DiMeo Schneider & Associates, L.L.C.

White Paper

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Capital Markets & Taxicab Rides

How to accommodate the "non-normal"

SYNOPSIS

Dr. Harry Markowitz's seminal paper, "*Portfolio Selection: The Efficient Diversification of Investments*," was published by The Journal of Finance in 1952. Markowitz postulated an "*efficient frontier*", a curve that shows how securities can be blended within portfolios to minimize risk at various levels of (expected) return. The Nobel Prize-winning research would later form the foundation of *Modern Portfolio Theory,* which would gain near universal adoption by the investment industry. The efficacy of *Modern Portfolio Theory* requires faith in the following three assumptions[1]:

1. **Normally distributed variability** - Risk can be explained by normal (*bell-shaped*) distributions.
2. **Markets follow a random walk pattern** - Today's return has no bearing on tomorrow's return.
3. **Diversification can be properly quantified by correlation** – Correlation is a mathematical measure of diversification that is based on normal (*bell-shaped*) distribution assumptions.

Elegantly precise theories can be very compelling, especially if you ignore certain facts. Unfortunately, empirical observation of capital market behavior (*and yes, taxicab rides*) conflicts with all three of the *Modern Portfolio Theory* assumptions. Rather than throw stones at the *efficient frontier* framework, we will explore a more accurate, but less mathematically precise framework that seeks to accommodate a truer picture of capital markets behavior. Such a framework must more accurately quantify risk and improve (true) risk-adjusted performance.

[1]Modern Portfolio Theory requires many additional assumptions. However, the scope of this paper only addresses the shortcoming of three assumptions.

Hailing Taxicabs

As a city dweller, I depend on the Chicago taxicab market to shuttle me across town. Obsessed with being on time, I decided to keep track of the time it took me to hail 1,186 taxicabs during a 3¼-year span in order to formulate a model to help me plan future cross-town travels.[1] The data reveals a 6-minute hail-time is typical (or median). Since about two-thirds (or 68.27%) of the hails took between 4 and 8 minutes, the standard deviation of hail times was 2 minutes (i.e., 6 minutes $^{+/-}$ 2 minutes). The vast majority (or 95.45%) of hail times were between 2 and 10 minutes (i.e., 6 minutes $^{+/-}$ 4 minutes). Exhibits I and II illustrate the parameters of my taxicab hailing model, built on the premise of a normal (*bell-shaped)* distribution.

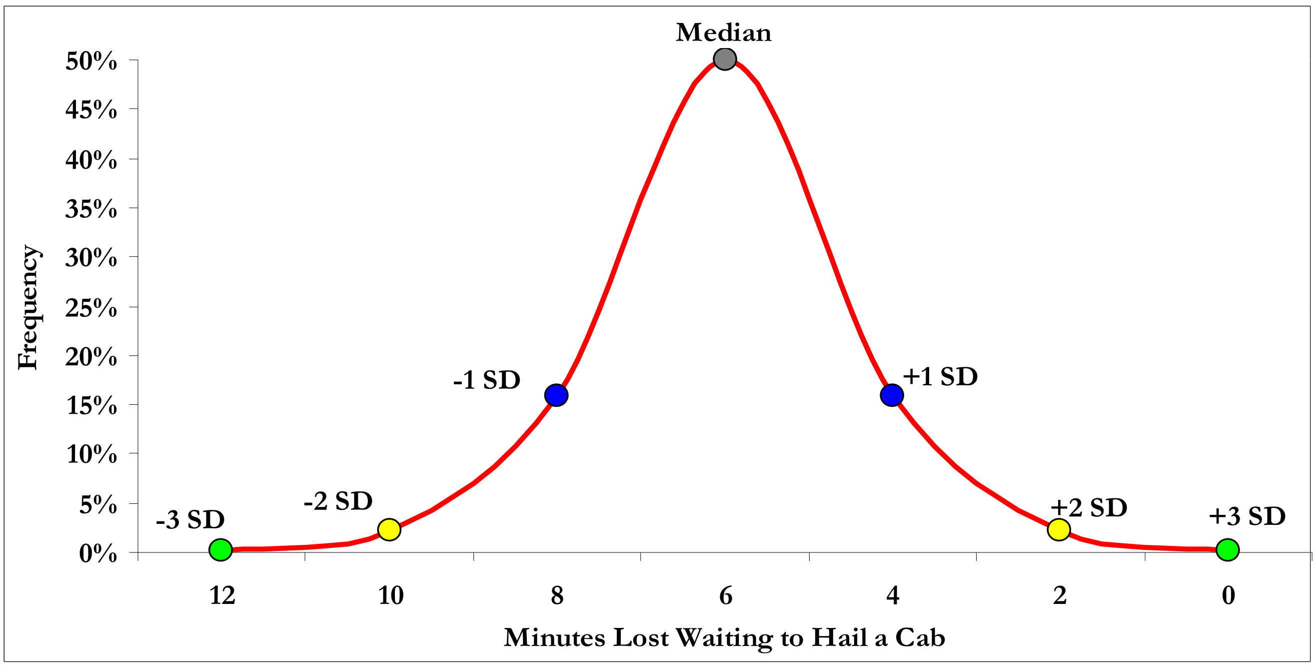
[1]Example for illustrative purposes only. The author did not track taxicab hail-times

Exhibit I
Taxicab Hail-Time Model

- ✓ Median minutes to catch a taxicab: 6 minutes
- ✓ Standard deviation of catching a taxicab: 2 minutes
- ✓ 68.27% confidence interval (or a 1 standard deviation event): 4 to 8 minutes
- ✓ 95.45% confidence interval (or a 2 standard deviation event): 2 to 10 minutes
- ✓ **99.73% confidence interval (or a 3 standard deviation event): 0 to 12 minutes*

**Note: Conclusion from extrapolating the 1 and 2 standard deviation events rather than empirical observation.*

Exhibit II
Taxicab Hail-Time Model Based on Normal (Bell-Shaped) Distribution

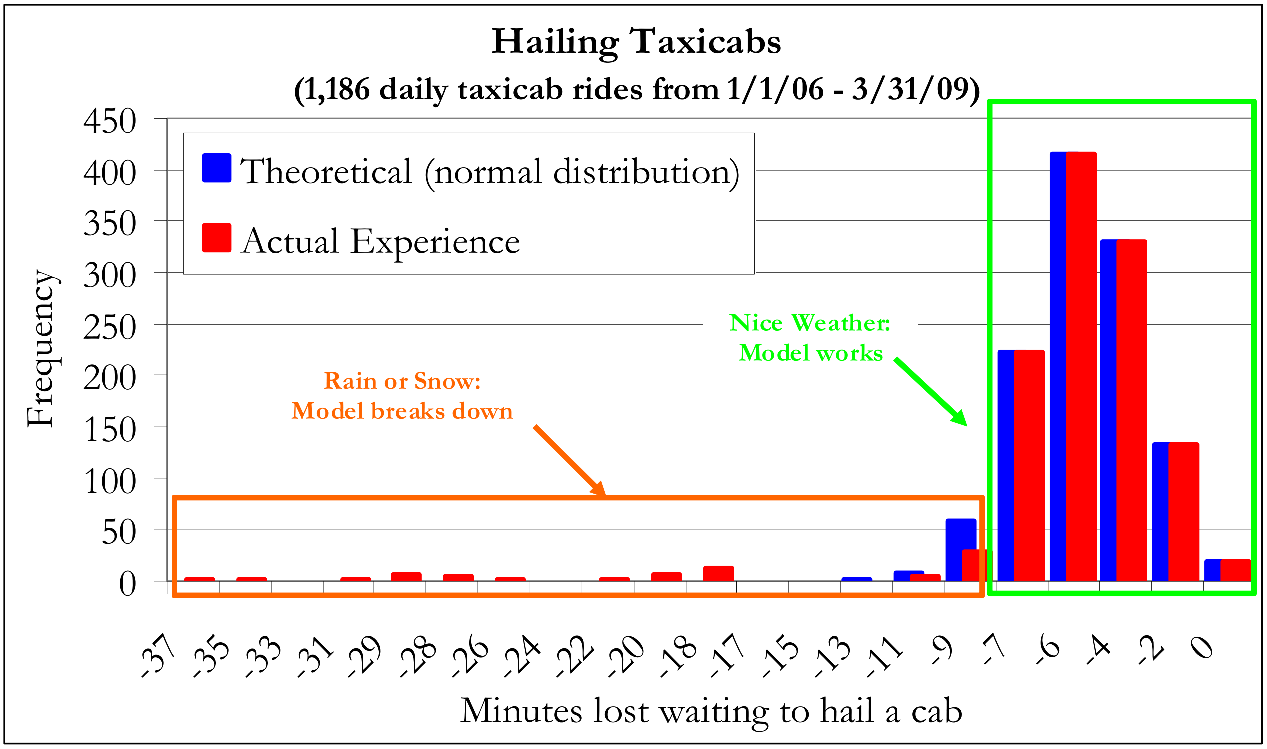


Extreme Hail-Times

Many variables can influence the time it takes to hail a taxicab, including the time of day, street location, day of the week and random luck. These variables converge to explain taxicab hail-times about 95% of time. However, the chief factor that causes taxicab hail-times to lengthen dramatically is **bad weather**. As every Chicago commuter has learned, when it rains or snows, taxicab hail-times jump off the normal (*bell-shaped)* distribution[2] (see Exhibit III). The demand for taxicabs by pedestrians seeking cover from the storm overwhelms the supply. The more severe the weather, the fatter the left tail. It may not thunderstorm or blizzard often in Chicago, but you had better be ready for delays when it does

[2] *The time series suffers from positive excess kurtosis and negative skewness.*

Exhibit III
Empirical Observation of Taxicab Hail-Times



A 10.7-minute hail-time cushion should make a commuter 99% certain of on time or early arrival[3]. However, empirical evidence of the data reveals a 10.7-minute cushion was insufficient 3½ times more frequently than predicted by the normal (*bell-shaped)* distribution assumptions. In order to have been on time 99% of the time during this 3¼ -year period[4], a 28.9-minute cushion was actually required (*or 2.7 times longer than the 10.7-minute normal distribution estimate*). If taxicabs played by normal distribution rules, a 20-minute (or greater) hail-time would be a 1-in-2.1 billion-year event. Instead, hail-times in excess of 20 minutes occurred 25 times between January 2006 and March 2009[5].

Like taxicab hail-times, empirical observation shows that capital market returns are prone to extreme events (often negative), which are inadequately explained by *Modern Portfolio Theory's* normal *(bell-shaped)* distribution requirements. For example, the high yield bond market was the worst left tail offender (see Exhibit IV) over the last 11¼ years[6]. It bored investors with steady month-to-month returns until the proverbial thunderstorm arrived in late 2008. When it rained, it poured! October 2008's loss (of -16.3%) was 6.0 standard deviations from the mean[7]. Such an extreme monthly loss should occur once every 72 million years based on normal distribution assumptions. The S&P 500's 16.8% loss in October 2008 was a mere 1-in-464-year event. While not represented in the 11¼-year sample period shown in Exhibit IV, the S&P 500's 21.8% monthly loss in October 1987 would have been a 1-in-33,958 year event.[8] Eight out of the eleven asset classes below had 1-in-1,000+ year monthly loss events between January 1998 and March 2009 based on *Modern Portfolio Theory's* normal (*bell-shaped*) distribution assumptions.

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[3] *NORMINV(Probability, Mean, Standard Deviation) = NORMINV(99%,6 minutes, 2 Minutes) = 10.65 Minutes*
[4] *1,168 taxicab rides in 3¼-year sample period.*
[5] *The longest hail-time, 36.9 minutes, should happen once every 4.94 X 10^{50} years based on normal distribution assumptions.*
[6] *This 11¼-year period allows for concurrent assessments across asset classes. TIPS index inception was March 1997.*
[7] *The Merrill Lynch high yield master index's standard deviation was 2.8% between January 1998 and March 2009. The mean monthly return was 0.27%.*
[8] *Based on a mean return of .11% and a 4.74% monthly standard deviation (observed between January 1998 and March 2009). October 1987 was not within sample period.*

Exhibit IV
Extreme Hail-Times for Asset Classes
Monthly Returns from January 1998 – March 2009 (or 11¼ Years)

Metric	TIPS	U.S. Bonds	Int'l Bonds	HY Bond	U.S. Stocks	REITs	Foreign Developed Equity	Em. Mkts. Equity	Commod-ity Futures	Fund of Hedge Funds	MLPs
Mean monthly return	0.6%	0.5%	0.5%	0.3%	0.1%	0.3%	0.2%	0.8%	0.7%	0.4%	1.0%
Monthly standard deviation	1.8%	1.1%	1.5%	2.8%	4.7%	6.4%	5.0%	7.6%	5.9%	1.9%	4.8%
100-year monthly loss (normal)	-5.1%	-2.9%	-4.2%	-8.4%	-14.8%	-19.8%	-15.4%	-23.0%	-17.8%	-5.6%	-14.0%
Skewness	-0.9	-0.3	0.3	-2.0	-0.7	-1.9	-1.0	-1.0	-1.1	-0.8	-0.6
Kurtosis*	5.4	1.3	0.1	10.2	1.0	7.0	1.8	1.9	4.6	4.1	2.4
Worst 4 out of 135 months											
1st worst month	-8.5%	-3.4%	-2.9%	-16.3%	-16.8%	-32.7%	-20.2%	-28.9%	-29.9%	-7.5%	-17.2%
2nd worst month	-4.8%	-2.6%	-2.7%	-8.4%	-14.5%	-24.7%	-14.4%	-27.4%	-15.5%	-6.5%	-17.1%
3rd worst month	-4.6%	-2.4%	-2.3%	-8.3%	-10.9%	-21.7%	-12.4%	-17.5%	-12.6%	-6.2%	-9.1%
4th worst month	-3.8%	-1.8%	-2.0%	-7.1%	-10.6%	-18.2%	-10.7%	-15.5%	-9.0%	-3.4%	-8.3%
Years between extreme monthly loss that should occur (based on the normal distribution)											
1st worst month	310,893	428	8	71,649,687	464	633,762	4,265	1,891	918,716	4,148	1,162
2nd worst month	57	37	5	97	79	1,742	53	820	29	564	1,091
3rd worst month	35	19	3	88	8	285	15	10	7	299	5
4th worst month	11	4	2	22	7	42	6	5	2	3	3

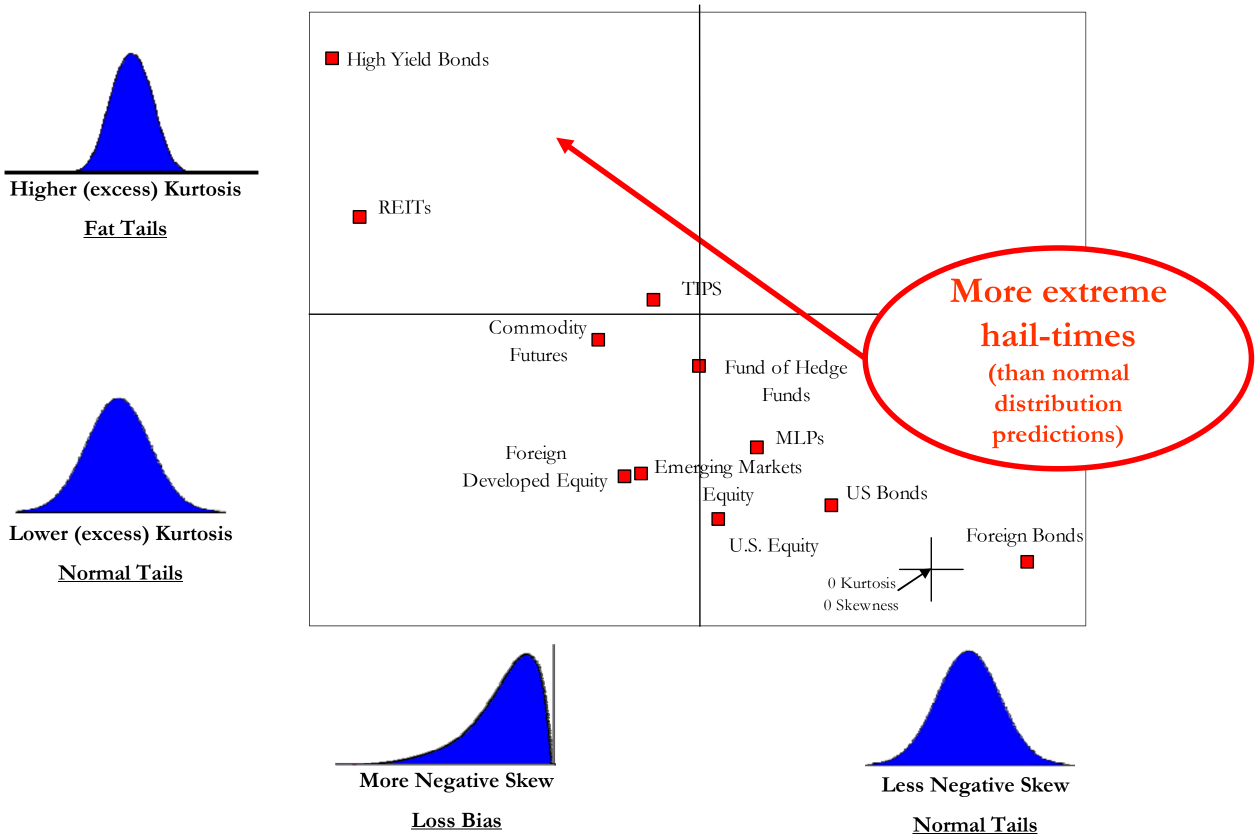
**Excess Kurtosis (or Kurtosis > 3).*

With the exception of foreign bonds, every asset class represented in Exhibits IV and V had at least a modest negative skew (or bias towards loss rather than gain) during the sample period. Exhibit V illustrates how asset classes performed relative to *Modern Portfolio Theory's* normal *(bell-shaped)* distribution assumptions between January 1998 and March 2009. High yield bonds and REITs had the most "**Extreme Hail-Times**" versus normal distribution assumptions, or the worst combination of extreme events[9] in the left tail.[10]

Modern Portfolio Theory requires us to treat all standard deviations equally. Wise Chicago commuters give themselves more than 10.7-minutes to hail taxicabs. In the same fashion, a wise asset allocation framework accommodates non-normal events and allocates to assets based on the expected magnitudes and frequencies of tail events (beyond normal distribution assumptions).

[9] *Positive excess kurtosis (or kurtosis > 3)*
[10] *Negative skewness*

Exhibit V
Extreme Hail-Times for Asset Classes (1/98 – 3/2009)



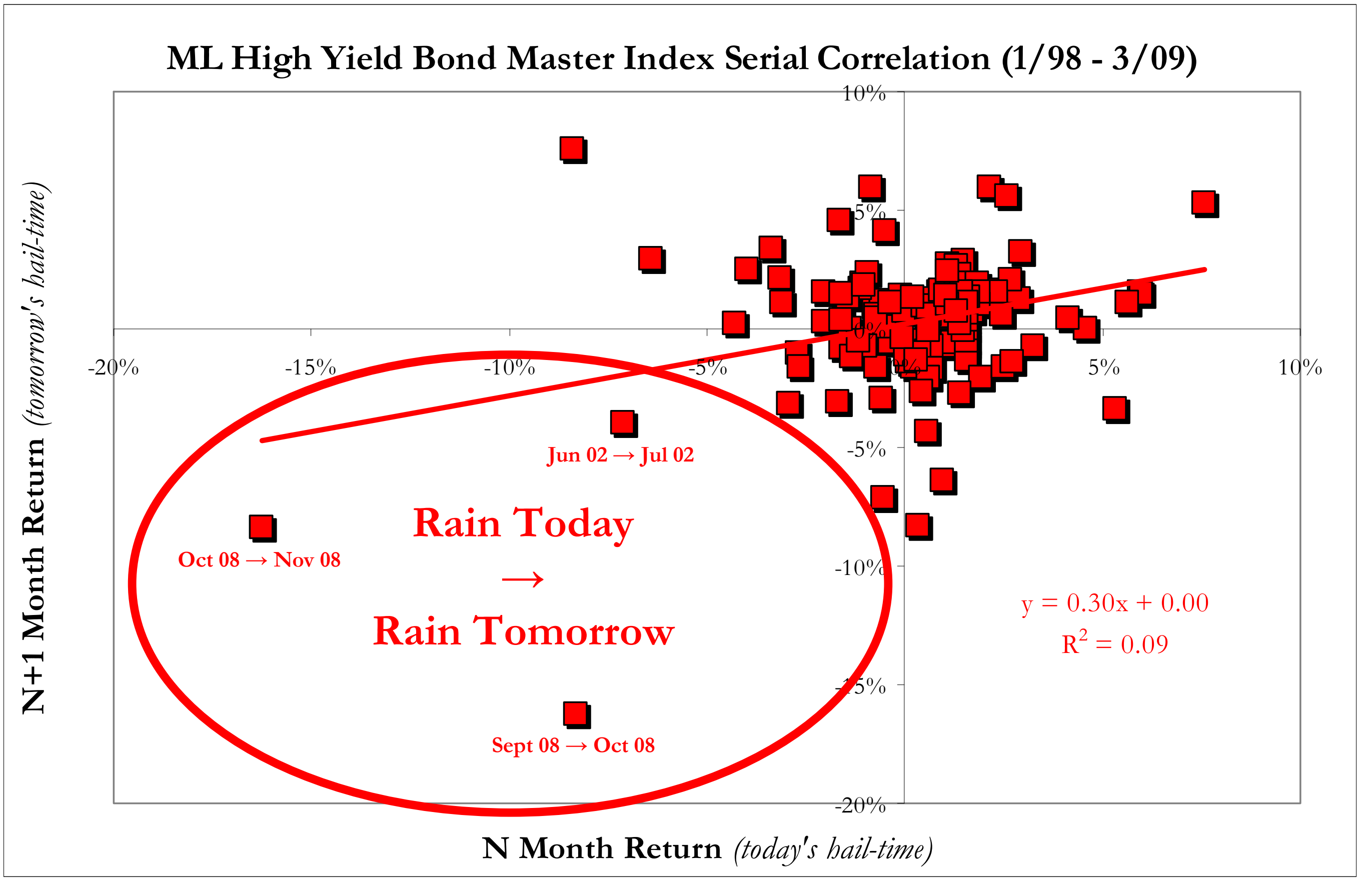
Rain Today → Rain Tomorrow

Normal distribution rules require today's taxicab hail-time to be completely independent of yesterday's hail-time.[11] Unfortunately, when it rained in Chicago yesterday, there is a higher probability than average it will rain again today (*or still be raining*). Therefore, yesterday's unusually long taxicab hail-time is often followed by today's long hail-time. For example, back-to-back 20-minute hail-times (*or 1-in-2.1 billion-year events based on normal distribution assumptions*) occur far more often than Chicago commuters would like.

Contrary to *Modern Portfolio Theory's* normal *(bell-shaped)* distribution requirements, the "**Rain Today → Rain Tomorrow**" effect[12] shows up in capital markets. Exhibit VI illustrates the dynamic for high yield bonds. October 2008's extreme loss (-16.25%), a 1-in-72 million-year event, is sandwiched between September 2008 (-8.3%) and November 2008 (-8.4%), which were both approximately 1-in-100 year events based on normal distribution assumptions. When "**Rain Today → Rain Tomorrow**" exists in a times series[13], a monthly standard deviation can dramatically understate an asset's true annual variability of returns. An accurate asset allocation framework that accommodates non-normal events must adjust the variability of the asset (upwards) to account for this.

[11] *Random walk assumption*
[12] *Serial correlation is present when an observation in one period is correlated to the outcome in the next period.*
[13] *Positive serial correlation*

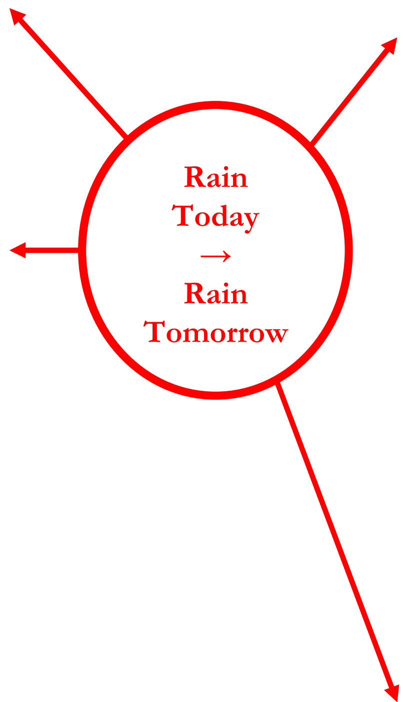
Exhibit VI
High Yield Bonds: Rain Today → Rain Tomorrow



The "**Rain Today → Rain Tomorrow**" effect is not only present in monthly capital market returns, but is often observable over annual periods. When "**Rain Today → Rain Tomorrow**" shows up in an annual time series, the expected variability of multi-year annualized returns (i.e., 3, 5 or 10 years) can be dramatically understated. Exhibit VII illustrates the calendar year returns of the S&P 500 Index from 1926 to 2008 (or an 83-year sample). Extreme calendar year losses were often followed by another extreme calendar year loss. The yellow highlights represent the calendar year losses that should happen less frequently than every 10 years based on *Modern Portfolio Theory's* normal (*bell-shaped*) distribution assumptions. An accurate asset allocation framework that accommodates non-normal events must accommodate the "**Rain Today → Rain Tomorrow**" effect by widening the expected variability of multi-year returns (i.e., 5, 10 and 20 years).

Exhibit VII
S&P 500 Index (1926 – 2008):
"Extreme Hail-Times" and the "Rain Today → Rain Tomorrow" Effects

Calendar year	S&P 500 Index return	Probability of Event Based on Normal Distribution*
1926	12%	<10-yr event
1927	37%	<10-yr event
1928	44%	<10-yr event
1929	-8%	11
1930	-25%	124
1931	-43%	6,829
1932	-8%	10
1933	54%	<10-yr event
1934	-1%	<10-yr event
1935	48%	<10-yr event
1936	34%	<10-yr event
1937	-35%	945
1938	31%	<10-yr event
1939	0%	<10-yr event
1940	-10%	13
1941	-12%	16
1942	20%	<10-yr event
1943	26%	<10-yr event
1944	20%	<10-yr event
1945	36%	<10-yr event
1946	-8%	10
1947	6%	<10-yr event
1948	6%	<10-yr event
1949	19%	<10-yr event
1950	32%	<10-yr event
1951	24%	<10-yr event
1952	18%	<10-yr event
1953	-1%	<10-yr event
1954	53%	<10-yr event
1955	32%	<10-yr event
1956	7%	<10-yr event
1957	-11%	14
1958	43%	<10-yr event
1959	12%	<10-yr event
1960	0%	<10-yr event
1961	27%	<10-yr event
1962	-9%	11
1963	23%	<10-yr event
1964	17%	<10-yr event
1965	12%	<10-yr event
1966	-10%	13
1967	24%	<10-yr event



Calendar year	S&P 500 Index return	Probability of Event Based on Normal Distribution*
1968	11%	<10-yr event
1969	-8%	11
1970	4%	<10-yr event
1971	14%	<10-yr event
1972	19%	<10-yr event
1973	-15%	24
1974	-26%	166
1975	37%	<10-yr event
1976	24%	<10-yr event
1977	-7%	<10-yr event
1978	7%	<10-yr event
1979	18%	<10-yr event
1980	32%	<10-yr event
1981	-5%	<10-yr event
1982	21%	<10-yr event
1983	23%	<10-yr event
1984	6%	<10-yr event
1985	32%	<10-yr event
1986	18%	<10-yr event
1987	5%	<10-yr event
1988	17%	<10-yr event
1989	31%	<10-yr event
1990	-3%	<10-yr event
1991	30%	<10-yr event
1992	8%	<10-yr event
1993	10%	<10-yr event
1994	1%	<10-yr event
1995	38%	<10-yr event
1996	23%	<10-yr event
1997	33%	<10-yr event
1998	29%	<10-yr event
1999	21%	<10-yr event
2000	-9%	12
2001	-12%	17
2002	-22%	76
2003	29%	<10-yr event
2004	11%	<10-yr event
2005	5%	<10-yr event
2006	16%	<10-yr event
2007	5%	<10-yr event
2008	-37%	1,473

**Annualized Standard Deviation*

Based on 15.2% annualized standard deviation assumption (observed during 30-year period between 1979 and 2008)

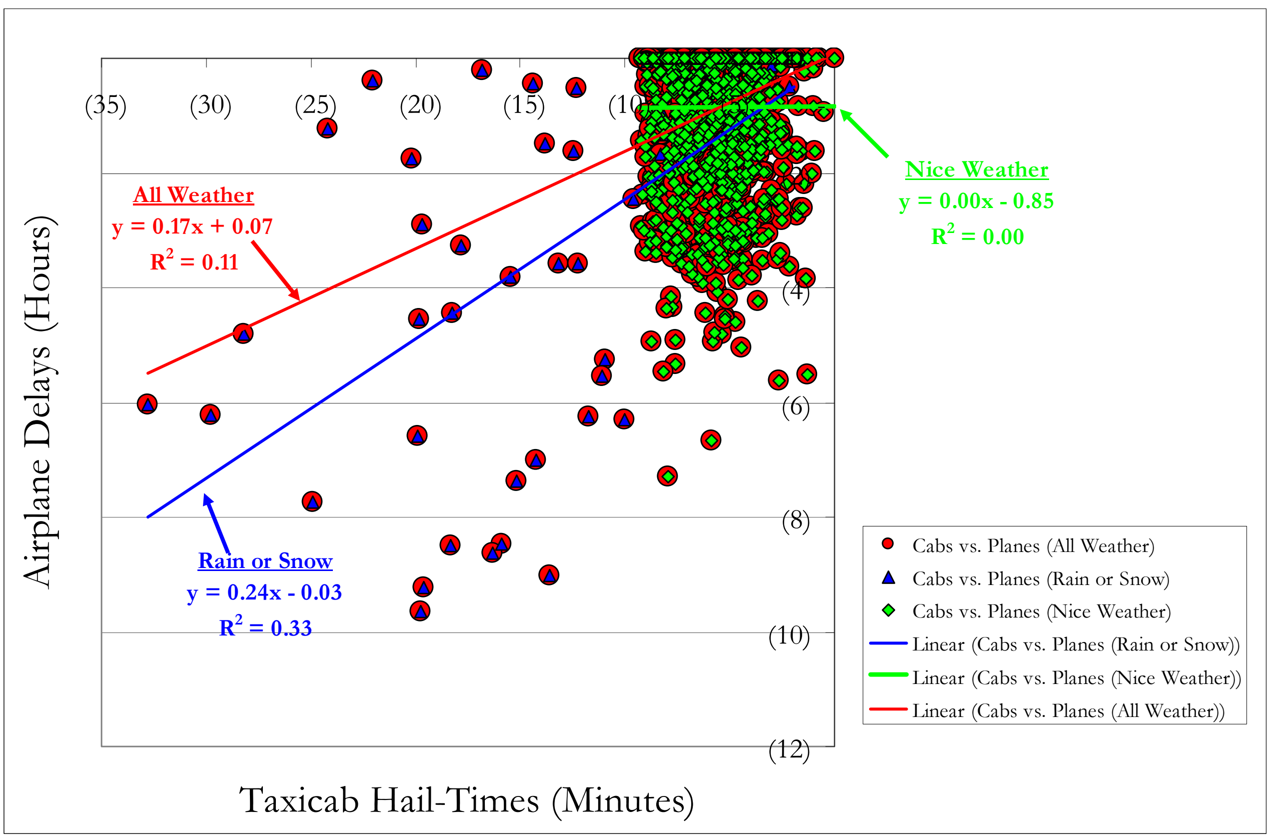
Annualized Standard Deviation

Years	Measurement Dates (Start-End)			Annualized Standard Deviation
83	1926	-	2008	19.2%
80	1929	-	2008	19.3%
70	1939	-	2008	14.9%
60	1949	-	2008	14.3%
50	1959	-	2008	14.7%
40	1969	-	2008	15.4%
30*	1979*	-	2008*	15.2%*
20	1989	-	2008	14.5%
10	1999	-	2008	15.1%

Planes, Trains and Automobiles
The “typical” variables that drive taxicab hail-times (*i.e., time of day, street location and day of week*) have virtually no effect on your delay times for trains, buses and airplanes. Some variables that apply to taxicabs may not apply to trains or airplanes at all (*i.e., street location*). A train or bus may be late because it breaks down. An airplane might be late because of engine trouble. Personal experience suggests that airplanes are often late for no apparent reason at all.

(Linear) correlations between the wait-times to catch taxicabs, buses, trains and airplanes are low. For example, it may take you only 1 minute to catch a taxicab to the airport, but your flight may be delayed by 4 hours. Your hail-time for the taxicab was much shorter than typical, but your delay time for the airplane was much longer than typical. However, when a blizzard hits Chicago, all modes of transportation seize up. Therefore, where the correlation of wait times appears to be (near) zero for many observations, they suddenly rise. Unfortunately, the rise in correlations is simultaneous with extreme wait-times (i.e., extreme left tail). Exhibit VIII illustrates the relationship between **taxicab hail-times** and **airplane delays** during nice weather, rain or snow, and all weather.

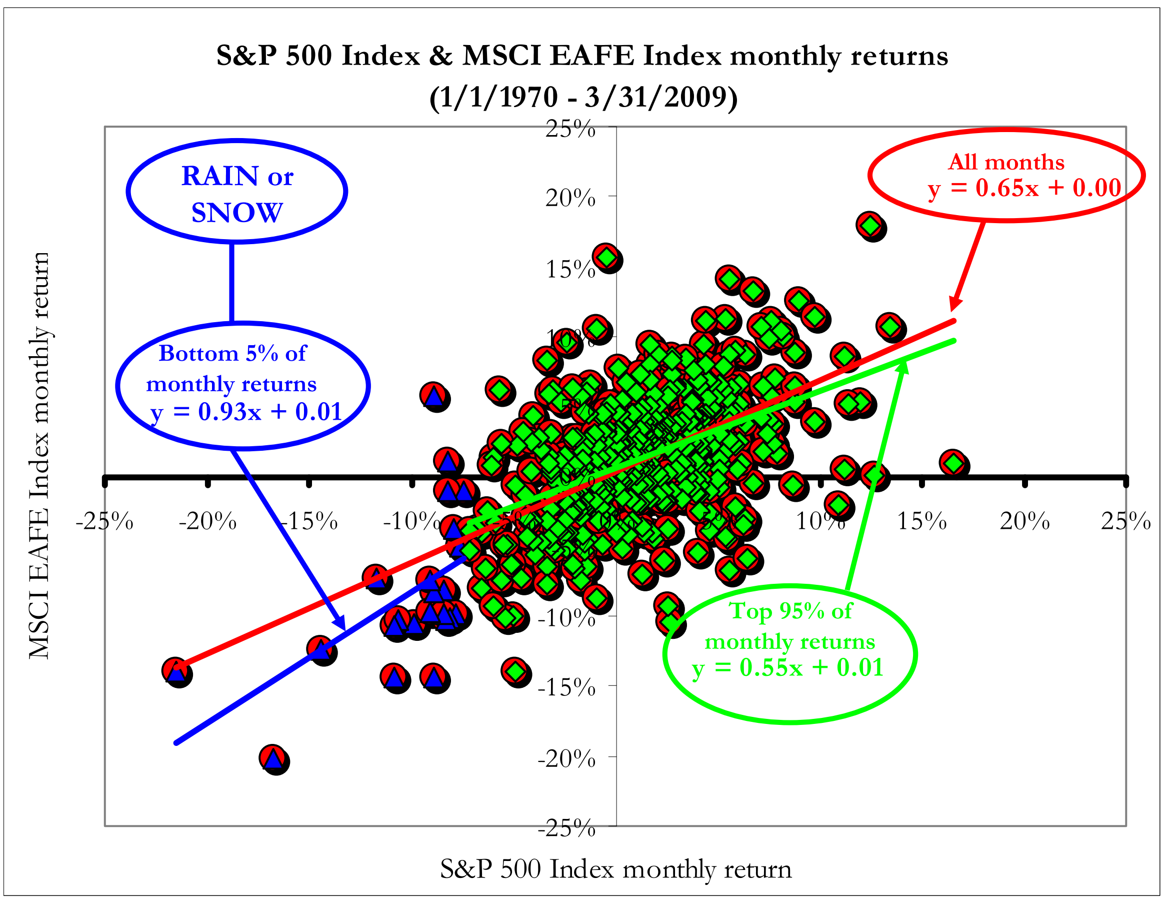
Exhibit VIII
Airplanes and Taxicabs: Correlations Rise in the Left Tail



Contrary to *Modern Portfolio Theory* assumptions, capital markets fall prey to this "**Planes, Trains and Automobiles**" effect. Exhibit IX illustrates the 39¼-year relationship between the S&P 500 Index (U.S. stocks) and the MSCI EAFE Index (foreign stocks). During all months, the beta[14] (or linear slope coefficient) of foreign stocks relative to U.S. stocks was 0.65. Therefore, *Modern Portfolio Theory* predicts that a 10% (monthly) return for U.S. stocks leads to an expected 6.5% return for foreign stocks, and a -10% return for U.S. stocks leads to an expected -6.5% return for foreign stocks.

Unfortunately, the facts contradict the grand theory. Diversification benefits often evaporated when needed the most. For example, during the worst 5% of monthly returns (or worst 23 out of 471 months), the beta of foreign stocks relative to U.S. stocks was 0.93. A 0.93 beta means that a -10% monthly return for U.S. stocks leads to an expected -9.3% monthly return for foreign stocks. Counting on a 0.65 beta between U.S. stocks and foreign stocks through good times and bad is like counting on 1/6th of a bullet firing every time you play Russian roulette.

Exhibit IX
U.S. Stocks and Foreign Stocks: "Planes, Trains and Automobiles"



[14] $Beta_{asset\ 1\ vs.\ asset\ 2} = Correl_{1,2}\ X\ SD_1/SD_2$

Exhibit X compares correlation coefficients of asset classes between January 1988 and October 2007 and between November 2007 and February 2009. November 2007 to February 2009 represents the 16-month stretch where the S&P 500 Index fell 51%. The correlation coefficients between large cap U.S. stocks and other asset classes are highlighted. As Exhibit X shows, correlation coefficients rose across the board for virtually all risky assets during the market decline. A jump in correlation (simultaneous with a rise in volatility) leads to rising betas between asset classes. An asset allocation framework that accommodates non-normal events must factor in rising betas (or rising correlation and volatility) during low frequency, but high consequence, periods of stress.

Exhibit X
Planes, Trains and Automobiles: Correlations Rose During Stress

Correlations Between January 1988 and October 2007

	US Bonds	HY Bond	Large Cap US	REITs	Int'l Equity	Em. Mkts. Equity	Commodity Futures	Hedge Fund
US Bonds	1.00	0.28	0.18	0.13	0.06	-0.05	0.20	0.14
HY Bond		1.00	0.49	0.41	0.36	0.42	0.01	0.32
Large Cap US			1.00	0.41	0.62	0.58	-0.02	0.43
REITs				1.00	0.28	0.34	-0.02	0.19
Int'l Equity					1.00	0.58	0.05	0.31
Em. Mkts. Equity						1.00	0.11	0.48
Commodity Futures							1.00	0.18
Hedge Fund								1.00

Correlations Between November 2007 and February 2009

	US Bonds	HY Bond	Large Cap US	REITs	Int'l Equity	Em. Mkts. Equity	Commodity Futures	Hedge Fund
US Bonds	1.00	0.37	0.38	0.34	0.52	0.40	0.42	0.12
HY Bond		1.00	0.73	0.68	0.76	0.80	0.61	0.71
Large Cap US			1.00	0.83	0.91	0.79	0.47	0.53
REITs				1.00	0.72	0.60	0.39	0.20
Int'l Equity					1.00	0.94	0.61	0.66
Em. Mkts. Equity						1.00	0.66	0.80
Commodity Futures							1.00	0.72
Hedge Fund								1.00

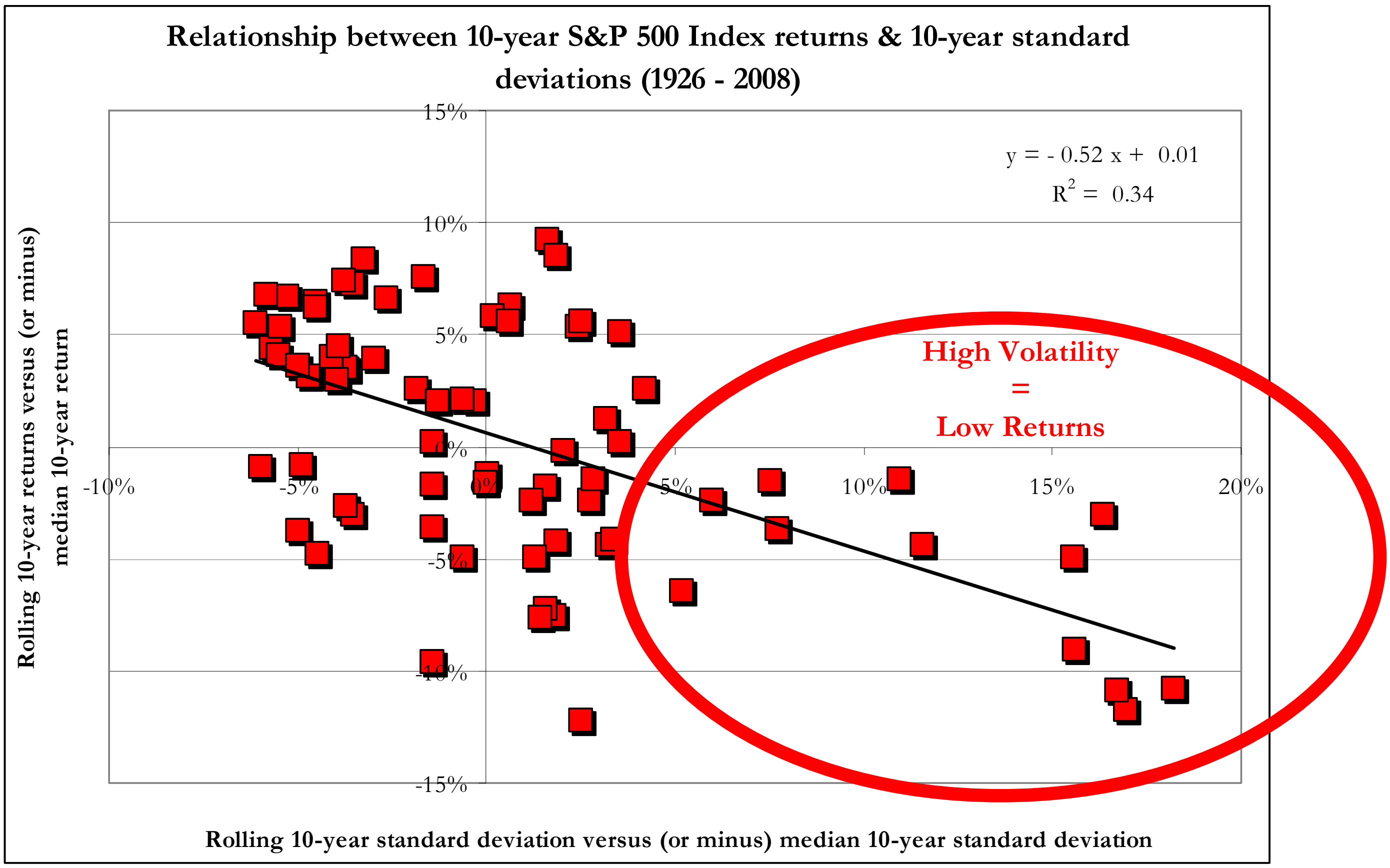
Modern Portfolio Theory's Cruel Joke

In good times, correlations tend to be low, volatility across asset classes is low, and returns are high. In bad times, correlations (and betas) rise, volatility rises and returns are low (or extremely negative).

Good Times	Bad Times
✓Low Correlations	✓High Correlations
✓Low Volatility	✓High Volatility
✓High Returns	✓Low Returns

Exhibit XI illustrates the relationship between 10-year S&P 500 Index annualized returns (vs. median 10-year return) and its 10-year annualized standard deviation (vs. median 10-year standard deviation). In the 10-year periods when volatility was higher, returns were often the lower. When we lose 20%, then gain 20%, we are still 4% behind from where we started. *[$100 falls to $80 (i.e., a 20% loss). The $80 rises to $96 dollars (i.e., a 20% gain)].* Extreme volatility, even when it is <u>both</u> up and down, is not helpful when the objective is to compound capital over time.

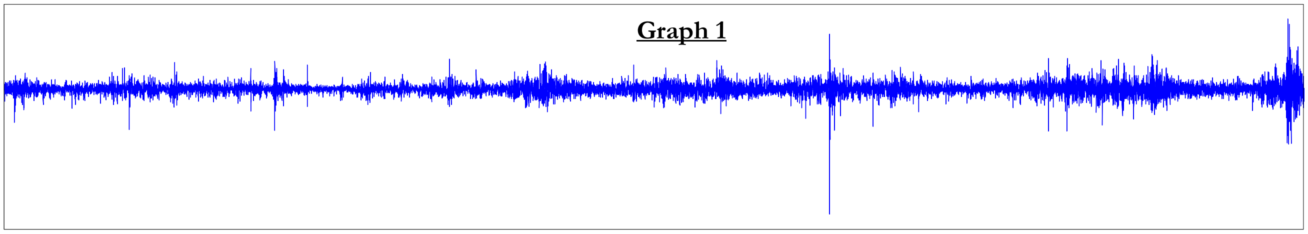
Exhibit XI
S&P 500 Index: Higher Volatility → Lower Returns

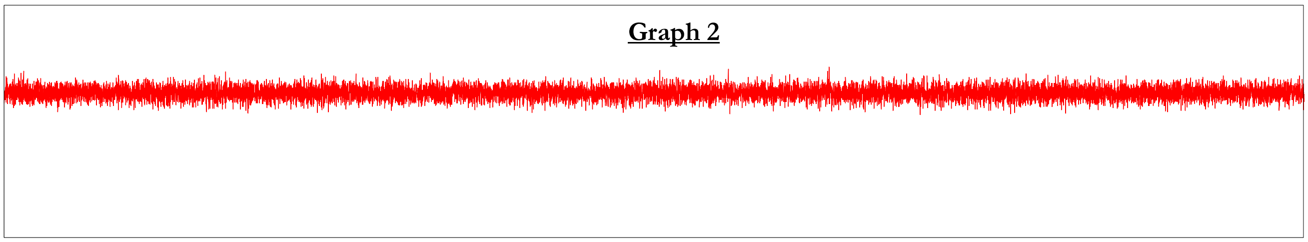


One of the two graphs in Exhibit XII illustrates the historical <u>daily</u> percentage moves of the S&P 500 Index from January 1, 1950 to July 8, 2009. The time series suffers from unstable volatilities (**Extreme Hail-Times**) and serial correlation[15] (**Rain Today → Rain Tomorrow**). The other graph, a phony, shows simulated daily returns based on *Modern Portfolio Theory's* normal *(bell-shaped)* distribution assumptions (*using the mean daily return and standard deviation from the real data*). It has static volatility (i.e., lacks **Extreme Hail-Times**) and each observation is unencumbered by the prior observation (i.e., no "**Rain Today → Rain Tomorrow**" effect).

[15] *Oscillated between positive and negative serial correlation*

Exhibit XII
Daily S&P 500 Index Returns (1/1/1950 – 7/8/2009)
Which Graph is the Phony?





Graph 1 is real and Graph 2 is the phony.

The real history (*Graph 1*) shows how the stock market returns clustered tighter around the mean in "typical" periods, but had extreme swings in the "atypical" periods. While "atypical," these wild swings are more frequent than many investors realize. When the wild swings occurred, they tended to persist. On the other hand, the phony simulation (*Graph 2*) that uses *Modern Portfolio Theory's* normal (*bell-shaped*) distribution rules tends to overstate the typical day-to-day swings, but vastly underestimates the frequency and magnitude of extreme events. As Graph 1 illustrates, the S&P 500 Index was not only volatile, but its volatility was volatile. Using *Modern Portfolio Theory's* normal distribution requirements to describe market returns is like trying to fit a round peg in a square hole. It just does not fit. An asset allocation framework that accommodates non-normal events must fix the naïve *Modern Portfolio Theory* assumptions used to generate Graph 2.

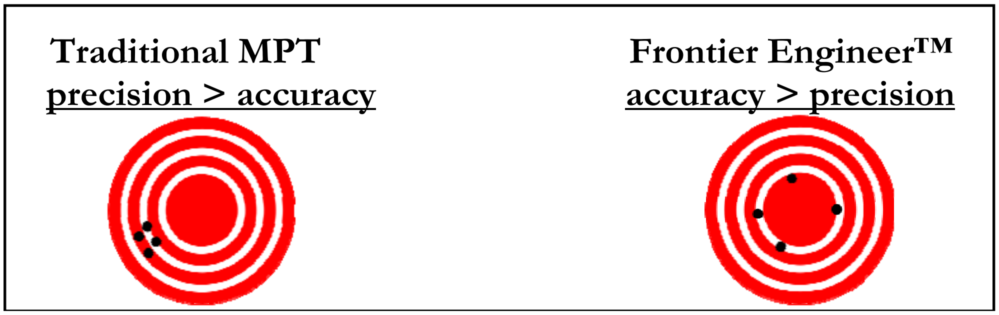
<u>The Frontier Engineer™ - Accommodating Non-Normal Events</u>

Long before 2008, it was easy to poke holes in *Modern Portfolio Theory's* foundation by pointing to the fat tails (**Extreme Hail-Times**), serial correlations (**Rain Today → Rain Tomorrow**), and unstable betas (**Planes, Trains and Automobiles**). Despite its many flaws, however, many practitioners still cling to the framework because few, if any, alternative methods generate such elegantly precise output. For example, *Modern Portfolio Theory's* precise normal distribution prediction is that a 1-in-83-year (worst) expected monthly stock market loss is -16.17%.[16] *Modern Portfolio Theory* and the elegant math of the bell curve allow us to "precisely" round this theoretical 1-in-83-year-loss to ten decimal places if we so desire (*e.g., -16.1678986625%),* or slice and dice risk expectations any other way we want. It is fun theory for the mathematically inclined. However, the annoying facts show us that the S&P 500 breached that (16.17% loss) threshold <u>ten times</u> in the 83-year period between 1926 and 2008.[17] The six worst months ranged from 1-in-5.5 million-year events to 1-in-1 thousand-year events based on normal *(bell-shaped)* distribution assumptions

[16] *Based on 1926 – 2008's mean monthly return (0.92%) and standard deviation (5.53%). NORMINV(1/(83*12),0.92%,5.53%) = -16.17%. A 5.52% monthly standard deviation equates to a 19.2% annualized standard deviation (or 5.52% X SQRT(12).*

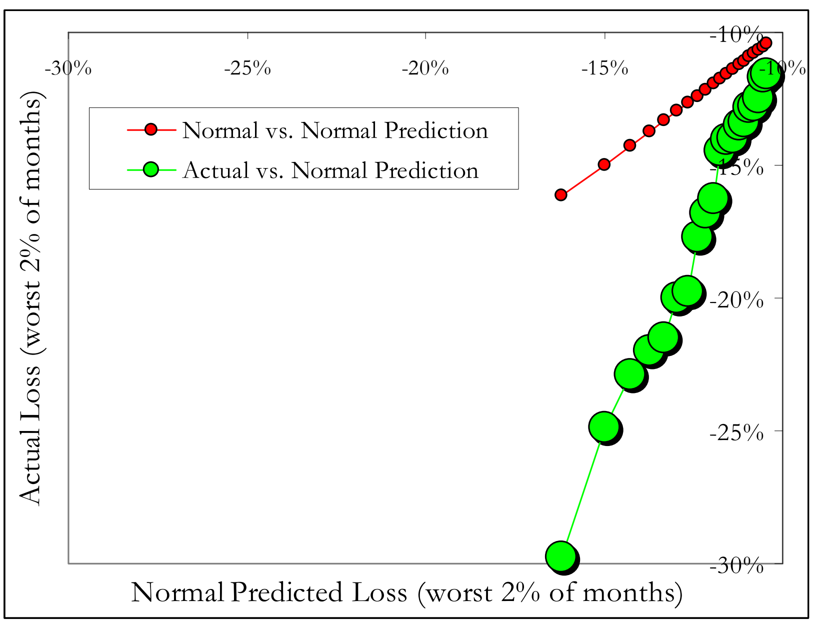
[17] *The 10 worst months were Sep-31 (-29.7%), Mar-38 (-24.9%), May-40 (-22.9%), May-32 (-22.0%), Oct-87 (-21.5%), Apr-32 (-20.0%), Oct-29 (-19.7%), Feb-33 (-17.7%), Oct-08 (-16.8%), Jun-30 (-16.3%). Aug-98 (-15.5%) narrowly missed the 83-year event designation by 1.7%.*

Exhibit XIII
Accuracy versus Precision



Perhaps it is a human trait to value precision over accuracy, even if it means being precisely wrong over mostly accurate (see Exhibit XIII). A model that accommodates non-normal events values accuracy over precision. Precision tells us a 1-in-83-year monthly loss is -16.1678986625%. Accuracy tells us a 1-in-83-year monthly loss is probably somewhere closer to -30%. Unfortunately, the more accurate estimate is more difficult to round to the nearest 1%, let alone ten decimal places. Exhibit XIV illustrates the 20 worst monthly losses (or the worst 2% of months) between 1926 and 2008 versus the elegant and precise math of *Modern Portfolio Theory's* normal (*bell-shape*) distribution assumptions.

Exhibit XIV
The S&P 500 Index's *Modern Portfolio Theory* prediction versus the actual worst 20 monthly losses (1926 – 2008)

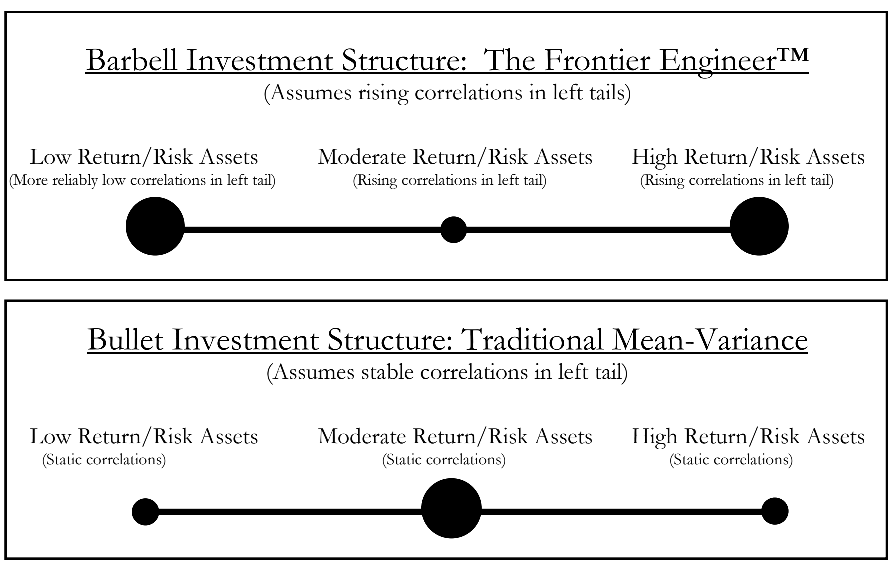


For the better part of the past decade, DiMeo Schneider & Associates, L.L.C. has advocated breaking free of the rigid traditional efficient frontier framework with our proprietary **Frontier Engineer™** framework. Rather than betting the farm on mean returns, volatilities and correlations, the **Frontier Engineer™** relegates "mean expected outcomes" to their proper nominal role as an academic exercise. It elevates the importance (*i.e., frequency and magnitude*) of "tail outcomes" around median[18] expectations.

The **Frontier Engineer™** replaces the academic *Modern Portfolio Theory* concept of "mean expectations" with "median expectations" for returns, standard deviations and correlations (among assets), then simulates thousands of possible outcomes for each asset class, factoring in the dynamic relationships between return, volatility and (non-linear) correlation. It simulates "**Extreme Hail-Times**," "**Rain Today → Rain Tomorrow**" and "**Planes, Trains and Automobiles**" and accounts for them in the portfolio optimization process.

The **Frontier Engineer™** algorithm accounts for diversification benefits among risky assets in "typical" times, but balances this diversification euphoria with the stark reality that low correlations among risky asset classes can be fleeting at extremes. The correlation coefficients of low risk/low return assets (*i.e., T-bills, TIPS, nominal Treasuries, foreign sovereign bonds, etc.)* are more persistent and given greater relative heft than correlation coefficients between risky assets (*i.e., U.S. stocks and foreign stocks*). Fleeting low betas lead **Frontier Engineer™** portfolios, along the entire risk spectrum, to have a more barbell (vs. bullet) structure compared to *Modern Portfolio Theory* optimized portfolios, which assume stable correlations among moderate and high risk/return assets across all variations in "the weather". Exhibit XV compares the barbell and bullet structures.

Exhibit XV
Barbell versus Bullet



[18] *Expected mean is the average of all possible outcomes. Expected median is the expected mid-point of all possible outcomes. When returns are normally distributed, mean = median. When returns have fat left tails, mean < median.*

Conclusion

Before opting to play Russian Roulette for the promise of a cash prize, be sure to measure accurately the number of bullets in the revolver! Layering "**Extreme Hail-Times**", "**Rain Today → Rain Tomorrow**" and "**Planes, Trains and Automobiles**" on top of each other means there are more bullets in the revolver than *Modern Portfolio Theory* and normal *(bell-shaped)* distribution assumptions estimate.

We live in a world where the weather often shifts on a dime. Small clouds on the horizon can rapidly turn into a thunderstorm or blizzard. Whether we hail taxicabs or build diversified portfolios, we must account for "non-normal" events because they always have been and will continue to be the norm. An asset allocation framework that passes muster, especially in a post-2008 world, must not disregard those annoying "outliers" because they are not going away.

*Please contact DiMeo Schneider & Associates, L.L.C. for more information on how the **Frontier Engineer™** algorithm can improve your portfolio.*

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Biography

*As a Principal and Chief Research Officer at DiMeo Schneider & Associates, L.L.C, Matt spearheads the firm's efforts in the areas of capital market analysis and forecasts, investment strategy, asset allocation and portfolio rebalancing modeling and alternative investments. In 2005, he co-authored **The Practical Guide to Managing Nonprofit Assets** (John Wiley & Sons). In his role as Senior Consultant, Matt advises a number of corporate and non-profit clients. Matt received a BA in Economics from Northwestern University, is a CFA Charterholder and a CAIA (Chartered Alternative Investment Analyst).*

Matthew Rice, CFA, CAIA
Chief Research Officer

Disclosures & Footnotes:

The taxicab hail-time data in this paper was a thought experiment used purely for metaphorical purposes. At no time did the author track taxicab hail-times. However, the assumptions used to build the Monte Carlos model to simulate random outcomes were based on actual experience hailing taxicabs in Chicago.

The following index proxies were used to represent asset class monthly returns:

Asset Class	Index Proxy
Cash	Citigroup 3-month T-Bill
TIPS	Citigroup Inflation-Linked Securities
U.S. Bonds	Barclays US Aggregate Bond Index
Int'l Bond	50/50 Citigroup Foreign Bond (UH)/Citigroup Foreign Bond (UH)
HY Bond	Merrill Lynch High Yield Master
Large Cap	S&P 500
Mid Cap	Russell MidCap
Small Cap	Russell 2000
REIT	DJ Wilshire Real Estate Sec.
Int'l Equity	MSCI EAFE
Em. Mkt. Eq.	MSCI Emerging Markets Free
Commodity Futures + TIPS	DJ AIG Commodity Index + Citi Infl-Linked Securities - Citigroup 3-Month T-Bill
Portfolio of Hedge Funds	HFRI Fund of Funds Index
MLPs	Alerian MLP Index

Past performance is no guarantee of future performance.
No diversification strategy can prevent loss or guarantee a gain.