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Examining CAPM in Today's Markets

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EXAMINING CAPM IN TODAY'S MARKETS

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ABSTRACT

The purpose of this work is to empirically assess the validity of the Capital Asset Pricing Model (CAPM) in terms of how can it model an equity's return. The goal of this work is not to challenge the theory behind CAPM, nor compare it to alternatives, but simply to test whether or not it is applicable in the real world. This is an exploratory research study: rather than testing a specific hypothesis, my goal is to let the data speak for itself.

The main difficulty with assessing CAPM is that there is no consensus on how much data we ought to use when calculating an equity's Beta. Overall, there are two divergent schools of thought:

1) The more data you use, the more accurate your approximation. (Rule of Large Numbers)
2) Companies have major shifts and trends; using too much old information will dilute the newer, more pertinent data.

Rather than taking a stance one way or another, I test the strength of both arguments. I use many different strategies for calculating the Beta of ten different individual equities and a single portfolio with 10% allocated in each. More importantly, I apply CAPM in a retroactive fashion to past data—if you *had* used CAPM to anticipate the return of an equity, how correct would you have been over the last five, ten, twenty, or even forty years?

EQUITIES USED (TICKER)[1]

1. 3M (MMM)
2. American Express (AXP)
3. ExxonMobil (XOM)
4. Johnson & Johnson (JNJ)
5. Verizon Communications (VZ)
6. Wal-Mart (WMT)
7. General Electric (GE)
8. United Technologies Corporation (UTX)
9. Coca-Cola (KO)
10. Apple Inc. (AAPL)
11. Hypothetical Portfolio: invest $10 in each of the above stocks starting September 11, 1984.

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[1] It should be noted that nine of the ten individual equities studied are currently in the Dow Jones Industrial Average (the exception being Apple Inc.).

OPERATIONAL DEFINITIONS

CAPM Variables:

The risk-free rates (Rf) and market returns (Rm) for my CAPM equations were taken from the Kenneth French Data Library.[2] For the purposes of this research, the Rf rate is set to the same time horizon as the returns being studied: for monthly returns, the 1-month US Treasury Bill return is used. For daily/weekly returns, as per Dr. French's methods, the Rf rates are taken backwards from the 1-month US Treasury Bill; if you compound the daily Rf rates every day the market is open per month, then you will get the return of the 1-month US Treasury Bill. Dr. French's Rm is ultimately derived from the U.S. equity market, and for comparison purposes it is similar to the S&P 500 Index.

Equity Values:

The values for the equities studied are taken from Yahoo Finance's Historical Data[3], using the closing prices adjusted for dividends and splits.

EXPERIMENTAL DESIGN

For each set of data, the following must be defined:

- What is the equity? (one of the eleven listed on page 2)
- What is the frequency of recalculation? (daily, weekly, or monthly)
- Is there a "fixed start-date" or a "moving window" method of finding Beta?

  Fixed Start-Date

  - What is the earliest data being used for the calculations? (since the equity's inception[4], 2000, 2005, or "One Year"[5])

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[2] French, Kenneth R. *Kenneth R. French - Data Library*. 2010. Web. 26 Nov. 2010. <http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html>.
[3] *Yahoo! Finance*. Yahoo! News Network, 2010. Web. 26 Nov. 2010. <http://finance.yahoo.com/>.
[4] The earliest available date on Yahoo Finance; September 11, 1984 for the hypothetical portfolio.
[5] The most recent data used is from January 29, 2010, and therefore "One Year" refers to all data after January 29, 2009.

- What is the earliest data being used to assess the accuracy of the data? (since the equity's inception, 2000, 2005, or "One Year")

Moving Window

- What is the size of the data window? (252 days, 2 months, etc.)

CAPM is then applied to the variables chosen in a rolling fashion. For example, I looked at the return on ExxonMobil (XOM) with monthly recalculation, a fixed start date of January 2000, and accuracy of the data being assessed since January 2005. This means that I first used all the applicable data from January 2000 to December 2004 to calculate the Beta for XOM using the formula:

$$\beta_i = \frac{\mathrm{Cov}(R_i, R_m)}{\mathrm{Var}(R_m)}$$

Using the Rf and Rm for January 2005 (along with the Beta I just calculated through December 2004) I used CAPM to determine the expected return of XOM for the month of January 2005:

*Expected R(XOM) = (Jan. 2005's Rf) + (Beta through Dec. 2004) * (Jan. 2005's Rm – Jan. 2005's Rf)*

I compared the expected return to XOM's actual return for that same period (using its adjusted closing prices). Then, I recalculated the Beta for XOM using all the data from January 2000 to January 2005. Next, I used the Rf and Rm for February 2005 and my *new* Beta as of *January* to find the expected returns for Feb. 2005, and so on. I repeated this process all the way through January 2010.

I used this method for all ten equities (eleven including the portfolio) and every possible combination of variables mentioned in the experimental design[6]. I compare the historical returns and the "CAPM returns" both statistically[7] and graphically—the graphical element is crucial to the goal of my research because it shows, on a rolling basis, how accurate you would have been by using CAPM to model the returns of an equity over a period of time.

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[6] At this point, it should be clear that there is an incredibly extensive amount of data involved with this research. In the interest of space and time, I cannot include all the charts, graphs, and data that I used, but please contact me if you would like more information.

[7] Mean, median, variance, and standard deviation of the differences in both actual and absolute value terms.

RESULTS

As an introduction, below are two examples of CAPM being radically wrong when calculating a single equity's returns. Figure A (below) compares the "CAPM Line" and actual price history of WMT using daily recalculation, with data taken since 2000. Here, you can clearly see the company underperforming the market growth from 2003 to 2008, rallying during the flight to quality, and then missing out on the market comeback (for industry and company-related factors).

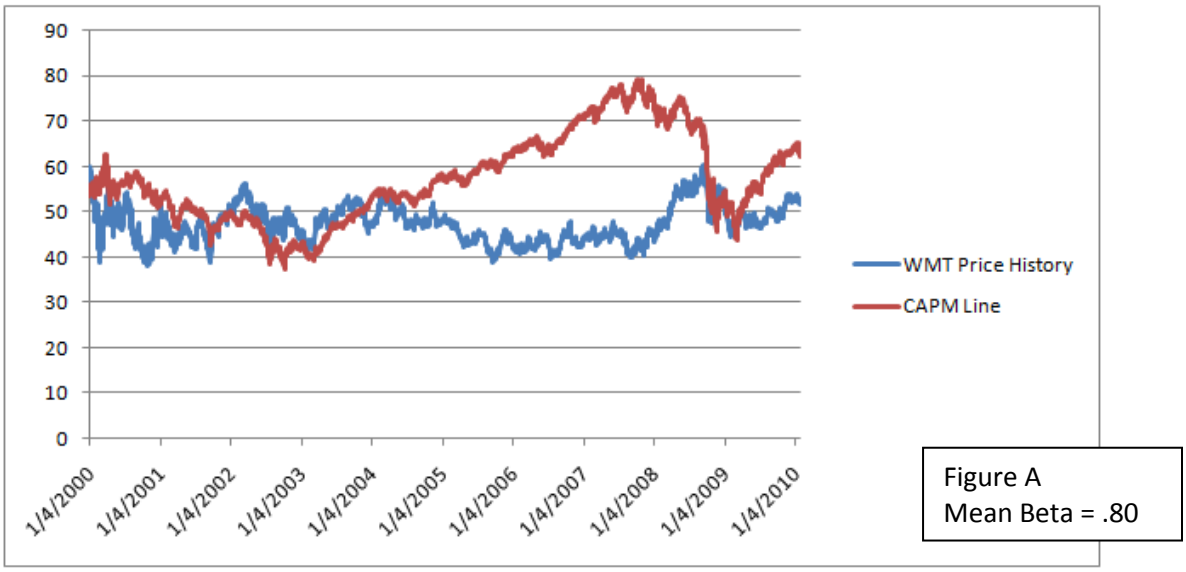

Figure A
Mean Beta = .80

Figure B (below) shows the CAPM and actual line of AAPL's weekly returns using data since 2005. The mean Beta for AAPL during this period was 1.46—though reasonably high, it is nowhere near where it should be to compensate for the explosive growth the company experienced over this time.

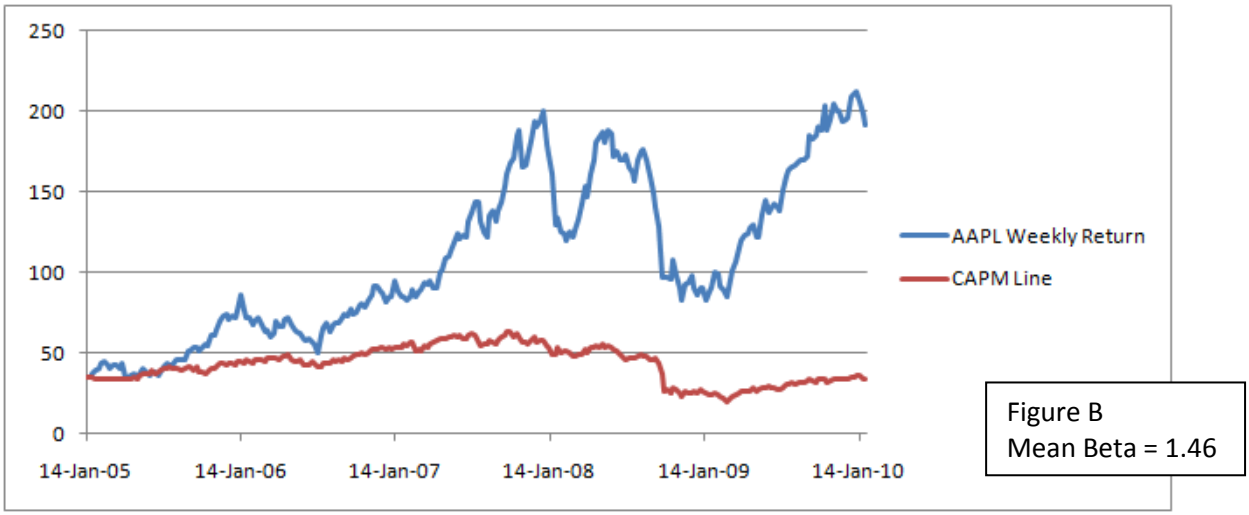

Figure B
Mean Beta = 1.46

Already, from these graphs, two clear trends are beginning to emerge:

1) The actual returns are much more volatile than the CAPM Line.
2) The CAPM Line cannot function as "predictor" for a single equity's returns.

Next, we will look more closely at the returns of KO. Figure C is a scatter plot of the daily returns of KO compared to Rm using all data since 2000, with the average Beta[8] as the line of best fit.

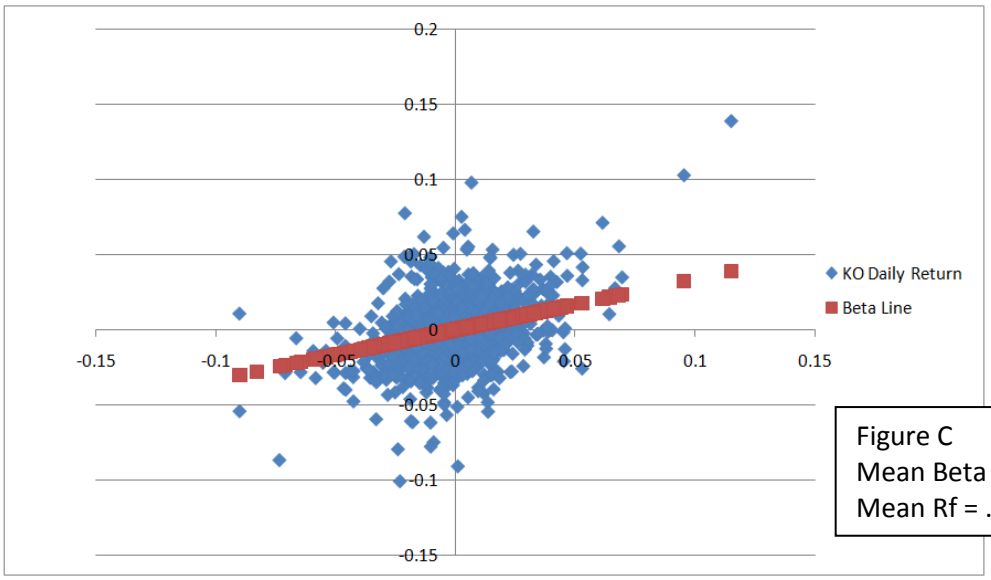

Figure C
Mean Beta = .34
Mean Rf = .0107%/day

This fits the linear requirements of CAPM—that the line of best fit to match the data above is:

Y=mx + b	**Y**=KO return	**m**=Beta
	x=Rm	**b**=Rf

In addition, I found that those same linear requirements are met with literally every other data set I worked with; the "line of best fit" approach works with all other variable combinations. However, this does not mean that CAPM works as a method to track an equity's return in the real world. Statistically speaking, this could be because of problems with compounding interest rates, but that is a discussion outside the scope of this work.

Figure D (on the next page) shows the CAPM Line and the actual daily returns of KO using all the data from 2000, fixed start-date[9]. Again, the actual returns are much more volatile than CAPM would anticipate. I find the same results when looking at other equities and data sets.

[8] This Beta is the mean of all the Betas calculated on a daily rolling basis since 2000 (fixed start-date).
[9] For reference, this is the same chart setup as the WMT chart on page 5.

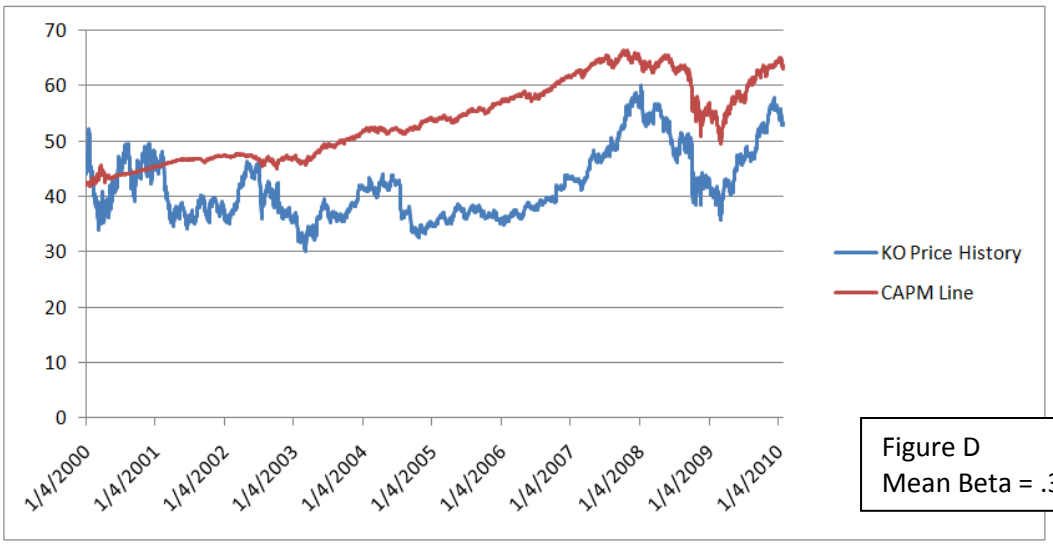

Figure D
Mean Beta = .34

Looking further into the issue of actual versus anticipated volatility, Figures E and F below graph the daily returns[10] of KO and the CAPM Line (respectfully) with the same axes and sizing.

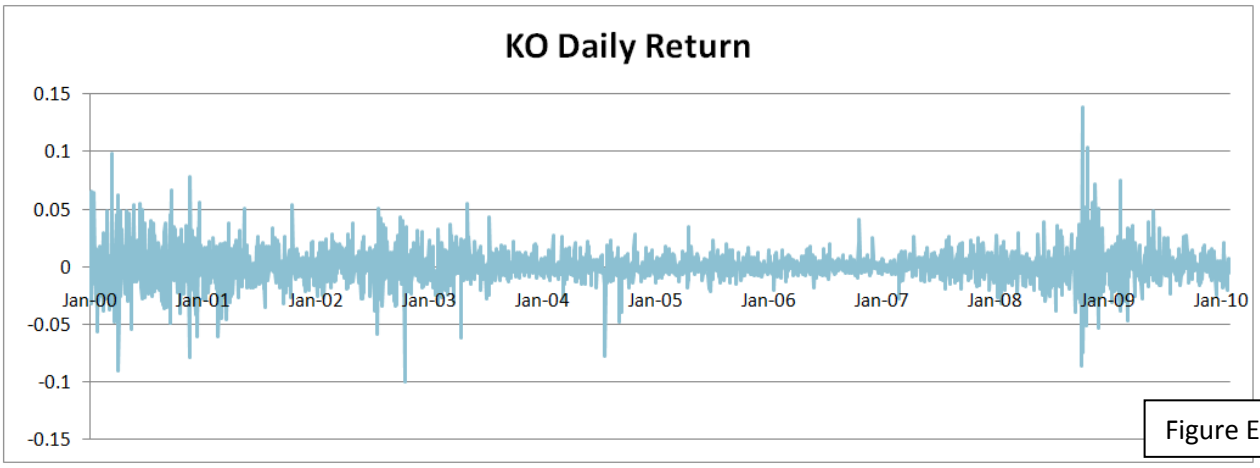

Figure E

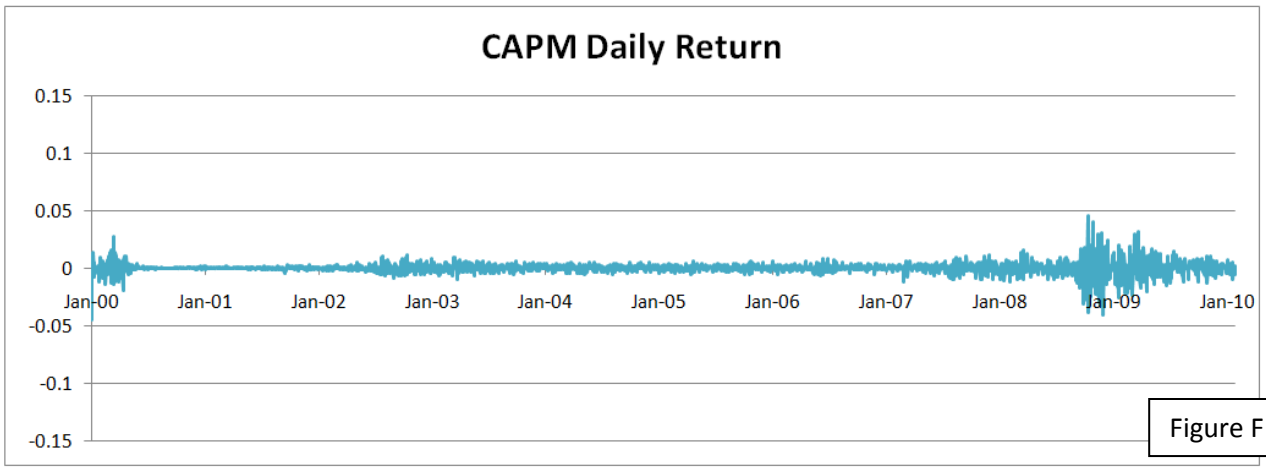

Figure F

[10] With the same variables as Figure D.

Clearly, it's a "tale of two equities". The relatively market-neutral returns of KO give it a Beta so low that CAPM grossly underestimates its actual volatility. Figure G shows the percentage difference between the data in Figures E and F. The difference breaks +/- 1,000% multiple times per year, with highs and lows at +/- 5,000%. These differences may explain why the lines in Figure D diverge so strongly.

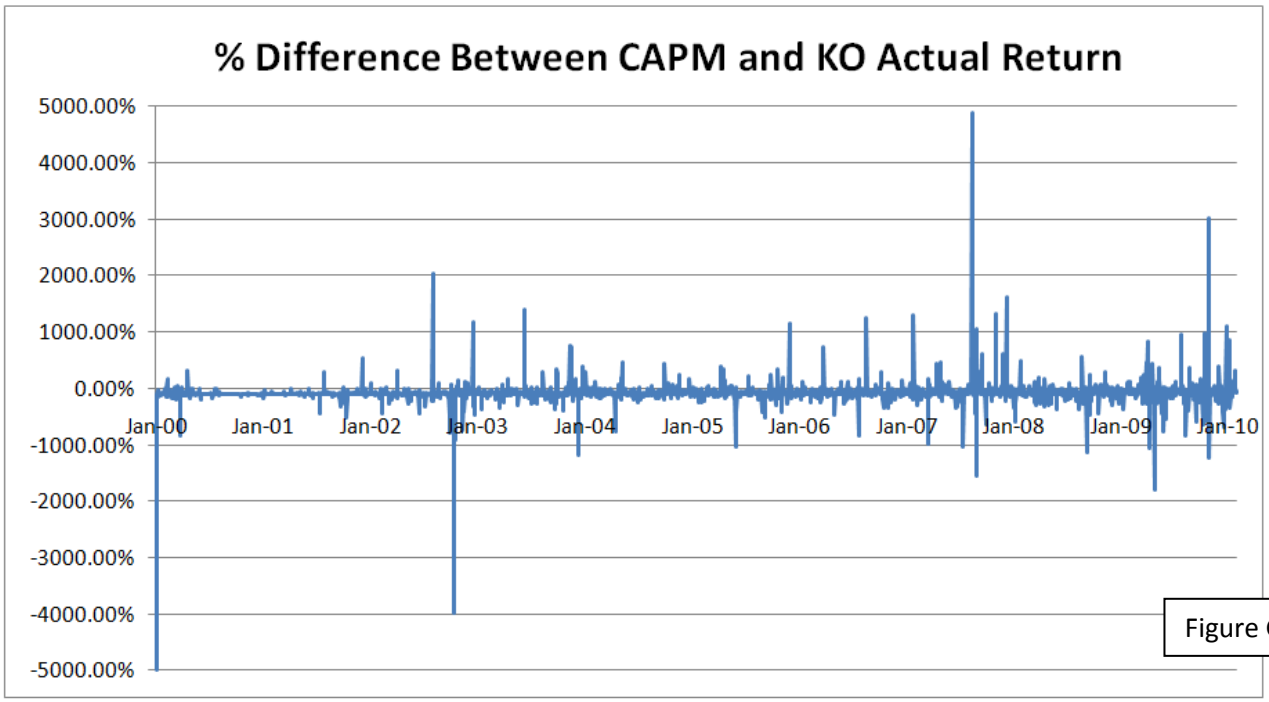

Figure G

Figure H (on page 9) and Figure I (on page 10) show the compiled data charts for KO for all the different combinations of variables discussed in the experimental design. Figure H shows the results of the "fixed start-date" method, while Figure I shows the statistics from the "moving window" approach for calculating Beta. Means and medians under +/- 50% are highlighted red, while standard deviations under 400% are highlighted green.

The CAPM Lines are rarely within any reasonable proximity to the actual returns, both in terms of their averages and its deviations. In addition, for this equity, the statistics are not more accurate when more data is added (looking at monthly versus daily returns, for example). The moving window method appears to have the least accurate averages, but smallest deviations. But overall, any accurate data sets appear to be the result of random chance, with no "trend towards accuracy" emerging.

Figure H: KO Returns – CAPM Statistics

FIXED START-DATE BETA

RECALCULATED:		DAILY									
CALCULATED SINCE:		INCEPTION				2000			2005		1YR
APPLIED SINCE:		INCEPTION	2000	2005	1YR	2000	2005	1YR	2005	1YR	1YR
ACTUAL DIFFERENCES:	MEAN	-68.83%	-54.78%	-24.58%	-31.88%	-81.31%	-66.30%	-61.54%	-48.12%	-53.57%	-60.80%
	MEDIAN	-75.72%	-61.66%	-46.06%	-44.19%	-90.25%	-77.28%	-68.57%	-62.67%	-61.49%	-68.12%
	STD DEV	347.29%	637.11%	555.35%	576.50%	236.19%	251.18%	325.58%	380.69%	391.07%	321.92%
	VARIANCE	1206.09%	4059.05%	3084.10%	3323.48%	557.86%	630.92%	1060.03%	1449.24%	1529.39%	1036.29%
ABSOLUTE VALUE:	MEAN	128.42%	221.85%	202.96%	256.54%	121.47%	125.01%	164.23%	153.59%	186.29%	165.34%
	MEDIAN	84.06%	93.19%	87.99%	97.20%	93.98%	82.91%	86.37%	78.97%	85.21%	86.35%
	STD DEV	329.93%	599.73%	517.48%	517.00%	218.26%	227.71%	287.62%	351.62%	347.82%	282.65%
	VARIANCE	1088.53%	3596.72%	2677.88%	2672.92%	476.39%	518.50%	827.26%	1236.33%	1209.76%	798.93%

RECALCULATED:		WEEKLY									
CALCULATED SINCE:		INCEPTION				2000			2005		1YR
APPLIED SINCE:		INCEPTION	2000	2005	1YR	2000	2005	1YR	2005	1YR	1YR
ACTUAL DIFFERENCES:	MEAN	-58.11%	-36.26%	-25.82%	-150.94%	-80.82%	-74.92%	-126.20%	-54.62%	-129.38%	-112.27%
	MEDIAN	-69.06%	-69.51%	-61.45%	-50.21%	-92.30%	-84.82%	-74.09%	-72.24%	-67.30%	-75.05%
	STD DEV	540.98%	1057.95%	1409.99%	1283.97%	423.83%	570.66%	671.67%	817.96%	847.54%	683.51%
	VARIANCE	2926.64%	11192.60%	19880.82%	16485.69%	1796.32%	3256.49%	4511.45%	6690.56%	7183.31%	4671.84%
ABSOLUTE VALUE:	MEAN	144.63%	282.48%	366.44%	458.32%	151.39%	185.99%	263.93%	246.27%	320.52%	281.16%
	MEDIAN	80.16%	105.69%	103.14%	112.39%	95.37%	90.31%	88.75%	94.21%	98.49%	94.11%
	STD DEV	524.51%	1020.11%	1361.60%	1207.35%	403.99%	544.57%	629.59%	781.77%	794.15%	632.01%
	VARIANCE	2751.16%	10406.32%	18539.63%	14576.92%	1632.12%	2965.61%	3963.82%	6111.70%	6306.81%	3994.34%

RECALCULATED:		MONTHLY									
CALCULATED SINCE:		INCEPTION				2000			2005		1YR
APPLIED SINCE:		INCEPTION	2000	2005	1YR	2000	2005	1YR	2005	1YR	1YR
ACTUAL DIFFERENCES:	MEAN	-77.71%	-107.97%	-36.56%	-113.18%	-79.89%	-87.79%	-107.32%	-65.14%	-111.89%	-129.31%
	MEDIAN	-66.78%	-67.23%	-57.33%	-47.79%	-92.66%	-89.25%	-79.08%	-74.74%	-61.65%	-84.64%
	STD DEV	211.52%	353.85%	212.20%	229.64%	93.63%	62.28%	90.94%	145.95%	171.88%	163.89%
	VARIANCE	447.40%	1252.11%	450.27%	527.37%	87.66%	38.79%	82.70%	213.00%	295.44%	268.62%
ABSOLUTE VALUE:	MEAN	123.64%	180.98%	149.39%	156.48%	105.68%	95.05%	107.63%	116.67%	130.20%	142.59%
	MEDIAN	77.34%	102.05%	91.30%	71.90%	96.71%	89.82%	79.08%	83.02%	80.27%	84.64%
	STD DEV	188.35%	322.39%	153.93%	200.21%	62.76%	50.30%	90.53%	108.50%	157.30%	151.40%
	VARIANCE	354.75%	1039.38%	236.95%	400.86%	39.39%	25.30%	81.96%	117.72%	247.43%	229.21%

Figure I: KO Returns - CAPM Statistics

MOVING WINDOW BETA

TYPE OF CALCULATION:		DAILY						
CALCULED SINCE PREVIOUS:		10 DAYS	22 DAYS	50 DAYS	100 DAYS	252 DAYS	500 DAYS	1000 DAYS
ACTUAL DIFFERENCES:	MEAN	-68.08%	-68.52%	-66.54%	-66.95%	-66.25%	-65.93%	-70.11%
	MEDIAN	-80.73%	-78.55%	-76.04%	-75.41%	-74.61%	-74.95%	-74.70%
	STD DEV	287.53%	288.13%	272.75%	272.80%	262.34%	243.50%	260.82%
	VARIANCE	826.74%	830.18%	743.91%	744.18%	688.24%	592.92%	680.27%
ABSOLUTE VALUE:	MEAN	124.63%	122.12%	120.58%	120.70%	122.07%	122.22%	128.05%
	MEDIAN	88.73%	86.98%	85.26%	85.43%	84.69%	85.62%	84.97%
	STD DEV	267.91%	269.81%	253.53%	253.63%	241.47%	220.68%	237.79%
	VARIANCE	717.74%	727.99%	642.78%	643.30%	583.09%	487.00%	565.44%

TYPE OF CALCULATION:		WEEKLY					
CALCULED SINCE PREVIOUS:		4 WEEKS	9 WEEKS	20 WEEKS	52 WEEKS	104 WEEKS	208 WEEKS
ACTUAL DIFFERENCES:	MEAN	-69.77%	-63.70%	-62.26%	-58.51%	-62.85%	-62.37%
	MEDIAN	-88.03%	-82.36%	-78.96%	-75.84%	-75.79%	-74.48%
	STD DEV	398.29%	353.49%	377.75%	392.55%	409.86%	492.04%
	VARIANCE	1586.39%	1249.56%	1426.95%	1540.92%	1679.82%	2421.00%
ABSOLUTE VALUE:	MEAN	169.63%	152.26%	153.09%	148.52%	153.61%	160.26%
	MEDIAN	96.88%	91.53%	90.21%	86.23%	86.95%	84.31%
	STD DEV	367.03%	325.29%	350.88%	368.03%	385.12%	469.35%
	VARIANCE	1347.11%	1058.15%	1231.19%	1354.44%	1483.20%	2202.87%

TYPE OF CALCULATION:		MONTHLY				
CALCULED SINCE PREVIOUS:		2 MONTHS	5 MONTHS	12 MONTHS	24 MONTHS	48 MONTHS
ACTUAL DIFFERENCES:	MEAN	-122.14%	-77.47%	-81.73%	-77.74%	-79.70%
	MEDIAN	-89.09%	-83.04%	-76.34%	-76.27%	-76.17%
	STD DEV	374.18%	196.86%	153.75%	173.34%	161.07%
	VARIANCE	1400.09%	387.52%	236.39%	300.48%	259.43%
ABSOLUTE VALUE:	MEAN	167.65%	133.59%	119.72%	122.14%	121.94%
	MEDIAN	97.04%	92.45%	85.26%	85.15%	85.41%
	STD DEV	356.05%	163.91%	126.34%	145.40%	131.88%
	VARIANCE	1267.75%	268.66%	159.61%	211.40%	173.92%

Figures J (on page 11) and K (on page 12) are the averages of the results for all ten individual equities[11]. It appears that the averages are more accurate, but the deviations are wider. (In other words, you see a little more red, but a lot less green.) And, the statistics for the "moving window" method appear to be much weaker than before. There appears to be some data supporting the second school of thought for calculating Beta—the idea that data from too early in the company's history can distort your accuracy. Still, as a whole, the relationship between the CAPM Line and the actual data remains weak. The combination of the loose averages and high deviations is simply unacceptable.

[11] Not to be confused with Figures L and M, which apply to the hypothetical portfolio.

Figure J: Average Returns – Average CAPM Statistics

AVERAGE OF INDIVIDUAL STOCKS

FIXED START-DATE BETA

RECALCULATED:		DAILY									
CALCULATED SINCE:		INCEPTION				2000			2005		1 YR
APPLIED SINCE:		INCEPTION	2000	2005	1 YR	2000	2005	1 YR	2005	1 YR	1 YR
ACTUAL DIFFERENCES	MEAN	-65.19%	-57.31%	-46.29%	-66.67%	-66.49%	-58.62%	-69.81%	-53.56%	-67.22%	-65.84%
	MEDIAN	-68.68%	-56.35%	-50.21%	-37.89%	-69.21%	-61.06%	-48.36%	-57.55%	-46.65%	-49.35%
	STD DEV	316.96%	503.30%	545.50%	601.18%	356.83%	428.09%	485.74%	465.55%	498.51%	459.53%
	VARIANCE	1043.85%	2680.78%	3204.95%	4384.48%	1373.43%	2022.63%	2843.17%	2388.38%	2894.89%	2351.51%
ABSOLUTE VALUE:	MEAN	128.02%	184.05%	190.34%	215.48%	144.89%	158.62%	180.01%	165.29%	183.67%	172.09%
	MEDIAN	80.40%	82.29%	81.18%	79.67%	82.13%	78.40%	75.56%	76.93%	74.59%	75.27%
	STD DEV	296.86%	471.78%	513.00%	564.57%	333.08%	401.63%	456.07%	438.35%	468.19%	431.33%
	VARIANCE	922.40%	2367.11%	2855.44%	3935.96%	1207.20%	1803.47%	2559.89%	2143.25%	2599.30%	2107.29%

RECALCULATED:		WEEKLY									
CALCULATED SINCE:		INCEPTION				2000			2005		1 YR
APPLIED SINCE:		INCEPTION	2000	2005	1 YR	2000	2005	1 YR	2005	1 YR	1 YR
ACTUAL DIFFERENCES	MEAN	-60.75%	-49.85%	-32.12%	-21.09%	-64.96%	-51.20%	-27.95%	-47.19%	-25.76%	-16.37%
	MEDIAN	-63.21%	-59.93%	-54.61%	-41.77%	-72.43%	-64.82%	-53.55%	-61.65%	-52.20%	-50.62%
	STD DEV	453.65%	748.97%	845.88%	720.48%	547.60%	648.40%	573.35%	715.27%	634.42%	619.65%
	VARIANCE	2169.93%	6020.96%	8225.57%	7272.19%	3401.35%	5053.05%	4844.32%	6299.79%	6395.93%	6630.94%
ABSOLUTE VALUE:	MEAN	146.46%	217.37%	234.96%	238.78%	168.81%	187.62%	191.89%	200.60%	204.61%	202.91%
	MEDIAN	77.35%	86.42%	83.80%	80.36%	84.74%	80.54%	73.13%	81.46%	74.58%	77.92%
	STD DEV	432.94%	717.23%	812.03%	681.62%	524.10%	621.56%	543.32%	686.95%	602.96%	588.03%
	VARIANCE	1992.22%	5570.37%	7664.80%	6716.38%	3157.73%	4726.32%	4529.39%	5911.24%	6027.87%	6270.66%

RECALCULATED:		MONTHLY									
CALCULATED SINCE:		INCEPTION				2000			2005		1 YR
APPLIED SINCE:		INCEPTION	2000	2005	1 YR	2000	2005	1 YR	2005	1 YR	1 YR
ACTUAL DIFFERENCES	MEAN	-66.23%	-51.33%	-67.41%	92.65%	-65.42%	-86.65%	-14.98%	-97.78%	-12.47%	-15.63%
	MEDIAN	-60.44%	-64.03%	-67.84%	-59.55%	-78.63%	-75.35%	-60.88%	-78.55%	-62.89%	-75.90%
	STD DEV	523.62%	766.96%	793.44%	752.07%	511.00%	486.72%	302.53%	517.14%	325.75%	394.64%
	VARIANCE	3471.23%	8835.09%	11096.56%	16169.55%	3423.71%	3298.71%	1615.87%	4645.89%	1506.38%	2514.34%
ABSOLUTE VALUE:	MEAN	182.55%	275.37%	287.77%	310.21%	198.70%	192.96%	162.33%	193.32%	170.87%	207.27%
	MEDIAN	77.70%	92.91%	92.50%	98.48%	87.86%	84.42%	76.76%	86.10%	79.76%	93.00%
	STD DEV	495.33%	719.73%	740.83%	695.77%	476.21%	454.37%	261.87%	484.82%	281.59%	342.84%
	VARIANCE	3160.25%	7897.21%	9866.38%	14599.46%	3039.09%	2951.57%	1292.08%	4317.41%	1154.72%	1983.03%

Figure K: Average Returns – Average CAPM Statistics

AVERAGE OF INDIVIDUAL STOCKS
MOVING WINDOW BETA

TYPE OF CALCULATION:		DAILY						
CALCULED SINCE PREVIOUS:		10 DAYS	22 DAYS	50 DAYS	100 DAYS	252 DAYS	500 DAYS	1000 DAYS
ACTUAL DIFFERENCES	MEAN	-68.01%	-66.85%	-66.15%	-65.74%	-65.90%	-66.15%	-67.32%
	MEDIAN	-77.99%	-74.67%	-72.25%	-71.56%	-70.64%	-70.32%	-70.00%
	STD DEV	289.41%	287.60%	289.20%	283.06%	285.94%	290.21%	302.67%
	VARIANCE	852.95%	845.53%	862.54%	819.68%	838.82%	868.76%	939.28%
ABSOLUTE VALUE:	MEAN	126.14%	124.10%	123.27%	123.32%	124.79%	126.95%	131.90%
	MEDIAN	87.04%	84.60%	82.88%	82.52%	81.84%	81.79%	82.09%
	STD DEV	269.05%	267.67%	269.46%	262.92%	265.32%	268.88%	280.41%
	VARIANCE	740.42%	736.61%	754.75%	711.21%	726.86%	751.74%	811.15%

TYPE OF CALCULATION:		WEEKLY					
CALCULED SINCE PREVIOUS:		4 WEEKS	9 WEEKS	20 WEEKS	52 WEEKS	104 WEEKS	208 WEEKS
ACTUAL DIFFERENCES	MEAN	-65.35%	-63.63%	-63.08%	-63.22%	-64.76%	-64.25%
	MEDIAN	-83.07%	-75.96%	-71.83%	-68.63%	-68.38%	-67.53%
	STD DEV	587.45%	493.65%	453.91%	434.99%	447.74%	459.52%
	VARIANCE	5119.04%	3154.93%	2317.39%	2064.81%	2190.39%	2288.34%
ABSOLUTE VALUE:	MEAN	172.05%	152.37%	148.39%	148.76%	150.84%	155.82%
	MEDIAN	92.91%	87.11%	83.60%	81.63%	81.51%	80.69%
	STD DEV	562.21%	471.28%	432.38%	412.48%	425.20%	435.79%
	VARIANCE	4862.82%	2961.87%	2137.09%	1883.87%	2005.16%	2087.43%

TYPE OF CALCULATION:		MONTHLY				
CALCULED SINCE PREVIOUS:		2 MONTHS	5 MONTHS	12 MONTHS	24 MONTHS	48 MONTHS
ACTUAL DIFFERENCES	MEAN	-102.29%	-86.70%	-74.58%	-84.01%	-83.85%
	MEDIAN	-82.33%	-79.24%	-72.03%	-71.12%	-70.73%
	STD DEV	650.02%	478.16%	487.31%	446.74%	473.41%
	VARIANCE	4797.95%	2593.46%	2800.34%	2278.68%	2729.70%
ABSOLUTE VALUE:	MEAN	209.61%	180.87%	173.29%	170.66%	181.05%
	MEDIAN	95.45%	90.37%	83.53%	82.49%	82.57%
	STD DEV	623.09%	450.03%	460.66%	420.50%	444.63%
	VARIANCE	4449.30%	2335.88%	2550.11%	2052.51%	2460.21%

Up until this point, I have only explored the data and graphs of individual equities. I find it remarkable that even as I average in the results, the standard deviations remain extraordinarily high, and the means/medians remain stubbornly distant from zero.

However, when you look at the hypothetical portfolio, which invested $10 in each of the ten equities in September 1984, the results are drastically different. Figures L (on page 13) and M (on page 14) speak for themselves. By diversifying company and industry exposure, CAPM works. For both the "moving window" and "fixed start-date" method, nearly all of the medians and most of the means are within the +/- 50% goal. The deviations, however, are surprisingly much broader than they were before. (Now, there's a sea of red, and very little green.)

Figure L: Portfolio Returns – CAPM Statistics

FIXED START-DATE BETA: Hypothetical Portfolio

RECALCULATED:		DAILY									
CALCULATED SINCE:		INCEPTION				2000			2005		1YR
APPLIED SINCE:		INCEPTION	2000	2005	1YR	2000	2005	1YR	2005	1YR	1YR
ACTUAL DIFFERENCES:	MEAN	0.03%	-111.97%	46.36%	-42.11%	-96.72%	14.40%	-52.16%	25.89%	-50.67%	-57.62%
	MEDIAN	-19.42%	-6.13%	-0.31%	15.39%	-33.86%	-23.31%	-4.57%	-15.20%	-2.03%	-14.86%
	STD DEV	10515.66%	5903.95%	2591.94%	702.52%	3905.50%	2066.65%	581.42%	2252.71%	595.52%	518.81%
	VARIANCE	1105791.70%	348566.04%	67181.33%	4935.31%	152529.20%	42710.29%	3380.48%	50747.20%	3546.49%	2691.69%
ABSOLUTE VALUE:	MEAN	458.23%	410.21%	221.97%	180.95%	287.17%	179.39%	148.63%	193.67%	152.27%	134.98%
	MEDIAN	56.91%	59.76%	53.48%	59.95%	53.62%	47.64%	44.65%	47.70%	45.60%	41.66%
	STD DEV	10505.67%	5890.74%	2582.82%	680.03%	3896.12%	2058.89%	564.45%	2244.52%	577.88%	504.19%
	VARIANCE	1103691.63%	347008.04%	66709.73%	4624.37%	151797.79%	42390.29%	3186.02%	50378.53%	3339.48%	2542.10%

RECALCULATED:		WEEKLY									
CALCULATED SINCE:		INCEPTION				2000			2005		1YR
APPLIED SINCE:		INCEPTION	2000	2005	1YR	2000	2005	1YR	2005	1YR	1YR
ACTUAL DIFFERENCES:	MEAN	-8.42%	68.89%	-31.09%	-52.68%	8.36%	-47.31%	-61.93%	-42.78%	-61.37%	-65.21%
	MEDIAN	-18.94%	-13.19%	-10.69%	8.31%	-38.54%	-31.70%	-12.33%	-25.30%	-11.46%	-16.77%
	STD DEV	1084.29%	903.58%	389.98%	646.49%	579.28%	304.70%	524.27%	326.75%	529.77%	501.99%
	VARIANCE	11756.85%	8164.63%	1520.85%	4179.48%	3355.65%	928.40%	2748.64%	1067.64%	2806.54%	2519.97%
ABSOLUTE VALUE:	MEAN	218.54%	261.13%	140.63%	195.49%	185.25%	116.77%	158.32%	122.66%	159.99%	151.66%
	MEDIAN	52.10%	62.10%	52.06%	61.98%	57.48%	51.40%	40.48%	49.48%	39.74%	38.04%
	STD DEV	1062.06%	867.70%	364.97%	617.92%	548.86%	285.30%	503.21%	305.78%	508.34%	482.58%
	VARIANCE	11279.61%	7528.97%	1332.04%	3818.27%	3012.50%	813.99%	2532.25%	934.99%	2584.04%	2328.83%

RECALCULATED:		MONTHLY									
CALCULATED SINCE:		INCEPTION				2000			2005		1YR
APPLIED SINCE:		INCEPTION	2000	2005	1YR	2000	2005	1YR	2005	1YR	1YR
ACTUAL DIFFERENCES:	MEAN	-63.08%	-106.14%	-96.55%	434.42%	-93.62%	-80.69%	294.87%	-53.72%	371.38%	396.80%
	MEDIAN	-15.31%	-9.82%	-19.46%	-3.15%	-53.99%	-41.82%	-30.78%	-37.43%	-15.35%	-26.05%
	STD DEV	650.45%	912.48%	1124.00%	1510.97%	574.05%	773.77%	1119.62%	931.89%	1333.97%	1406.04%
	VARIANCE	4230.91%	8326.14%	12633.66%	22830.16%	3295.39%	5987.19%	12535.45%	8684.27%	17794.86%	19769.51%
ABSOLUTE VALUE:	MEAN	195.04%	290.26%	363.34%	452.84%	189.80%	256.54%	348.22%	268.36%	404.14%	449.41%
	MEDIAN	46.05%	52.19%	47.52%	15.28%	61.94%	63.92%	35.75%	61.78%	23.26%	34.86%
	STD DEV	623.63%	871.22%	1067.07%	1505.10%	549.59%	733.78%	1102.89%	893.38%	1323.62%	1388.66%
	VARIANCE	3889.18%	7590.20%	11386.29%	22653.14%	3020.51%	5384.28%	12163.73%	7981.23%	17519.61%	19283.85%

Figure M: Portfolio Returns –CAPM Statistics

MOVING WINDOW BETA: Hypothetical Portfolio

TYPE OF CALCULATION:		DAILY						
CALCULED SINCE PREVIOUS:		10 DAYS	22 DAYS	50 DAYS	100 DAYS	252 DAYS	500 DAYS	1000 DAYS
ACTUAL DIFFERENCES:	MEAN	19.74%	-33.13%	-29.02%	-12.98%	-2.84%	22.20%	39.06%
	MEDIAN	-36.99%	-32.12%	-29.58%	-29.17%	-28.51%	-28.36%	-27.32%
	STD DEV	7917.63%	6694.56%	7744.54%	7210.63%	7421.81%	8779.15%	10566.48%
	VARIANCE	626889.31%	448171.23%	599778.75%	519932.19%	550833.11%	770734.33%	1116505.22%
ABSOLUTE VALUE:	MEAN	339.09%	345.47%	370.73%	345.66%	351.37%	373.16%	424.63%
	MEDIAN	56.77%	54.92%	55.11%	54.61%	54.66%	54.82%	55.62%
	STD DEV	7910.39%	6685.72%	7735.71%	7202.35%	7413.49%	8771.24%	10558.02%
	VARIANCE	625743.21%	446988.54%	598412.55%	518738.88%	549598.37%	769346.57%	1114717.08%

TYPE OF CALCULATION:		WEEKLY					
CALCULED SINCE PREVIOUS:		4 WEEKS	9 WEEKS	20 WEEKS	52 WEEKS	104 WEEKS	208 WEEKS
ACTUAL DIFFERENCES:	MEAN	-42.73%	-39.05%	-35.19%	-34.92%	-28.66%	-36.26%
	MEDIAN	-48.11%	-36.02%	-31.98%	-29.02%	-29.77%	-29.35%
	STD DEV	867.26%	818.39%	1027.20%	1127.55%	1012.18%	1091.12%
	VARIANCE	7521.41%	6697.55%	10551.48%	12713.68%	10245.06%	11905.43%
ABSOLUTE VALUE:	MEAN	171.24%	170.11%	185.28%	194.50%	198.74%	207.88%
	MEDIAN	65.05%	57.16%	53.99%	52.37%	53.36%	53.28%
	STD DEV	851.25%	801.45%	1010.96%	1111.18%	992.87%	1071.73%
	VARIANCE	7246.22%	6423.22%	10220.33%	12347.29%	9857.99%	11486.08%

TYPE OF CALCULATION:		MONTHLY				
CALCULED SINCE PREVIOUS:		2 MONTHS	5 MONTHS	12 MONTHS	24 MONTHS	48 MONTHS
ACTUAL DIFFERENCES:	MEAN	-56.85%	-64.32%	-69.53%	-67.77%	-70.51%
	MEDIAN	-58.29%	-42.60%	-34.16%	-34.03%	-28.68%
	STD DEV	455.75%	571.00%	546.85%	577.42%	607.30%
	VARIANCE	2077.11%	3260.36%	2990.47%	3334.18%	3688.13%
ABSOLUTE VALUE:	MEAN	153.31%	160.99%	166.31%	176.57%	189.23%
	MEDIAN	68.38%	57.44%	50.32%	49.67%	50.01%
	STD DEV	432.86%	551.53%	525.50%	553.84%	581.25%
	VARIANCE	1873.71%	3041.82%	2761.46%	3067.37%	3378.54%

Figure N (below) shows both the actual and CAPM-based returns of the portfolio since its inception[12].

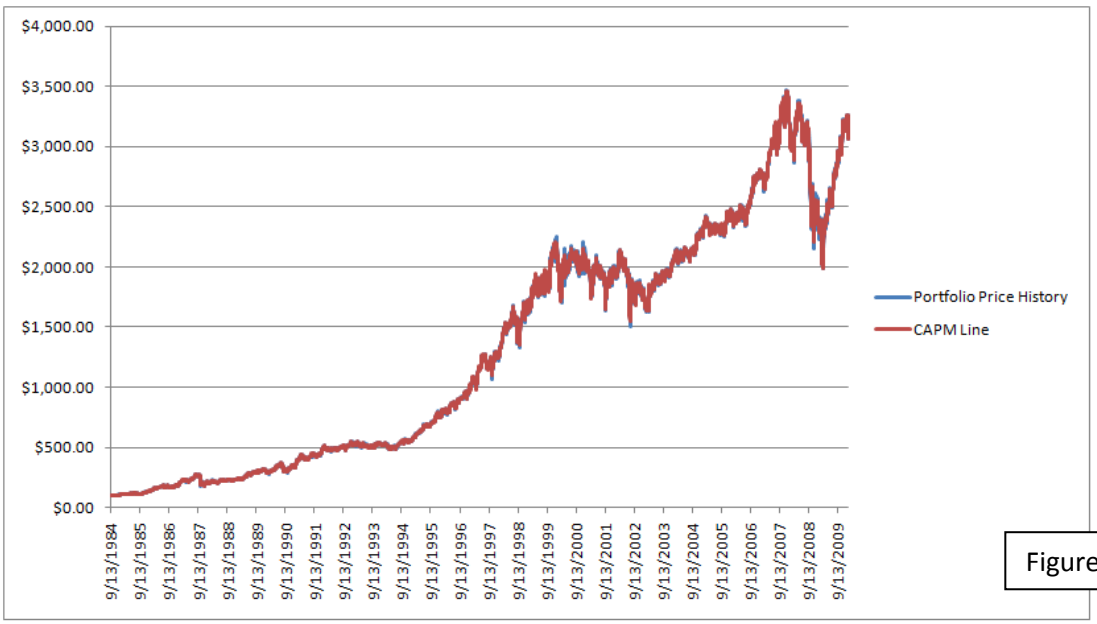

Figure N

[12] The actual inception date was 9/11/1984, but there needs to be two past days of data to calculate Beta.

Initially, it looks like only the red line is showing in figure N. Figures O and P are enlarged portions of Figure N over 1999-2001 and 2007-2009 (respectfully); with a closer look, you can see the blue line.

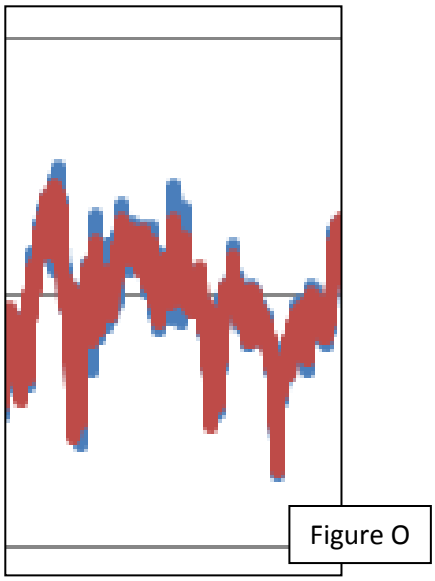

Figure O

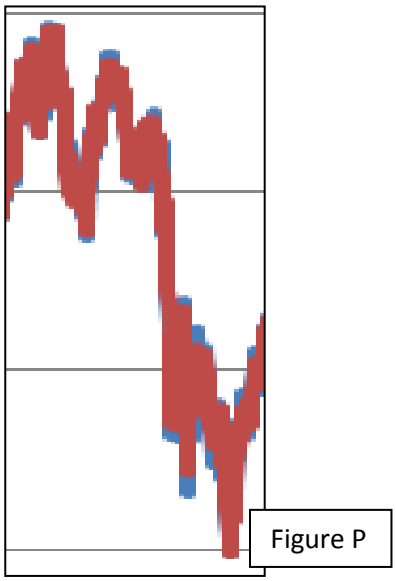

Figure P

The CAPM Line and actual historical lines are nearly identical. They have remarkable similarities, though the actual data (blue) is more volatile than the CAPM Line (red). The mean difference between the two lines is .03%, but the standard deviation of the difference is over 10,500%. Figure Q (below) shows the percentage difference between the two sets of data.

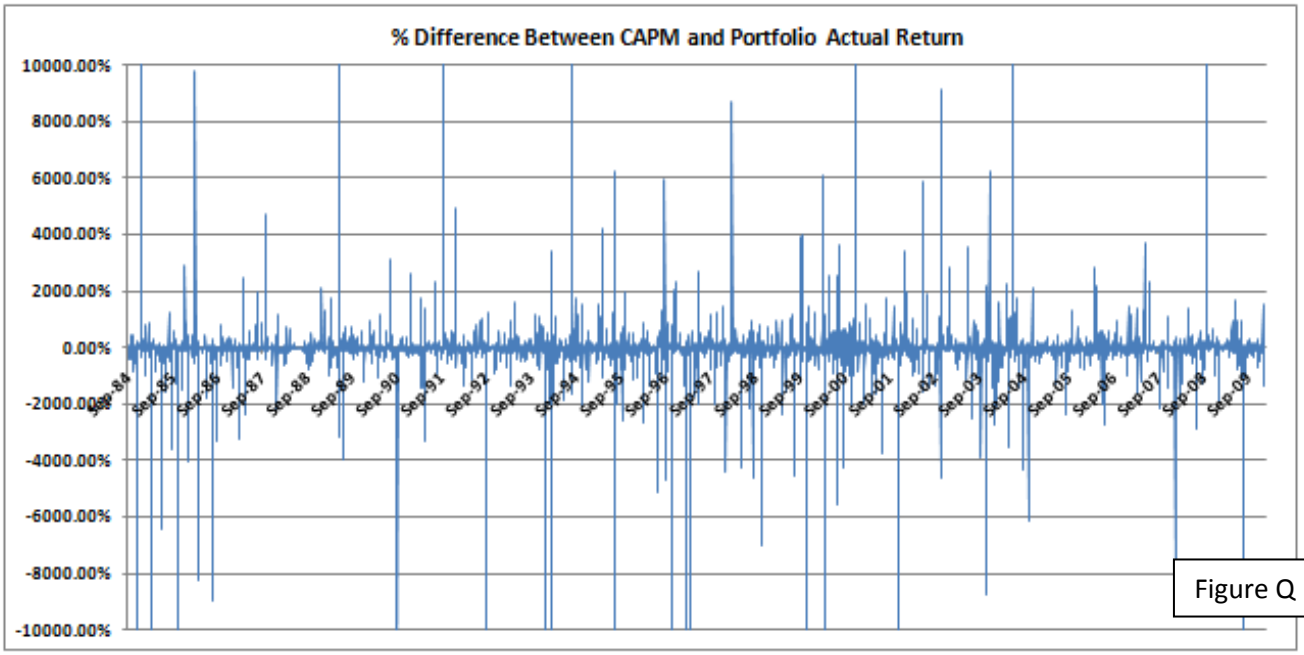

Figure Q

Figure R is the same graph as Figure Q, but with a much larger axis.

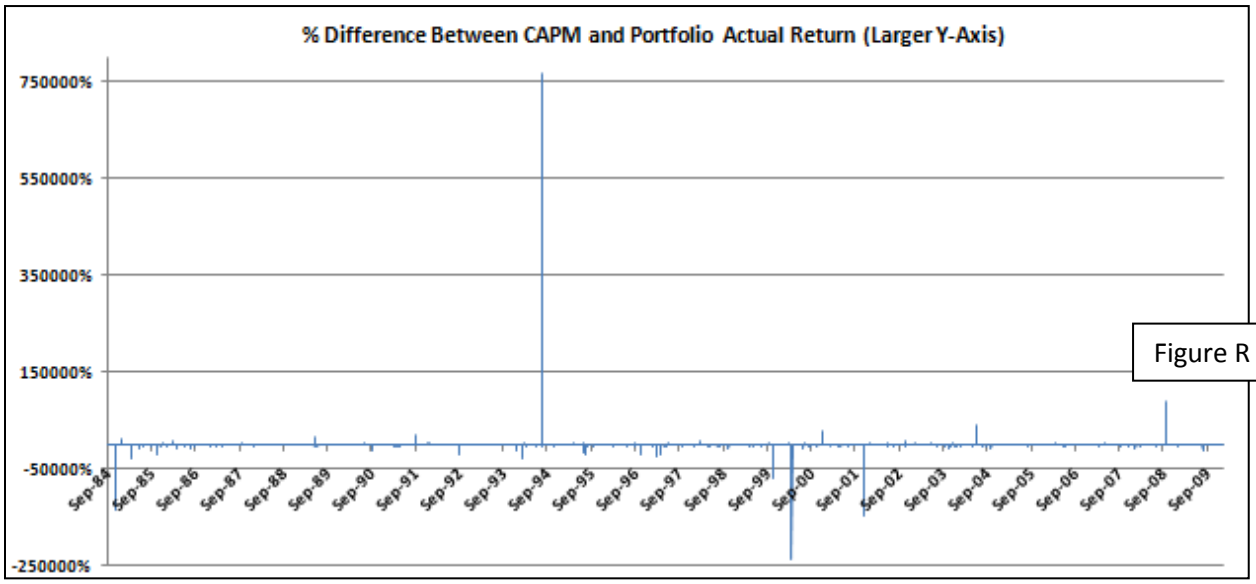

Figure R

This appears to be an instance in which the extreme outliers are heavily skewing the data. Figure Q shows a high of 750,000% and a low of -250,000%. Figure R shows roughly twenty-five occasions in which the difference approaches or surpasses +/- 10,000%, but considering that there are over 6,400 points of data, that doesn't seem entirely unreasonable.

For the sake of comparison, Figure S shows the CAPM and Portfolio History Lines over the same time period as the earlier charts for WMT and KO (Figures A and D, respectfully).

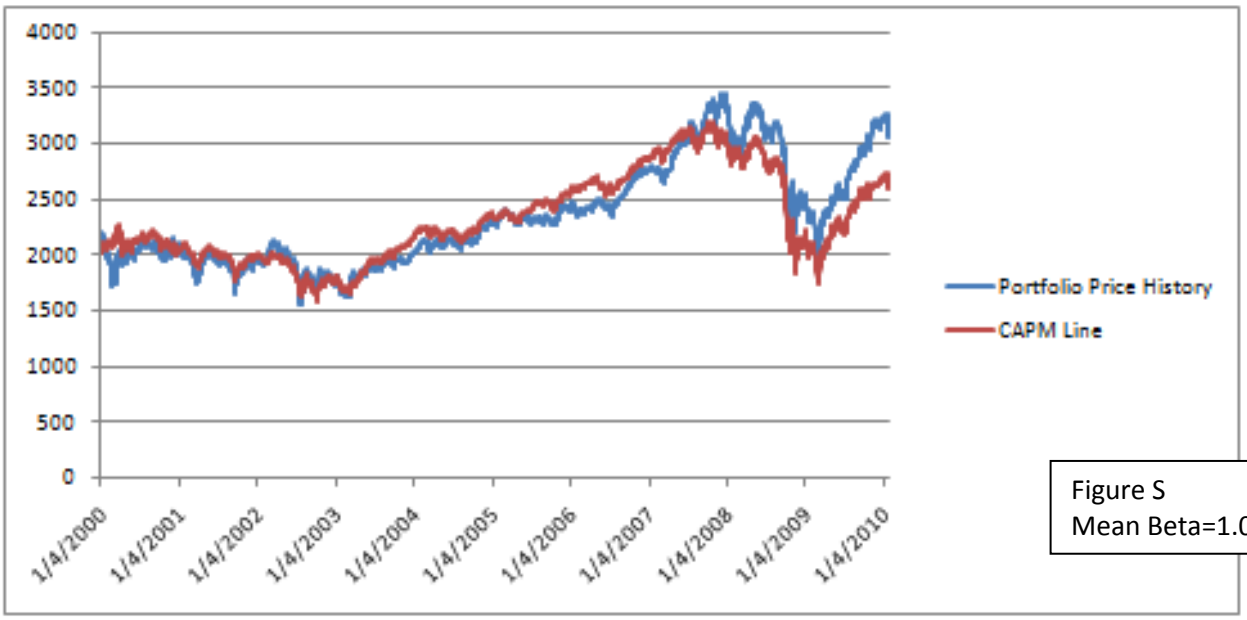

Figure S
Mean Beta=1.04

The comparative statistics for the differences between the lines in Figures S and D are:

	Figure S (Portfolio)	**Figure D (KO)**
Mean:	-96.72%	-81.31%
Median:	-33.86%	-90.25%
Std. Dev:	3,905.50%	236.19%

In statistical terms, Figure S's data is not strikingly more accurate than Figure D's. Yet, it is safe to say the CAPM Line in Figure S is much more "visually" appropriate. In other words, using CAPM and Rm, you would have been much more successful tracking the returns of the portfolio than with KO's returns.

CONCLUSION

The Capital Asset Pricing Model works in the real world, so long as you are sufficiently diversified. The consistently small mean and median differences between the CAPM-generated lines and the actual lines in hypothetical portfolios show evidence that CAPM works; this holds true in over forty of the forty-eight ways I tested CAPM with the portfolio. And though the data returned exorbitantly high standard deviations, it appears to be skewed by outrageous outliers; the data as a whole retains strong integrity, and the CAPM Lines graphically match the historical lines with surprising accuracy. However, using CAPM to try and model an individual equity does not work; if it does work, then it is pure luck. The specifications that allow CAPM to be an appropriate predictor of returns for some equities will not work for others.

Further research should be done to try and define at what point a portfolio is diversified enough so that CAPM will work as a predictor—my research could only show that while it *cannot* work for individual equities, it *can* work for a portfolio. In addition, more research needs to be done to find the "best" way to calculate Beta, or examine if such a universally "best" way exists. From my research, I believe that diversification is more important than any particular method of calculating Beta—moving window, fixed start-date, five years back, ten years back, etc. If you have minimal company-specific and industry-specific exposure, then you *can* model the expected returns of a portfolio based on the Capital Asset Pricing Model.