BWM

Investment
Guidance

Investment Risk Awareness
Physical Sciences Provide a Perspective of Uncertainty

Key Points

- Physical science inquiries into uncertain issues are more detailed and complex than investment analyses
- MPT mean variance distribution inadequacy
- Added risk factor considerations

Executive Summary

Modern Portfolio Theory uses a simple normal investment risk management approach. Yet, a better insight into uncertainty and risk may be developed by considering the physical sciences over the past 350 years. They were based on a deterministic, linear model - Isaac Newton's Three Laws of Motion. Later nonlinearities and mathematical pattern concepts showed that the universe is more complex. Investment risk and uncertainty concepts are related to our current knowledge of physical sciences to consider investment theory in this BWM Letter. Independent scientific thinking is then added to standard risk/return analysis and overall investment management theory.

Overview

Investment risk analysis and management is currently based on Modern Portfolio Theory (MPT). The key papers are Harry Markowitz's *Portfolio Selection* (1952) and William Sharpe's *Capital Asset prices: A theory of market equilibrium under conditions of risk* (1964). They and Merton Miller received Nobel Laureates in Economics (1990) for the theory. Yet, the theory is difficult to apply for optimum portfolio performance, because it is essentially based on a linear view of asset transactions that require an unlikely large number of data points to be statistically useful. Linear probability distributions of asset returns or other data points are based on a normal or Gaussian distribution, named for the brilliant early 19th century mathematician and astronomer Johann Gauss. At the time, Gauss' model explained the theory of our physical world well. It was consistent with the Isaac Newton's deterministic world. However, later the concepts of chaos and nonlinearities were needed in the physical sciences to deal with uncertainties.

Evolving Physical World Theory or
How the World Works!

Warning! The discussion may seem complex. An historical sciences review may seem a bit too technical for non scientists and technicians. Yet, it is useful to follow the connection of the dots, especially mathematical concepts, to sense uncertainty in the physical as well as investment world. Truly liquid transparent markets for stocks, bonds, and commodities have been available for only about one hundred years. There were not enough prior regulated transactions in the world for efficient markets to exist and be well studied. On the other hand, a few mathematicians, astronomers, physicists, chemists, biologists, and other scientists could control their experiments and work in a world over the past four hundred years with far less noise and no rigged transactions than in markets to advance physical science theories.

Sir Isaac and an orderly world

The physical science or more specifically mechanics was developed as an organized orderly theory in the late 17th century. Copernicus postulated a sun centered (solar) planetary system at the end of the 15th century and Galileo developed an earth terrestrial gravity hypothesis in the early 17th century. These observations were an extraordinary leap forward that ancient and medieval thinkers did not make. Isaac Newton took them to the next step forward with his *Principia Mathematica* (1687) that explained the theory of terrestrial and orbital mechanics by the 3 laws of motion. The seemly deterministic theory of an orderly universe required the invention of calculus (slightly different than the Leibnitz calculus symbols used today) for a simple linear world. The second law of motion (a force acting on a body can be expressed as $F = G (m_1 \times m_2)/r^2$ where F = force, G = gravity force, m = mass, and r = radius or distance between masses) is important to many non scientists, because it is used to confirm grand planetary predictions, such as the periodic appearance of Halley's Comet. Newton realized there were problems, which may require less certain non linear solutions, such as the 3 bodies in space problem. Yet, his planetary motion theory showed extraordinary conceptual thinking and discipline. Note that Newton's insights, while Chancellor of the English Currency, were less extraordinary as an investor. He owned shares of the infamous South Seas Company, which had a monopoly charter for the South American slave trade under a treaty with Spain.

The shares were bid up more than 300% in 1720 and then crashed in price in September. Sir Isaac's South Seas Bubble Company experience showed investment uncertainties differ from physical science theory uncertainties.

The orderly physical universe models advanced throughout the 19th century. Maxwell's 4 laws of electromagnetic radiation theorized the order of the light spectrum. Experiments by Joule, Clausius, Kelvin, Fourier and others in the discipline of small gas, liquid, and solid particles developed the hypotheses that led to the 3 basic laws of thermodynamics.

Sensitivity to Initial Conditions; Nonlinearity

Henri Poincare solved the 3 bodies (in space) problem near the end of the 19th century, which alluded Newton. Consider simply locating the sun, earth, and moon in space at a specific time. Poincare postulated a 6 dimensional space to show the probability of a body in an unexpected location. In other words, he showed that the solution could be converged upon, but that instability is normal. This was a big deal for statistical science in a world of uncertainties and nonlinearities. Advances in 3 broad sciences; thermodynamics, quantum physics, and theoretical mathematics, can be observed to notice a world that is orderly, uncertain, and thus more complex than the linear concepts of MPT investment returns and risks.

Thermodynamic systems feature a dissipation of energy or as stated in the 2nd law; entropy is the unavailable system energy for conversion to work. Think of a human body consuming food, performing work, excreting waste, and finally dying when a critical function shuts down. The dissipation is part of an open system living process that is in non equilibrium and requires added input energy. Alternatively, equilibrium takes place at death when a vital physical process becomes inactive. The thermodynamic systems are based on the scientific concept of chaos; i.e. the complexity of causality in the relationship of events. The common example of a seemly insignificant catalyst of a critical chain reaction is the butterfly's flapping wings that can cause a weather change on the other side of the world. The catalyst is not part of a deterministic order and the open system is both complex and non linear. Feedback and the irreversibility of some processes (time goes one way) are the other key system concepts. A very sensitive system can be triggered into a resonating state, where little added energy is required. For example, when playing with a child on a swing, a critical push at the ideal location needs a minimum amount of energy. However, if the push is too hard, the swing ropes may not remain taut and the child may panic and let go. Investors also panic, when the expected results (e.g. Google earnings) are slightly non-linear. More specifically, high expectation assets are very sensitive to nearly unstable initial conditions.

Quantum physics since the beginning of the 20th century is a fine example of non-linearity and uncertainty. Albert Einstein presented the Special Theory of Relativity (1905), which showed mass energy equivalency $E = mc^2$ where c = the speed of light, and other important papers in a year nearly as important to physical sciences as 1687. He later presented his General Theory of Relativity (1917) that included a cosmological constant in a model behavior of the universe, added the 4th dimension of time to Newton's theory, and established the theory for stimulated emissions (the theory for the LASER). Yet Einstein had a long running debate with Neil Bohr about the uncertainty principle. Einstein believed that any randomness in physical processes reflected our ignorance, while Bohr believed there are irreducible probability distributions and that any measurement approach will impact the result. Bohr supported the Heisenberg Uncertainty Principle (1925), which stated that locating a particle in a small region of space makes the velocity of the particle uncertain or visa versa. It is also referred to as the observer or measurement effect. Quantum physics has advanced with theories and measurement insights since then; yet initial conditions, catalysts, and phase state changes are part of a non linear uncertain world.

The theoretical mathematicians also made valuable contributions to the physical sciences. They noticed aberrations in various chaotic processes and tried to determine if natural distributions are linear and Gaussian (normal). They looked for patterns that could identify and filter out noise, instead of just turning up the signal (e.g. a radio or TV volume.) Fractals (1975) are late 20th century approaches to break up (decompose) problems using an infinite number of points in recognizing randomness, as well as true patterns. Benoit Mandelbrot is generally referred to as the father of fractal geometry. While at IBM Research Labs, he solved some important phone analog transmission line problems. Everything from weather forecasting and topology to studies of DNA and growth of living organisms from embryos in specific environments to adult plants, animals, and human beings are being studied with fractals as an uncertain world functions in chaotic non-equilibrium. The key insight is that many processes are best described by power law probabilistic distributions, instead of normal (Gaussian) distributions. Similar to normal distributions, most power law events occur near the middle (mean) of the distribution, however, there are far more occurrences at the extremes (i.e. $1/2^2$, $1/2^3$, $1/2^4$, etc.) Mandelbrot also bridged the gap into the world of financial markets. In his book *The (Mis) Behavior of Markets* he states "I have been arguing for years that conventional (MPT) models aren't applicable for managing risk. Prices can and do vary enormously in a very instantaneous fashion. We have seen this happen time and time gain." Note the impact (i.e. large losses or gains) of the extreme occurrence is also considered, when analyzing risks in power law distributions.

Rethinking MPT – A different risk awareness

Modern Portfolio Theory is based on normal distributions of asset returns, volatilities (standard deviations), and correlations. Exchange traded stock, bond, and Treasury bill asset class data is well documented by Ibbotson and S&P since 1926. This historical data includes extreme periods such as the Great Depression and the Technology bubble. However, it does not include discontinuities, such as wars which bankrupted the German republic after World War I and various countries after World War II. The U.S. has fortunately grown without a major economic discontinuity in the past century. The sample size is simply too small from a scientific perspective to imply a normal distribution. Finally, the issue of short time period relevance is not considered by MPT. After periods of low inflation and extreme overconfidence, markets tend to feel a false stability. Market environments were described by Hyman Minsky in his *Financial Instability Hypothesis* (1992). He felt that markets are inherently susceptible to bouts of speculation. Long periods of stability, such as the 1980's and 1990's are built on unstable premises of low risk premiums. Assets are priced for perfection of high productivity, low inflation, and unrealistic low cost security. The world is too complex and inherently unstable for these expectations. Chaos is part of investment markets, as well as the physical world.

The concept of MPT risk should be broadened to recognize that mean-variance models change dramatically over any 10 year period. Non-linearity exists (Oct. 19, 1987, Sept. 11, 2001, etc.) and individual risk tolerances change. After a long period of market advances the portfolio assets expected return per unit risk efficient frontier line changes significantly. Units of volatility or standard deviations of returns are normally calculated from the most recent 36 months of asset returns (limited data). Portfolio asset returns are more correlated, especially during a general downturn in asset class prices, than indicated by portfolio frontier lines. Thus, total portfolio returns are more volatile and risks are higher than historic data indicates. Human behaviors of overconfidence (greed) and depression (fear) drive market asset values far from fundamental asset valuations.

Portfolio Risk Awareness Suggestions

1. Portfolio asset return/risk relationship graphs should include short term (3 yr.) and longer term (10 yr.) data sets updated annually to notice changing portfolio risk.
2. Independently estimate asset potential risks (probability and impact) with expected power law asset return distributions that recognize the impacts of outlier events.
3. Work hard to create a truly diversified (10 low correlation assets minimum) portfolio. An adequate discussion of this point requires a separate topic BWM Letter.
4. Recognize your own behaviors toward overconfidence and greed. When everything looks great (Dec. 1999?) take some profits off the table and be thankful for good luck!

Summary:

- Physical science concepts of uncertainty and complexity can be applied to portfolio risk.

References

Gribbin, John *Deep Simplicity* 2004
Mauzy, Stephen *Risk Runs Roughshod* CFA Magazine May-June 2008