THE PENNSYLVANIA STATE UNIVERSITY
SCHREYER HONORS COLLEGE

DEPARTMENT OF FINANCE

ASSET CLASS MEAN REVERSION AND THE IMPLICATIONS ON LONG TERM INVESTING

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Spring 2011

A thesis
submitted in partial fulfillment
of the requirements
for a baccalaureate degree
in Finance
with honors in Finance

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Abstract

Patterns and predictability of asset returns has always been an intensely debated topic. Some believe in the random walk theory, where successive security returns are completely independent of one another. Others believe and have found evidence of mean reverting tendencies in securities. In this paper, I look to not only review past studies to analyze prior results, but I plan to answer the very question of return predictability through empirical data.

Furthermore, I focus more specifically on how this affects the asset allocation of long term investors. With investment horizons exceeding 20 to 30 years, I plan to study how the effects of time diversification work to benefit investors willing to take on greater risk with their capital. If asset classes do indeed tend to revert to a long term mean, truly long term investors should approach asset allocation differently than those with shorter investment horizons (one to five years.)

I back test historical asset class returns and interpret the results to formulate a practical investment strategy for long term investors. I also use these historical returns to test return predictability found within three different asset classes: stocks, corporate bonds, and treasury bills. I address the question, do we find mean reverting tendencies within asset classes, and are the effects of time diversification real? If so, how should long term investors best allocate their capital to not only maximize return, but do so without taking on excessive risk?

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Acknowledgements

I would like to thank both Professor James Miles and Professor Lou Gattis in assisting me through the creation of this thesis.

Also, a special thanks goes out to my parents, Anthony and Tina. Every step of the way, they always supported, believed, and encouraged me. Their positive influences throughout my life has undoubtedly shaped me into the person I am today.

Introduction

When constructing a portfolio using some of the fundamental concepts of Modern Portfolio Theory, not many can argue the clear benefits an investor reaps by diversifying his or her portfolio. By taking note of the correlation between assets or asset classes, one can essentially work to constructively diversify away company specific risk or perhaps find the most attractive risk return tradeoff. In essence, over shorter time horizons, (1-3 years) diversification between assets classes lowers overall risk, which investors find calming. However, what I would like to explore further is just how beneficial diversification is among investors with much longer time horizons. Furthermore, in examining this, an important point is debated whether equities, or any other asset class for that matter are either mean reverting over time, or instead follow a random walk.

This topic is crucial in determining whether or not time diversification can and should be applied to real life portfolios. If asset classes are found to indeed revert to a mean over time, this should have serious implications on typical asset allocations. However, if this is found to be false, one would argue that asset returns instead follow a random walk, and yearly returns are independent of each other. In this case, investors would reap no benefit in using long term horizons as a diversification tool. After researching each respective concept, I plan to propose an investment strategy leveraging longer investment horizons to not only boost overall real returns of a given portfolio, but also at a reduced risk level. Also, when analyzing return data, I plan to examine the real return of an asset class in addition to nominal return. I want to show how inflation poses an enormous risk for the purchasing power of an investment, especially when investing in a fixed income asset class.

In exploring this topic, I would like to be lucid and point out the time horizons that I plan to focus on. I want to find the best possible strategic portfolio allocation for a young person investing for retirement, with an expected investment horizon over thirty years. The asset class selection will be broad - consisting of equities, bonds, and treasuries. I believe the risks and implications of different horizons are vastly underestimated. I will start by explaining some of the basics of Modern Portfolio Theory, the concept of risk, and short and long term returns. Afterwards, I will talk about various elements that long term investors should be cognizant of when making asset allocation decisions that may appear to defy some of the fundamental concepts of Modern Portfolio Theory. Furthermore, risk and asset return variability will be looked at not on an annual basis, but over longer time frame increments. Conventional knowledge and theory tend to overstate risk, especially when examining time horizons of thirty-plus years. What people fail to take into account are the mean reverting tendencies of asset classes and the effects of time diversification.

PART 1: Overview of Past Studies

1.1 Random Walk Theory vs Mean Reversion

When constructing a portfolio consisting of equities, bonds, and treasuries, I believe there is a clear and distinct misunderstanding when measuring the risk of a portfolio. Often, one year standard deviations are used in models to gauge the level of risk of a given asset class. I believe for long term investors in particular, this is not only inappropriate, but very misleading. Deviations should be taken from time periods of much greater length in order to better measure actual risk. If one plans to hold an asset for 30 or more years, what good is it to measure deviations in yearly terms? Are stock returns indeed less risky in the long run because of this phenomenon of time diversification? In the 8th edition of "Essentials of Investments" by Bodie, Kane, and Marcus, they don't think so (Bodie, Kane, & Marcus, 2010). They first explain mathematically how the concept of time diversification can be proven, then follow by attempting to reveal its flaws. On the surface, it appears stocks do indeed look less risky over the long run after reviewing the math. The variance and standard deviation of the total return over *n* years, generalizing to an investment horizon of *n* years, they prove will grow to:

Var(*n*-year total return) = $n\sigma^2$

(Equation 1)

Standard deviation (*n*-year total return) = $\sigma\sqrt{n}$

(Equation 2)

To put standard deviation of total return on a per-year or annualized basis, standard deviation is divided by the number of years to obtain:

σ (an annualized standard deviation for an n-year investment) = $\frac{1}{n}\sigma\sqrt{n} = \frac{\sigma}{\sqrt{n}}$

The evidence above may lead one to believe that risk does indeed decline as years, *n*, increase. However, Bodie, Kane, and Marcus beg to differ and argue that this logic is flawed. The flaw lies mainly in the use of the annualized standard deviation to measure the risk of long-term investments. Annualized standard deviation is an appropriate measure of risk, only when measuring annual horizon portfolios – it cannot stand to measure risk of portfolios with different length and scale. To illustrate this point, they describe a scenario and use the possible outcomes as evidence against time diversification[1]. In examining probabilities of different outcomes, they believe the correct comparison is based on risk of a given total (end of horizon) return, which accounts for magnitude and probabilities of possible losses.[2] Thus, the variance of the total rate of return grows in direct proportion to the number of years, and the standard deviation grows likewise to $\sqrt{n}$, as in Equation 1. Risk compounds for a greater number of years, despite the fact that average risk may be smaller with longer horizons, as shown in Equation 2, making your cumulative outcome riskier.

However, the premise of their explanation and example is based on one very critical assumption: successive yearly stock returns are uncorrelated and independent. If the returns on any particular asset class were given a probability in the same way of a coin flip, then I believe this logic is flawed and warrants debate. If successive stock returns were indeed independent of

[1] Their example consists of a situation in which investors can invest in safe bonds, which return zero, and the value of a stock portfolio in any year either doubles or falls by one-half with equal probability. Also, the second option is short-term risky strategy that invests the entire budget in stocks for one year, then liquidates and invests the proceeds in a safe bond in year two. The long-term risky strategy invests the entire budget in stocks for two years.

[2]

A. One Year in Stocks		**B. Two Years in Stocks**	
Possible Outcome	**Probability**	**Possible Outcome**	**Probability**
Value doubles	.5	Value quadruples	.25
Value falls by half	.5	Value unchanged	.5
		Value falls 75%	.25

each other, the example detailed above may have a legitimate case; the fact of the matter stands, this all depends if you believe stocks follow a random walk, or revert to a mean over time. Later in the paper I examine this issue using empirical evidence – for the time being however, I will observe and review studies done prior to this in support of both the random walk theory, and those who believe in mean reverting tendencies.

What is the random walk theory and what are its implications on modeling overall portfolio returns and risk? The concept of stock prices following a random walk was explored extensively by Eugene Fama in "The Behavior of Stock Market Prices" (Fama E. F., 1965). The purpose of his paper was to not only discuss the theory underlying the random walk model, but to test the model's empirical validity as well.

He points out that the theory of random walks in stock prices involves two separate hypotheses: (1) successive price changes are independent, and (2) the price changes conform to some probability distribution. When he speaks of independence, he refers to this as probability distribution for the price change during time period *t* being independent of a *sequence* of changes in price during previous periods of time. Despite his belief in this theory, he does admit how perfect independence most likely does not exist; instead, he wanted to find dependence in a series of successive price changes to not be above some "minimum acceptable" level. This level of course is subject to opinion and interpretation. However, on a tick by tick basis, changes in prices, he states, may in fact just be randomly generated "noise." This creates opportunities for many different kinds of investors looking to either buy or sell a given security relative to what they see as the intrinsic value. As new information is received and digested, that very same intrinsic value may also be constantly changing. Assuming markets are efficient, one would then be led to believe that price changes would occur instantaneously to fully reflect the new information, which in itself is random and unexpected.

On the contrary, suppose that this same noise generating process we see is dependent. The idea here is as someone steps into the market, hoping to take advantage of a mispriced security, others may follow and thus attract a crowd. With the assumption that many sophisticated traders are participating in this event, one would be hard-pressed to believe these same traders will choose to "follow the crowd." Disciplined traders will notice these run-ups and sell-offs and eliminate these dependencies by selling an overpriced security and buying an underpriced one[3]. That brings us back to what alters a security's intrinsic value – and that is new information, which again we point out is random in itself.

In Fama's paper, the data used consisted of daily prices for each of the thirty stocks in the Dow-Jones Industrial Average. Despite findings that point strongly in favor of the random walk theory, this should not be confused with the study conducted in this paper. Fama's paper is targeted more toward daily, minute-by-minute, second-by-second fluctuations and technical aspects of security analysis, rather than long term fundamental trends. It is almost impossible to argue his findings; however in the context of this paper, his work does not warrant the dismissal of the mean reversion theory. To show this, over very prolonged periods of time[4], much greater factors play into the changes seen in stock prices – these being large scale demographic trends and shifts, technological advances, crisis, long lasting effects of natural disasters, and other broad based shifts in market fundamentals. When comparing these advances and setbacks to simple,

[3] Fama notes that even though he is vague about the certainty of intrinsic values, as long as traders have sufficient resources, their actions will tend to erase dependencies and make actual prices closer to their intrinsic values
[4] When referring to a prolonged period of time, I am speaking of horizons exceeding 30 years

sporadic daily events talked about by Fama, they appear minuscule in the grand scheme of the secular trends that can unfold over prolonged periods of time.

Min Deng provides copious insight not only into generic flaws of the random walk theory, but does so by directly criticizing Fama's findings (Deng, 2007). He first makes an interesting point dealing with the common comparison of stock price movements to other random probability occurrences, such as throwing a dice or flipping a coin. While such instances lack particular meaning in the world, whether it be present or future, stock prices fluctuate with a purpose. Behind each tick of a stock, lies a fundamental story that needs years, perhaps even decades to come to fruition. Furthermore, stock price fluctuations contain prospect values of an investment community. Deng argues that "any random time sequences or emulated stock price sequence cannot embody the elements of investor prospect values and the investor community's collective aspirations." Consequently, any random time sequences or emulated stock price sequences is not fit for describing or approximating the stock price historical sequences[5]." If one concurs with this idea, it would put a dent into the foundation of Fama's early work on the random walk model.

Moreover, Deng states yet another flaw in the reasoning of random walk theorists. They think of stock price movements to be comparable to digits in a game of roulette – they lack memory, rhyme, or reason. With this logic, stock price movements follow no rules at all; it is simply a casino. In reality, stocks prices tend to rise over time with an ultimate goal of growth and prosperity. Although this is not always the case, simply look at a chart of the S&P 500 during the 21st century and immediately notice the upward trajectory. This market is constantly

[5] Deng, M. (2007). Death of the Efficient Market Hypothesis. *20th Australasian Finance & Banking Conference* , 24.

changing and evolving towards prosperity and growth for investors; it does not exist in a vacuum.

To build off this point, Deng discusses the fatal flaws in some of the famous studies conducted by Bachiler, Osborne, and Fama. "They are all engaged only in studying the statistical behavior of the stock price to the total neglect of the three principal elements, viz. direction of the stock price movement (rise and fall), the magnitude of the stock price movement, and the unit of time of the stock price movement[6]." Despite the downfalls, many scholars hoped to formulate a model that accurately reflected and interpreted stock price behavior. Standard statistical techniques were used in attempt to fully validate the findings and prove the random walk theory.

Despite these findings, there lies one unshakable assumption that leaves much to be desired: in order to apply the standard statistical techniques to the analysis of the time sequence of a stock price, one must first assume that the behavior of the time sequence of a stock price has the same statistical nature as the behavior of a random time sequence. As mentioned in a prior point, it may not be fair to label stock fluctuations as a completely random event, especially over longer periods of time. Taking this thought to an extreme, this would imply that stock returns over time should effectively return 0% forever, given magnitude of change stays constant. According to Deng however, magnitude of stock price change was an aspect of past studies that went undocumented. Nevertheless, past studies have been conducted in support of equity mean reversion, and I will also share my findings later in the paper.

[6] Deng, M. (2007). Death of the Efficient Market Hypothesis. *20th Australasian Finance & Banking Conference* , 25.

1.2 Factor variables effect on subsequent returns

In some instances, theorists argue and empirically test whether specific variables or parameters have any effect or correlation with subsequent equity returns. This topic is frequently discussed and well documented by many in the field. The work of Campbell (1990) uses the change in expected future dividends and expected future returns to explain future unexpected stock returns (Campbell, A Variance Decomposition for Stock Returns, 1990). His dataset includes U.S. monthly values on the New York Stock Exchange value-weighted index from 1927-88; and he estimates specifically that a 1% increase in expected return is associated with a capital loss of 4 or 5%. Furthermore, increases in future expected cash flow tends to be associated with decreases in future expected returns. Campbell notes how this finding is strikingly similar to an "overreaction to fundamentals" that Cambell and Kyle note earlier in "Smart Money, Noise Trading, and Stock Price Behavior" (Campbell & Kyle, Smart Money, Noise Trading, and Stock Price Behavior, 1988).

The tests I plan to run may not be quite similar to that of Campbell in a couple of ways. First, the data set I plan to use contains monthly stock returns dating all the way back to 1871. This, in conjunction with a different method of calculation may shed new light on the topic. Nevertheless, Campbell's work does indeed reveal correlations and patterns among stock returns.

Even more recently, extensive studies have been conducted in attempt to solidify prior conventional tests of stock return predictability[7]. Campbell and Yogo (2005) developed a pretest in order to determine whether the conventional *t-test* leads to invalid inferences and also developed an efficient test of predictability that corrects this problem. In their paper, despite

[7] See Campbell, J. Y., & Yogo, M. (2005). Efficient Tests of Stock Return Predictability. *Journal of Financial Economics*

coming across new challenges, they do indeed find evidence for predictability yet again. As predictor variables, the dividend-price ratio, earnings-price ratio, and even measures of interest rates were highly persistent. On the whole, their "results suggest that there is a predicable component in returns, but one that is difficult to detect without careful use of efficient statistical tests" (Campbell & Yogo, Efficient Tests of Stock Return Predictability, 2005). These findings bode extremely well for the mean reverting school of thought, revealing almost irrefutable empirical evidence. Although these results do not directly prove how overall risk level of stock holdings generally decrease over holding periods, this is a step in the right direction.

Critical assumptions of mean reverting tendencies of equities should then have material implications on asset allocation decisions. Equally important in market timing decisions are predictor variables, such as price-to-earnings ratio and dividend yield. Research in support of these variables as viable predictors of future stock returns boost conviction and validity that stock returns are not independent of each other.

For the sake of this paper at least, one of the most important and crucial areas of focus lies within the evidence of variability (or lack thereof) and predictability of equity returns over long time horizons. As stated numerous times in this paper, arguments for and against mean reversion have been duly noted and documented by many sources; however, Cochrane (1999) sheds a new light on prior shortcomings, and introduces a "revolution in the way financial economists understand the world around us" (Cochrane, June 1999).

Cochrane argued of three main pillars of the investment world acting as the backbone to financial theory, up until about a quarter of a century ago. The first proclaims the capital asset pricing model (CAPM) as a solid measure of risk, and therefore explained different levels of returns for different assets. CAPM incorporates beta as a determining factor in the expected return of a given asset[8]. The second pillar is the assumption of unpredictability in returns – again comparing returns to a coin flip. This is another way of saying stock returns follow a random walk, and expected future returns will for the most part be about the same. Cochrane also talks about this unpredictability with bond returns, foreign exchange, and stock market volatility. The third and final pillar states how professional money managers do not consistently outperform index and passively managed portfolios, once corrected for risk. Another supporter of this theory, Burton Malkiel, (Malkiel, 2007) shows through his empirical findings how investors are best off invested passively through lower fee index funds[9]. These views are essentially an extension of the work of Fama in 1970 and 1991 about asset markets being informational efficient.

Despite these past studies and findings, Cochrane's paper dealt with how these prior "pillars" have changed, and how the dynamics of the investment world have changed over time to tell us something different. The three pillars are a result of three decades of carful and meticulous work. However, after a new wave of empirical studies and research, Cochrane argues how status quo has changed, and it should "enlarge our view of what activities provide rewards for holding risks, [challenging] our economic understanding of those risk premia."

According to Cochrane, we understand now the existence of assets, portfolios, funds, and strategies whose average returns aren't explained by their beta[10]. More importantly and relevant as it pertains to this paper, he states how returns actually *are* predictable. Certain predicting

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[8] Capital Asset Pricing Model (CAPM) = Risk-free rate +Beta*(Market risk premium) where the market risk premium is the expected return of the market minus the risk free rate

[9] For more information on this topic, see Malkiel, Burton Gordon. *A Random Walk down Wall Street: the Time-tested Strategy for Successful Investing*. New York: W.W. Norton, 2007. Print.

[10] Beta is the relationship between the return of an asset class with the broader market as a whole

factors such as dividend/price ratio and term premium can tell us considerable amounts about stock return variation. To be clear, similar to the argument I make earlier in this paper, this phenomenon occurs over longer time horizons; not daily, weekly, or monthly returns. These shorter time horizons still remain very unpredictable – technical analysis is also inadequate as any kind of predictor. Furthermore, he states how bond returns and foreign exchange are now predictable, and stock market volatility does change through time. Thirdly, outperformance is seen in some funds – multifactor controls explain most fund persistence[11]. The views stated above summarize a cornucopia of empirical work[12].

Cochrane did go into the topic most relevant to this paper though: predictability of stock returns. "It now turns out that average returns on the markets and individual securities *do* vary over time, and that stocks are *not* random walks; hence, returns are predictable." This is seen mainly over long horizons, and also is associated with business cycles. To prove this, he showed how low prices, relative to dividends, book value, earnings, sales or other divisors, are a good predictor of subsequent returns. His regressions reveal negative slopes and r-squared values that increase with horizon[13]. The chart in footnote 13 implies that the predictability of stock returns is seen to essentially "add up" over time with the given sample. To put this in perspective, Cochrane illustrates a simple, easy to understand analogy. We can predict that the temperature in a given city will rise ½ degree per day in the spring. This may not exactly predict the precise

[11] He found that funds earn persistent returns by following fairly mechanical styles, not by stock selection skill
[12] For a more in-depth look at the foundation of these findings, see the rest of Cochrane's paper (1999)
[13] OLS regressions of excess returns (value-weighted NYSE – treasury bill rate) on VW price-dividend ratios

Horizon *k*	***b***	**σ *(b)***	**R^2**
1 year	-1.04	(0.33)	0.17
2 years	-2.04	(0.66)	0.26
3 years	-2.84	(0.88)	0.38
5 years	-6.22	(1.24)	0.59

Sample 1947-1996. Source: Cochrane (1997) day-to-day change, but it does account for the entire rise in temperature from January to July. It may be difficult to measure the exact daily change with great accuracy, but it may not be relevant if all that matters is the general rise seen over time. You can see this as the r-squared value increases with horizon; validating results further. This study tells us how using a factor variable, such as price-dividend ratio, can give us hints as to which direction subsequent returns may go.

In further support of equity return predictability, Fama and French conducted an in-depth study on expected stock and bond returns showing an undeniable term or risk premium related to long term aspects of the business-cycle[14] (Fama & French, 1989). As discussed earlier in this paper, by implying stock market returns are predictable, that supports the notion that prior year returns, or even particular indicating variables can give us insight on what subsequent returns may look like. Fama and French use empirical evidence and try to find a connection between stock and bond returns and business conditions. To gauge business conditions, they use three factors: dividend yield, default spread, and term spread[15]. Ultimately, although their findings may have seemed quite trivial at the time, the results tell us yet again something very important about asset class tendencies. Amidst recessions and economic downturns, with current equity returns very low, they found subsequent stock and bond returns to be very high. Realizing how three variables effectively forecast stock and bond returns suggests that implied variation in expected returns are very common across securities.

1.3 Empirical evidence in support of mean reverting tendencies

One of the largest advocates of mean reverting tendencies of different asset classes is Jeremy Siegel. He explains in great detail not only his argument in support of mean reversion,

[14] For example, returns are seen to be low during business cycle peaks and high near toughs.
[15] Dividend yield is commonly used to forecast stock returns. The default spread is the difference between the yield on a market portfolio of corporate bonds and the yield on Aaa bonds. The term spread is the difference between the Aaa yield and the one-month bill rate.

but he also compliments this with ample data and empirical evidence dating back from 1802. In his book, “Stocks for the Long Run,” Siegel goes as far as saying equities are *the* best investment choice for a long term investor (Siegel, 2008). He presents his data in a manner that makes aggressive asset allocation extremely appealing to the long term investor[16].

I plan to ultimately make a similar argument as Mr. Siegel. Empirically, he makes a case for equities behaving in a less volatile manner than corporate bonds and t-bills over longer periods of time. I hope not only to show this, but extend the returns of these particular asset classes into real returns, in addition to nominal returns. In taking account for real returns, as opposed to just nominal returns, I hope to reveal flaws in the fixed income investments that unveil close to negligible real returns[17]. Especially in the context of this paper, it is vital for investors to be cognizant of the purchasing power of their investments over long periods of time. To illustrate this point, in Siegel’s book, he shows how $1 in currency in 1802 turned into about $0.06 by 2001. On the other hand, $1 invested in stocks eventually grew to $755,163 by 2001[18]. This may seem like an extreme example, but realizing how inflation slowly erodes the purchasing power of a dollar means a lot when it comes to one’s personal investments. Nevertheless, I hope to build upon Siegel’s work to validate and reaffirm the aggressive asset allocation needs of long term investors.

[16] Refer to page 34 of “Stocks for the Long Run” (Siegel 2008)
[17] Real return = nominal return - inflation, or (1+nominal rate)/(1+inflation rate)-1
[18] For a more detailed illustration, see page 11 of “Stocks for the Long Run” (Siegel 2008)

PART 2: The Analysis

2.1 Data

The dataset used in this paper was a combination of data collected by Robert J. Shiller and from Ibbotson SBBI 2010 Valuation Yearbook[19]. Robert Shiller provides monthly data dating back to January 1871 that includes S&P 500 levels, dividends, earnings, consumer price index, and the 10-year treasury yield. I believe using the S&P 500 would yield the most accurate and comprehensive results as the index not only consists of a wide array of equities, but is also one of the most common indices used as a benchmark. In addition to that, I assumed this benchmark would be most useful for the average retail investor to relate to. Gaining broad equity exposure through an S&P 500 ETF (Exchange Traded Fund) is simple and can be added to any portfolio quite easily. Furthermore, with data dating back to 1871, the set was analyzed not only as a whole, but in individual parts as well. This was done to closely examine perhaps different trends or patterns seen in different time periods.

Aside from S&P 500 index levels, which measures the returns by means of capital gains, returns from dividends were also included to provide a total investor return. With both capital gain and total return data, monthly returns were calculated geometrically[20]. To be specific, the geometric returns were calculated as follows, assuming the geometric value for time period, t_0 = 1 and the Equation 3 is applied recursively:

Equation 3

$Geomtric\ value\ period\ t_1 = \ Geometric\ value\ period\ t_0 * (1 + \ return\ in\ t_1)$,

$Geomtric\ value\ period\ t_2 = \ Geometric\ value\ period\ t_1 * (1 + \ return\ in\ t_2)$, ect.

[19] Shiller data can be found on his website: http://www.econ.yale.edu/~shiller/data.htm

[20] The main benefit to using geometric returns is that the actual amount invested need not to be known; this calculation focuses entirely on the returns figures and present the information in an “apples-to-apples” comparison

To find one, five, ten, twenty, and thirty year returns, the appropriate geometric values were divided based on the time period. For example, to calculate one year returns, the geometric value for period t+12 was divided by geometric value t, period t+13 was divided by period t+1, ect. The twelve periods of separation represent each month of a one year period. The same principle was applied to the calculation of all other investment horizons[21].

Given the simple methods of calculation described above, this gave me nominal returns for one, five, ten, twenty, and thirty year time periods. To sharpen my results even further, I combined the nominal return data with the CPI data provided by Shiller to include the real returns of both capital gains and total return (capital gain plus dividends.) By using the Fisher equation, the real returns were calculated to provide this paper with more practical and useful results; as they can be applied and examined to actual portfolio construction[22].

Moreover, despite gathering equity data dating back to 1871, this paper only includes t-bill and corporate bond data starting in January of 1926. The source of this data was the Ibbotson SBBI 2010 Valuation Yearbook (Morningstar, Inc, 2010). In the context of this paper, I wanted to stay as broad as possible in my asset class selection to best represent the differences seen over time in both return and risk. Therefore, I chose "Long-Term Corporate Bonds" and "U.S. Treasury Bill" returns. As described by Ibbotson, the corporate bond data series construction consists of the total return of long-term high grade debt as well as the corporate bond index with an approximate maturity of 20 years. Also, the U.S. t-bill data series construction consists of the total return of a one-bill portfolio with an approximate maturity of 30 days.

[21] Data calculated from five, ten, twenty, and thirty year time horizons were all annualized

[22] Fisher's equation states the following: $(1+i) = (1+r)(1+\pi)$, where i = nominal return, r = real return, and π = inflation rate

With monthly data dating back to 1926, both real and nominal returns were calculated in the same manner as the Shiller S&P 500 data. Also similar to the Shiller data, results were broken down into definable time periods after 1926 to better examine and analyze trends and patterns of risk and returns.

Finally, the annual return data from the Ibbotson SBBI 2010 Valuation Yearbook was used to run regressions on all three asset classes. Year by year returns were regressed as well as two, five, ten, twenty, and thirty year trailing averages.

2.2 Results and Interpretation

A major question asked throughout the course of this paper dealt directly with whether asset classes exhibited either mean reverting tendencies, or instead had the propensity to follow a random walk. I presented both sides of the argument and supported these sides with papers written in the past, claiming to find evidence of both.

2.2.1 Regression

In dealing with the issue of mean reversion, one must assume that if stocks do indeed revert to a long term mean, future year returns should be predictable to a certain extent. For example, if past stock returns are seen to be substantially below the long term average, one would expect subsequent stock returns to be above average – this is due to the tendency of returns to mean revert. Think of it almost as gravity; no matter how high you jump, there will always be a force bringing you back down to earth. In the same way, there should always be a subtle force pulling returns back to the long term average. If instead you believe stocks follow a random walk, then each year's return should be completely unrelated to one another. A large spike or drop in stock prices should have no bearing on what future returns may look like. Just because the market rallied substantially in one year should not make it any more likely that we see a drop the next year.

Therefore, in a mean reverting world, past returns should be able to partially explain future returns. To test this, I ran regressions on return data from stocks, bonds, and t-bills[23]. Negative slopes would indicate mean reverting tendencies, and r-squared values would help determine the conviction of the results. In Fama's early work in "The Behavior of Stock Market Prices" (Fama E. F., 1965), as described earlier in this paper, Fama's main objective was to determine stock market predictability over relatively short periods of time (time frames of days or weeks.) My study on the other hand, tests predictability regressing prior year's return, as well as 2, 5, 10, 20, and 30-year trailing averages. Regressing returns as the *y* variable, and prior year returns/trailing averages as the *x* variable, I was able to develop a comprehensive dataset.

Table 1

		Trailing 1 year	2-year trailing average	5-year trailing average	10-year trailing average	20-year trailing average	30-year trailing average
Stocks	Slope	0.01750	(0.13134)	(0.45589)	0.12964	(1.07116)	(5.92146)
	R-Squared	0.00031	0.00890	0.03318	0.00124	0.03445	0.18992
Bonds	Slope	0.05918	0.19476	0.29611	0.57649	0.53786	0.36437
	R-Squared	0.00348	0.02001	0.02445	0.06442	0.04064	0.01144
T-bills	Slope	0.91474	0.89697	0.89699	0.86390	0.59032	0.09848
	R-Squared	0.82366	0.74864	0.66360	0.58378	0.25881	0.00585

As seen in Table 1, the results were very underwhelming for the support of mean reversion within asset classes, generally speaking. Corporate bonds and t-bills especially showed very little evidence of mean reverting tendencies. Although the severity of the slope weakened as larger time frames were used, this still does not demonstrate mean reversion within these specific asset classes.

[23] Data was taken from Ibbotson SBBI (Morningstar, Inc, 2010) for stocks, bonds, t-bills. Returns were annual figures from 1926 to 2010. Equity data was taken from "Large Common Stocks" returns.

The most interesting of results were seen within stocks, which as it pertains to this paper, provided some promising data. With 2,5,20, and 30-year trailing average data showing negative slopes relative to base year returns, this bodes positively for the case of mean reversion. Most importantly though, note the slope and r-squared values for the 30-year trailing average. This relatively large negative slope value is exactly what we were looking for in these results. The main question and argument in this paper dealt specifically with the asset allocation issues of longer term investors – and if time diversification was a useful tool within their long term investments. With a slope of -5.92146 and a r-squared value of 0.18992, this is the diamond in the rough among an otherwise lackluster group of results.

Moreover, aside from regressing prior year returns to seek mean reverting tendencies within asset classes, I will try to find clues among historical returns and empirical data in search for mean reversion among asset classes.

2.2.2 Returns

It will be crucial to look at the empirical results found within the data. The stock, bond, and t-bill data should be examined very closely as they can provide us with clues as to how each asset class behaves not only in the short term, but over extended periods of time. More importantly, I plan to pay very close attention to how they perform on a stand-alone basis as well relative to each other.

Stepping back and observing the bigger picture sometimes can put very complex ideas into an easy-to-understand perspective. Let’s first look at how a $1 investment has performed since 1926 if invested in each respective asset class; those being stocks, bonds, and t-bills.

Figure 1

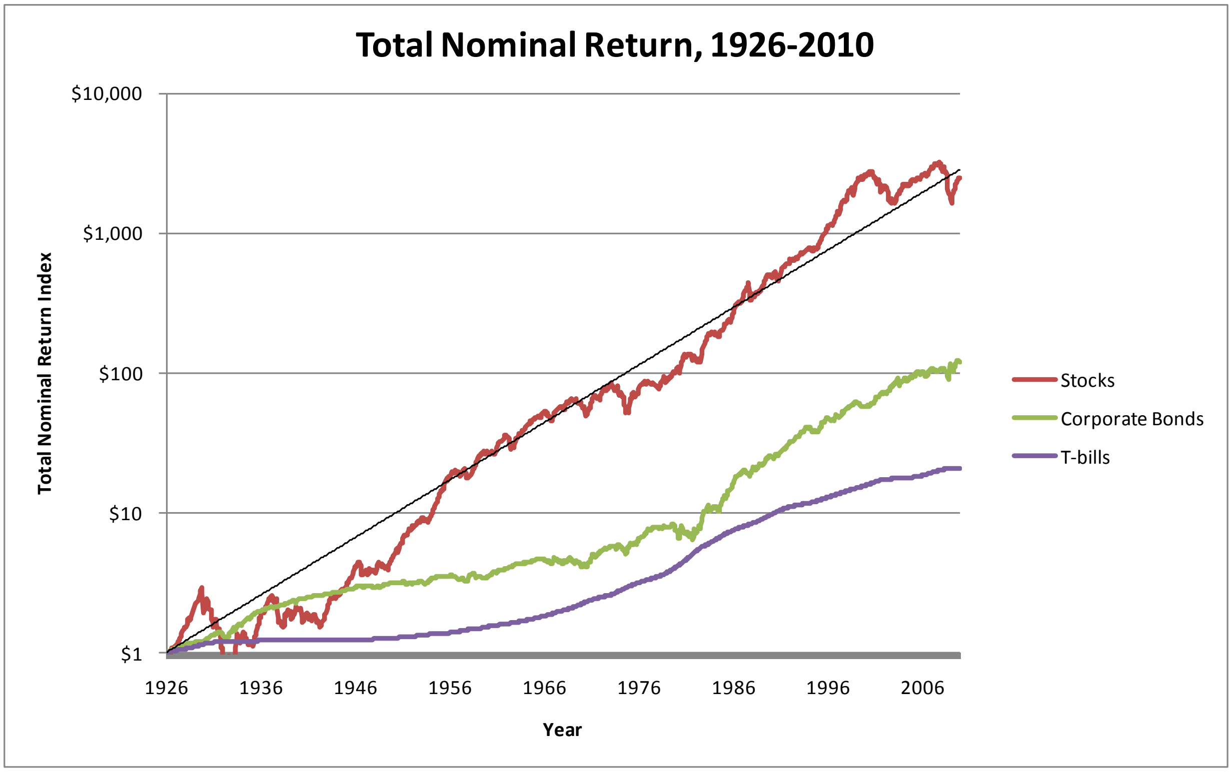
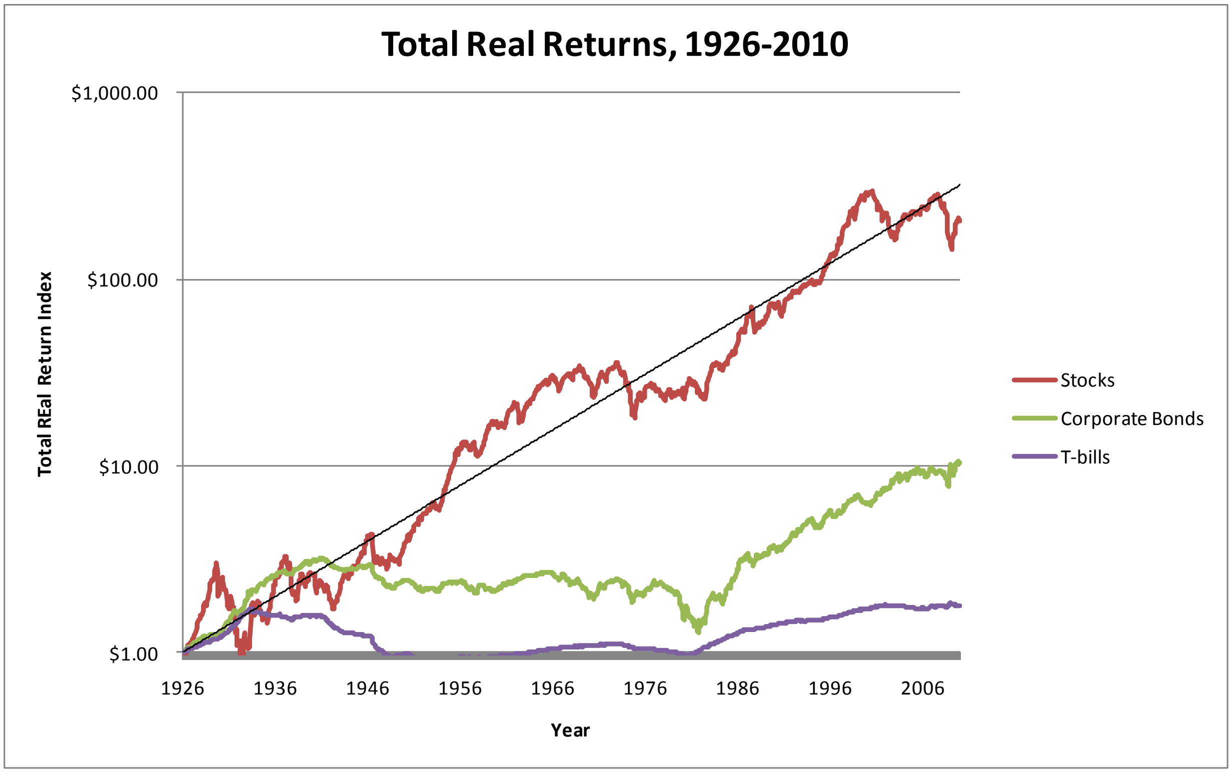


Figure 2



As seen in Figure 1, bonds and t-bills do not come even remotely close to the performance of stocks. If you invested $1 in the year 1926, you would have turned that single dollar into $2,487.29 by 2010. That compares to $199.50 for corporate bonds and a meager $20.91 for t-bills. Why is this important you might ask? As stated earlier in this paper, the ultimate question needed to be answered is what is one's best asset allocation choice if investing purely for the long term? If taken in the most extreme sense, Figure 1 clearly shows the power of equities over both bonds and t-bills.

Let us not be fooled by the inflating nature nominal returns have on your return on investment. What I mean by this is by looking solely at nominal returns, the figures will sometimes vastly overstate the real purchasing power of your dollars. Examining real returns as opposed to nominal returns is one of the most important issues in evaluating the success of an investment. As shown in Figure 2, when looking at the real purchasing power of a $1 investment in 1926, the result is much different. In the grand scheme, stocks still easily beat out bonds and t-bills, but in real terms, the investment shows how nominal values can overstate actual return. A single dollar invested in stocks in 1926 turns into $213.00 by 2010; that compares to $10.27 for bonds, and a paltry $1.80 for t-bills.

Another important point to observe from both Figure 1 and 2 is the solid and robust upward trajectory of equity returns over the past eight decades. This idea will become very relevant when dealing with the issue of long term returns. Some retail investors spend ample time trying to "time the market" or wait for an equity index correction to invest capital, looking for a "bargain" price. For most long term investors with horizons over 30 years, this appears to be unimportant as the upward trajectory in stock market prices thrust in the upward direction. Even the sharpest of market crashes or corrections exist as mere blips on Figures 1 and 2.

On a similar note, breaking down returns and standard deviation can tell us a lot about certain time periods, market patterns, or specific cyclical trends. I found it most helpful to break down returns into specific and relevant time periods in American history, much like Jeremy Siegel does in "Stocks for the Long Run." This allows for the observation of different risk and return profiles for different time periods.

Table 2

Annualized Equity Returns and Risk from 1871-2010							
		Capital Gains			Total Return (Capital Gains + Dividends)		
		Real Return	Nominal Return	St. Dev	Real Return	Nominal Return	St. Dev
Major Periods	1871-2010	3.82%	5.80%	18.94%	8.52%	10.57%	19.51%
	1871-1925	2.22%	2.43%	15.58%	7.70%	7.90%	15.96%
Postwar periods	1926-2010	4.81%	7.88%	20.46%	9.03%	12.22%	21.25%
	1946-2010	4.63%	7.69%	20.51%	8.82%	12.01%	21.28%
	1946-1965	6.62%	8.21%	24.01%	11.92%	13.58%	24.90%
	1966-1981	-3.04%	3.42%	14.25%	0.76%	7.49%	14.90%
	1982-1999	11.13%	14.80%	14.40%	14.69%	18.49%	14.59%
	2000-2010	-2.14%	0.35%	18.85%	-0.39%	2.14%	19.17%

As seen in Table 2, equity returns are broken down into numerous time periods and measured in both real and nominal terms. In addition to that, standard deviations of nominal returns were duly accounted for – this will become especially relevant when dealing with portfolio construction. Not only do investor's care to maximize their return, but they want to do so in a way that minimizes risk level. What strikes me most about this data collected was the consistency of real total returns over almost 140 years. With a long term real return of 8.52% since 1871, both pre and post 1926 data showed averages very close to the long term mean. This is remarkable consistency and speaks volumes about how reliable stocks have been over extended periods of time. Notice the spike in standard deviation when shifting from 1871-1925 to the 1926-2010 period. With a gradual increase in market participants, market knowledge, and data transparency, it does not come as a surprise to see this increase in subsequent market risk.

Breaking down the postwar periods may look worrisome to most though. The inconsistency of returns and spikes in volatility seem alarming at first; however, later in the paper, we'll break down the data even further to ease most concerns. It also becomes very evident just exactly how important dividends are in the total return of an investment. Reinvesting dividends has a tremendous compounding effect and works wonders in boosting overall returns. This becomes apparent when observing and comparing capital gains with total returns.

Table 3

Annualized Fixed Income Returns and Risk from 1926-2010							
		T-Bills			Long Term Corporate Bonds		
		Real Return	Nominal Return	St. Dev	Real Return	Nominal Return	St. Dev
	1926-2010	0.76%	3.75%	3.06%	3.18%	6.14%	8.67%
Postwar periods	1946-2010	0.63%	4.55%	2.96%	10.29%	6.30%	9.55%
	1946-1965	-0.79%	1.88%	0.99%	-0.18%	2.51%	4.01%
	1966-1981	-0.22%	6.51%	2.49%	-3.49%	2.93%	8.37%
	1982-1999	3.00%	6.57%	2.51%	9.44%	13.17%	11.51%
	2000-2010	0.57%	3.16%	1.78%	4.46%	6.88%	8.26%

When comparing the returns on fixed income securities to equities, bond returns look very lackluster through history[24]. With data on t-bills and long term corporate bonds, seen in Table 3, dating back to 1926, t-bills have only managed barely a positive real return at 0.76%. Long term corporate bonds managed a return a few percentage points higher at 3.18%. At first glance, observing the nominal returns of these asset classes makes these securities seem like viable investment options, especially given the relatively muted risk. However, as mentioned

[24] Standard deviations are for nominal returns

before in this paper, investors should be concerned most about the purchasing power of their investment through time, taking into account the eroding effects inflation has on nominal returns. This is especially true for t-bills – with returns so low, investors are at huge risk of negative real returns.

The most important takeaways from this section should be the pure dominance of equities relative to bonds and t-bills throughout history, and the impact inflation has on eroding purchasing power through time.

2.2.3 Risk, Return for various holding periods

In answering the question of optimal asset allocation over various holding periods, it will be important to look back into history and recognize how our asset classes actually performed over one, five, ten, twenty, and thirty year time frames. If the past is any indication of the future, there are some very compelling arguments in favor of equities.

There are many ways to present historical returns over various holding periods, but one of most popular methods is portraying returns in a worst-case/best-case scenario. This not only puts asset class returns into perspective, but also allows one to analyze the risk profiles and how they change over time.

As seen in Figure 3 and 4, maximum and minimum real returns are graphed in a comprehensive manner, allowing one to compare the three asset classes. Unsurprisingly, stocks show the most volatility in one and five-year time horizons relative to both bonds and t-bills. This is to be expected, as equities pose as the riskiest asset of the three. However, one cannot help but notice the effect time has on maximum and minimum returns for stocks, bonds, and t-bills. In Figure 3, stocks remain the dominant asset class in every time frame through 30 years.

Figure 3

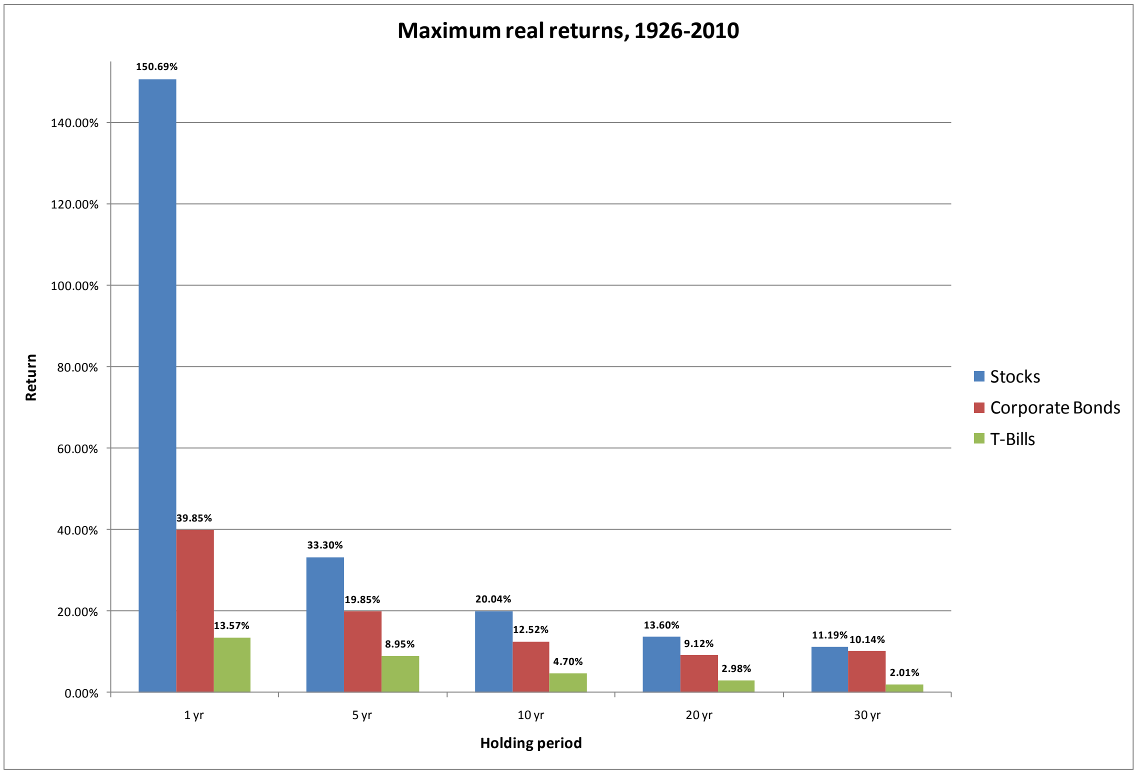
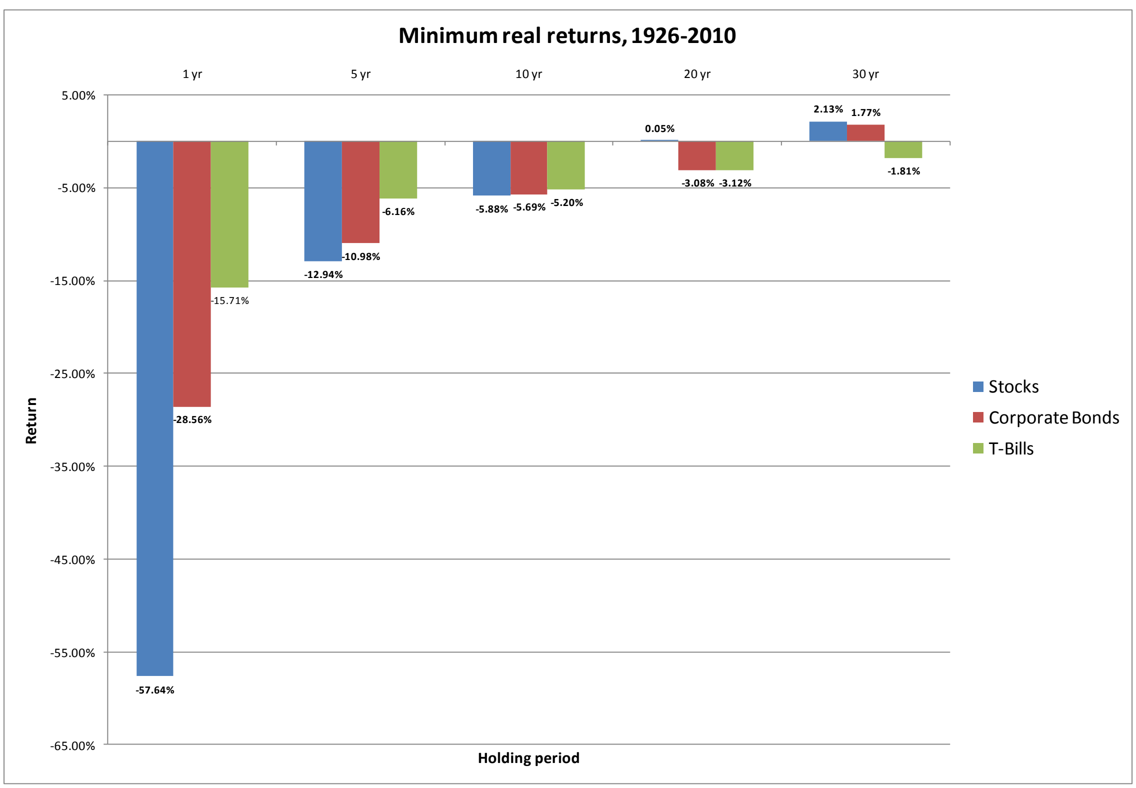


Figure 4



Moreover, Figure 4 shows the most interesting results. Through one and five years, stocks show the lowest minimum returns – yet, as we progress to 10, 20, and 30 years, the picture changes. Through every 10-year period since 1926, the minimum real return for stocks actually rivals that of bonds and t-bills. The lowest return for stocks was -5.88%, while bonds and t-bills returned -5.69% and -5.20% respectively. The argument for stocks as a long term investment gets even stronger when looking at 20 and 30-year time frames. Over every 20 and 30-year time period since 1926, the minimum real return for stocks has outpaced both bonds and t-bills. The minimum return seen for t-bills over a 30-year holding period is not even in positive territory.

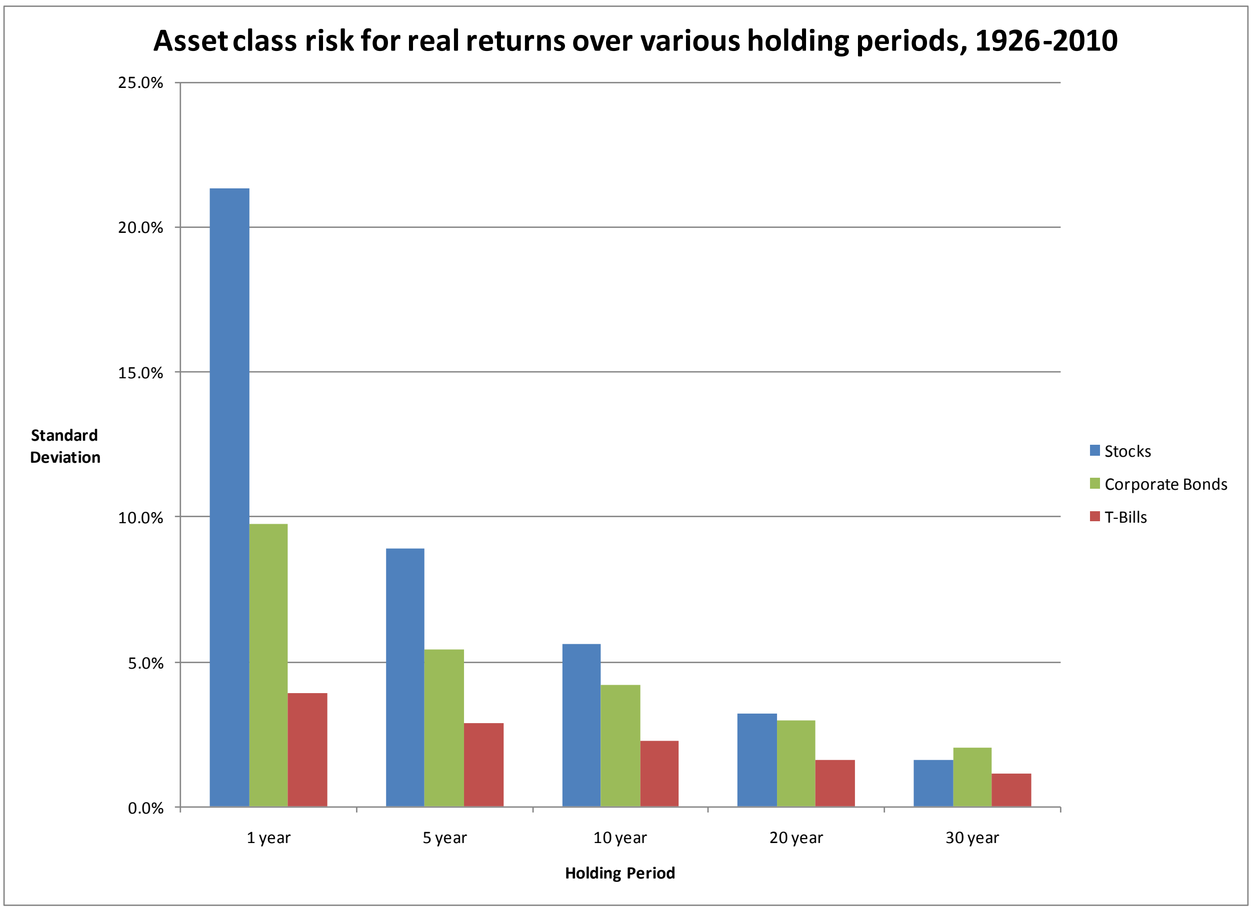
The data in Figures 3 and 4 bode extremely well for equities as the premier investment asset class for the long term investor. Back-testing real returns for each asset class reveals that stocks not only have an edge in potential upside, but also look more attractive on the downside relative to bonds and t-bills.

Let's shift our focus now on the risk profile of these asset classes. Despite equities showing their dominance over bonds and t-bills over longer investment horizons, we need to evaluate the risk profile of each respective asset class. I do this by using a standard measure of risk, standard deviation. Standard deviation is a measure used commonly in portfolio theory and asset allocation models.

Figure 5 shows asset class risk for real returns for numerous holding periods. Using the data collected on stocks, bonds, and t-bills, notice the precipitous decline of equity standard deviation over time. This decline is so drastic, that when examining the riskiness of stocks over 30-year time frames, standard deviation is actually seen to be less than that of corporate bonds –

and quite close actually to that of t-bills! This is a great example of time diversification at work and the possible mean reverting tendencies of stocks seen over long investment horizons. Over time, the standard deviation of equities, bonds, and t-bills fall drastically due to the tendency of these asset classes to revert closer to their mean over time. Over short time frames, an investor can experience ample volatility and uncertainty; however by smoothing this out into long time horizons, one can empirically see significantly less volatility.

Figure 5



2.3 Implications for portfolio construction

Relating back to portfolio construction, given the long term average returns and respective measures of risk of these asset classes, those investing with longer time horizons seem to be best off in equities. Undoubtedly, no one can ignore the positive effects diversification can bring to a portfolio. Obvious benefits exist to diversification when asset class returns are less than perfectly positively correlated (Bodie, Kane, & Marcus, 2010). This applies mainly however to shorter investment horizons, one to ten years. When faced with longer investment horizons though, investor's are able to take advantage of time diversification and mean reversion to maximize returns without taking on additional risk.

The most practical scenario this applies to would consist of a new college graduate entering the workforce with the intentions of saving for retirement. This new graduate, most likely around 22 years old, has an investment horizon close to over 35 years[25]. With an investment horizon that long, I would argue that it would be foolish to allocate capital anywhere other than equities. The empirical evidence showed us not only the consistency of equity returns under these extended holding periods, but if analyzed over a 30-year time frame, risk levels are actually shown to be comparative or even lower than bonds or t-bills. The new graduate should take advantage of his investment horizon and allow the effects of time diversification to carry his investments higher. If the past is any indication of how his investments will perform, he best off allocated solely into equities.

[25] If investing in a Roth IRA, the earliest one can withdraw money from this account is 59 ½ years old

Conclusion

In the review of prior studies done on the topic of random walk theory, it can be safe to assume that tick-by-tick price changes or short term movements may not behave with any particular dependence on prior ticks or market swings. However, when expanding these returns to numerous decades, prior studies (and empirical evidence in this paper) reveal how asset class movements are influenced either by prior returns, or some predictor variable. This is important to investors as they should absorb this knowledge into actionable asset allocation decisions. On a year-by-year basis, equity returns appear quite volatile and unpredictable. This may seem worrisome as first, but it is something a long term investors can take advantage of. Empirical evidence found within this study reveal the stability of equity returns over multi-decade time periods coupled with relatively low risk levels.

The dominance of real returns seen in equities over corporate bonds and t-bills comes at the same time we see greater predictability in long term equity returns. How should this effect the asset allocation decision of a long term investor with an investment horizon exceeding 30 years? With a time horizon of that length, the investor should not worry about asset class diversification, they should instead use the effects of time diversification to boost overall real return with less risk to the purchasing power of their investments. I feel as if investors are best off allocating 100% of assets into the investments that have historically provided the greatest real returns. In this case, the effects of mean reversion would take place over time, giving investors the greatest possible real return.

Possible extensions to this paper could include adding more asset classes in addition to stocks, corporate bonds, and t-bills. In addition to more asset classes, stocks could be broken down into more specific parts, such as small cap and large cap stocks. In most examples shown in this paper, the time period of choice was 1926-2010. By expanding this, we can see even more so if the same assumptions hold true. Finally, modeling portfolio returns may be extremely beneficial to those who want even more clarity on risk/return profiles.

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