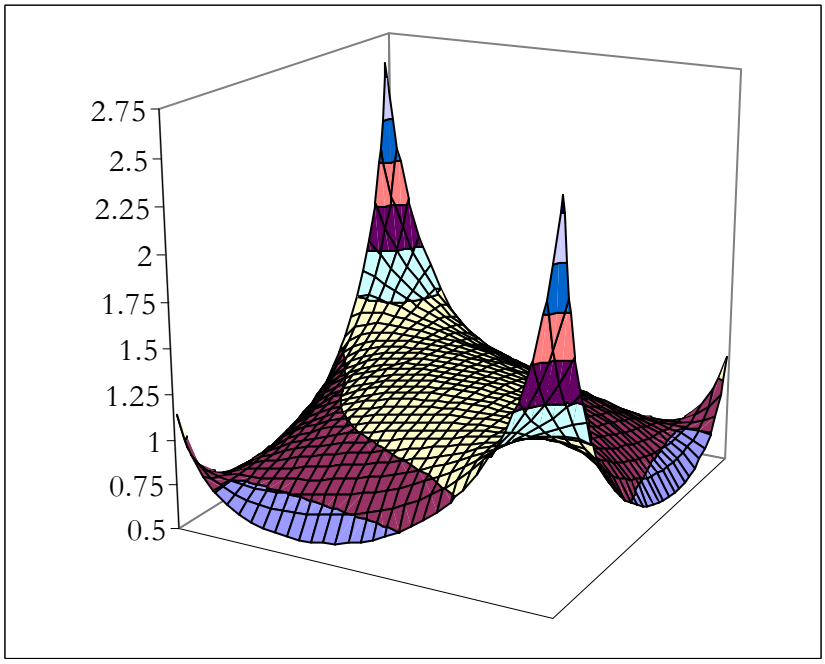
Here are two pictures of a normal mixture copula density. A normal mixture assumes that each of the financial return series is normal; but, that means and variances are conditional on the regime (bull or bear market). Graph one illustrates results assuming a -0.1 correlation value; graph two illustrates results assuming a +0.7 correlation value. Note that the base of the graphs is a unit square representing the possible range of correlation relationships.

Graph One:

[9] Joint distribution of X and Y = (Marginal Distribution of X)(Conditional Distribution of Y).



Graph Two:



The two graphs look very different from the bell-curves that usually represent normal distributions. Bell curves have most of the probability mass in the center, and the tails are relatively skinny. Extreme events are considered to be unlikely. Copula structures also exhibit

skinny tails (located in the four corners), but they do a much better job capturing higher corner values. This reflects the relative importance of tightening correlations (i.e., greater dependence) in extreme market conditions.

In the Aftermath of the Global Recession

As the dust settles on the global bear market for stocks, investors ponder whether they should reexamine their macro allocation—ratio of stocks to bonds. MPT suggests that stock risk is manageable in the portfolio context because asset classes like securitized real estate, emerging markets stocks, and blue-chip U.S. stocks manifest differing pair-wise correlation values. Further research, however, suggests that this statement should be modified—the asset classes manifest differing pair-wise correlation values *on average*. In extreme volatility regimes, however, the correlation values often differ significantly from their historical averages; and, in down-market regimes, the pair-wise correlation values may move towards +1. For those investors electing to reach for higher yields by holding junk bonds or mortgage-backed debt instruments, the recent convergence of the correlation structure towards unity was particularly devastating. So the question now is: do we go back to a static blueprint for investment decision making or do we rethink how best to manage wealth in a dynamic environment?

During the recent recession some advisory firms recommended a stay-the-course posture because, in their view, stocks were "on sale." Equities were likely to go up in value as the business cycle moved out of the recession. Other firms encouraged clients to re-examine their attitude towards risk as a first step in selecting a new, more comfortable, long-term macro allocation. They recommended increasing the relative portfolio weight to short-term, government-guaranteed fixed income instruments. The astute reader may recognize that the financial advice profession has, to a great extent, landed clients back into the old fear/greed decision making structure that has been discredited for decades. Decisions are driven by a P&L metric ("today's the day to make money" / "don't lose any more money") that, at the end of the day, is not helpful. Is there a better solution path?

The underlying goal of asset allocation—calibrating systematic risk exposures to the trust's required return and risk tolerance—is to enhance satisfaction with wealth. The asset allocation decision has a measureable and potentially significant impact on investor welfare. Investors come to the table with competing objectives, uncertain expectations, and changing attitudes towards wealth and risk. Finding the optimal single-period solution is a difficult undertaking; finding the optimal multi-period solution path is an extremely problematic undertaking. In the presence of path dependencies created by cash flows, the emerging standard of practice suggests that advisors should model outcomes based on credible simulation programs. Just as a flight simulator cannot duplicate the reality of piloting an aircraft, financial simulation models will never duplicate economic reality. However, they can provide investors with an opportunity to test drive asset management decisions prior to implementing them. This seems like a prudent approach to investment policy design and asset management elections.