Paper 199-29

Risk Management : Using SAS to Model Portfolio Drawdown, Recovery, and Value at Risk

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ABSTRACT

Portfolio risk management is an art and a science that is critical to maintaining and understanding financial instruments. While drawdown, recovery, and value at risk (VAR) refer to standard monitoring devices in the industry, there is little clarity on the approaches used for each. Comparing established approaches like risk metrics that are based on historical correlations, with newer approaches using a layered boot strap of historical data can reveal discrepancies.

INTRODUCTION

" What was the biggest loss?" Drawdown is defined as the relative equity loss from the highest peak to the lowest valley of a price decline within a given window of observation. " How long did it take to recover those losses?" The time that it takes to recover from that drawdown is called a recovery. " What might I typically lose tomorrow?" Value at risk measures the maximum expected loss for a given portfolio in a given holding period at a given confidence level. " What could I lose in a worse case scenario?" A newer metric called a Crash Kappa can provide insights to this question.

Using SAS (%MACRO, STAT, GRAPH), to model drawdown and recovery reveals discrepancies between the observed distribution and the normal distribution. This argues strongly that empirical distributions should be used for the drawdown measurements of the strategies. These discrepancies also suggest that empirical distributions are probably necessary for other measures of risk, like value at risk (VAR), and the crash Kappa.

DRAWDOWN

The SAS calculation of drawdown is relatively simple, although the %MACRO code doesn't suggest that. We calculated drawdown for 2 days, 5 days (1 week), 20 days (1 month), and 60 days (1 quarter), as held by the macro variable &W.

```
%DO A = %EVAL((%SCAN(&W,&C)) %TO 1 %BY  -1;
 %DO B = %EVAL(&A -1) %TO 1 %BY -1;
A&A.B&B = (LAG&B(sp500) -LAG&A(sp500))/ LAG&A(sp500);
 %END;
%END;

DRAW = MIN(A%EVAL(%SCAN(&W,&C))B%EVAL((%SCAN(&W,&C))  -1)
%DO A = %EVAL((%SCAN(&W,&C)) %TO 1 %BY  -1;
 %DO B = %EVAL(&A -1) %TO 1 %BY -1;
 ,A&A.B&B
 %END;
%END;
);

P0 = sp500;
%DO A = 1 %TO %SCAN(&W,&C);
 P&A = LAG&A(DOLLAR%SCAN(&Y,&D));
%END;

PEAK = MAX(P0
 %DO A = 1 %TO %SCAN(&W,&C);
 ,P&A
 %END;
 );
```

.

```
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.

%DO E = 300 %TO 1 %BY  -1;
 IF LAG&E(DOLLAR%SCAN(&Y,&D)) GE PEAK THEN RECOVER = &E;
%END;
```
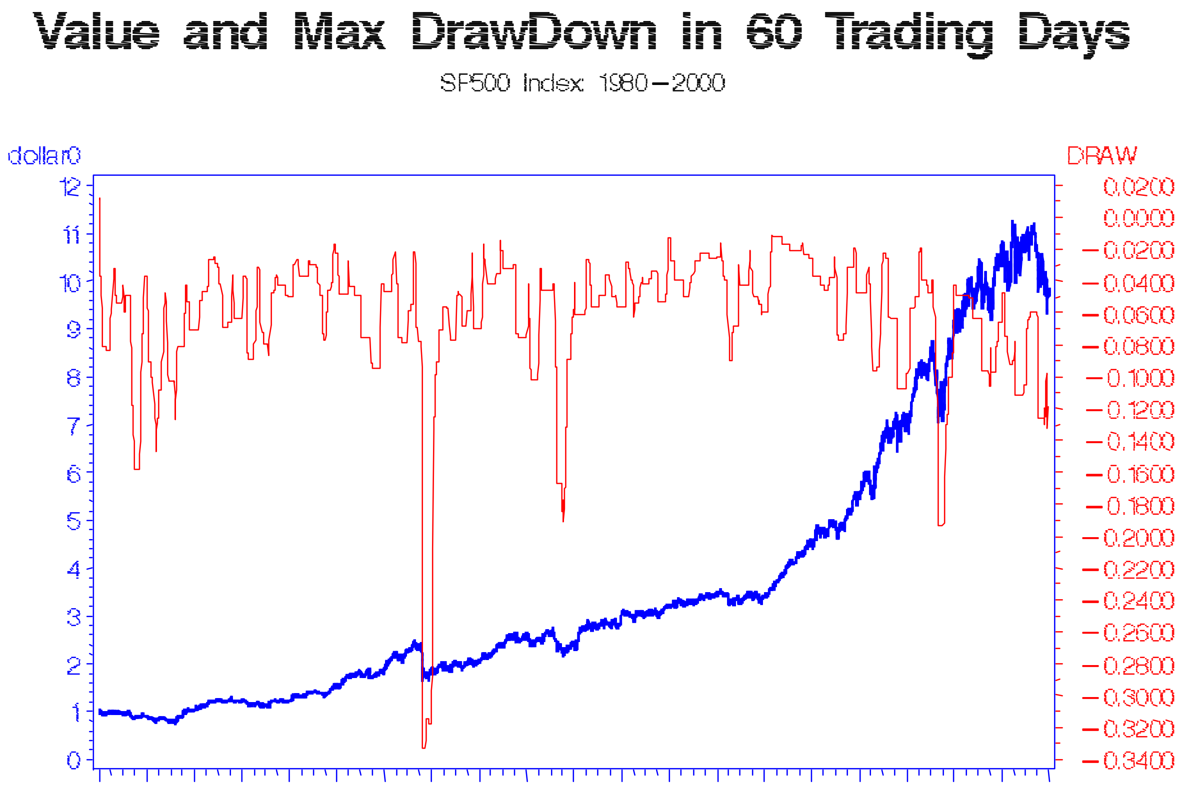

Figure 1 shows both the daily close price as well as the maximum drawdown for the Index over the 21 year period. Note that the value axis ranges from $1 to $12 assuming that you invested just one dollar from the start. On the right hand axis, percent drawdown ranges from –34% to 2%. This figure is very informative in terms of the frequency and depth of drawdown that is likely to be experienced.

```
proc gplot;
TITLE1 "Max DrawDown and Recovery in %SCAN(&W,&C) Trading Days";
TITLE2 "Strategy: %SCAN(&V,&D) 1981 -2000";
   plot DRAW * DATE /
      haxis=axis1
      vaxis=axis2
      frame
      ;
   plot2 RECOVER  *  DATE /
      vaxis=axis3
      ;
```

Figure 1. S&P500 Index daily close price (blue), and percent maximum drawdown (red) in rolling quarters from 1980 to 2000.



Several observations can be made from the Index analysis alone. The percent drawdown has a clustering that looks a little Gaussian on the right hand side of the distribution in Figure 2. Table 1 describes the important moments in the distribution, which is definitely not normally distributed.

Figure 2. Density function of percent maximum drawdown of S&P500 Index from 1990 to 2000.

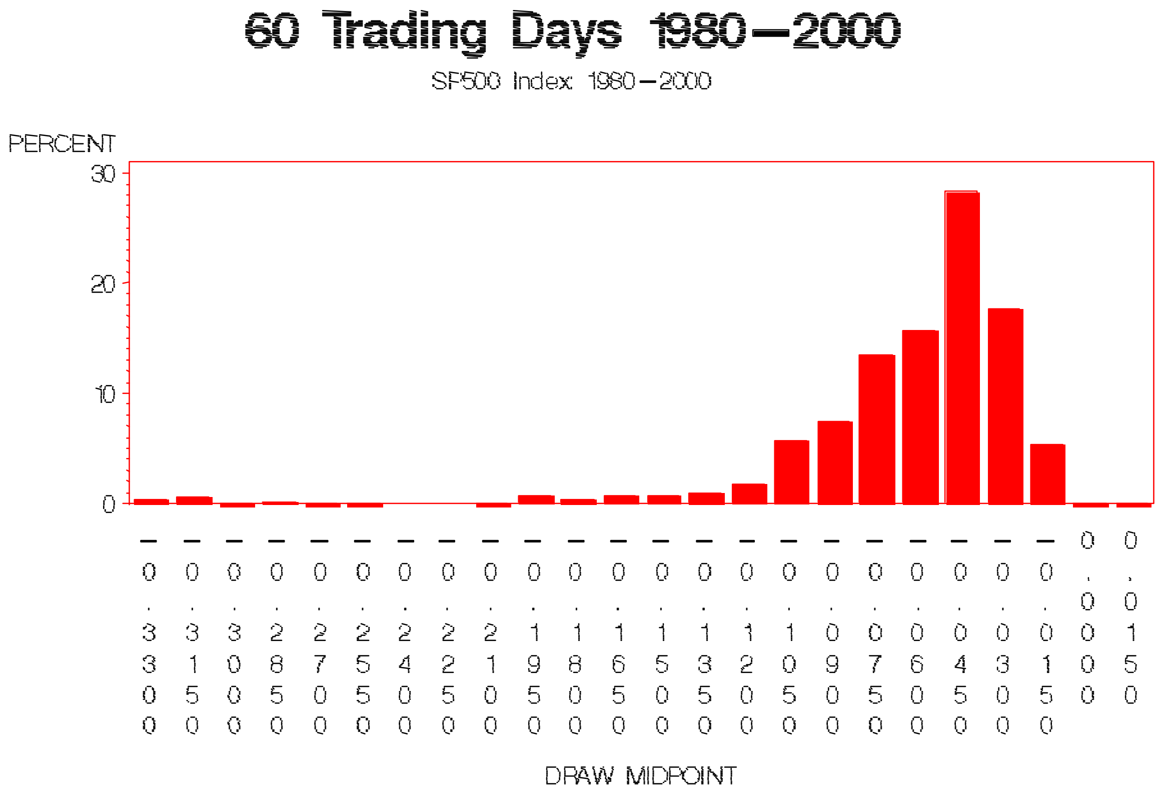


Table 1. Descriptive statistics of the maximum quarterly drawdown of the S&P500 Index from 1990 to 2000.

N	5051
Mean	-0.0624893
Std Deviation	0.0416796
Skewness	-3.16897
Uncorrected SS	28.4965358
Coeff Variation	-66.698756
Sum Weights	5051
Sum Observations	-315.63358
Variance	0.00173719
Kurtosis	15.4108872
Corrected SS	8.77280605
Std Error Mean	0.00058646

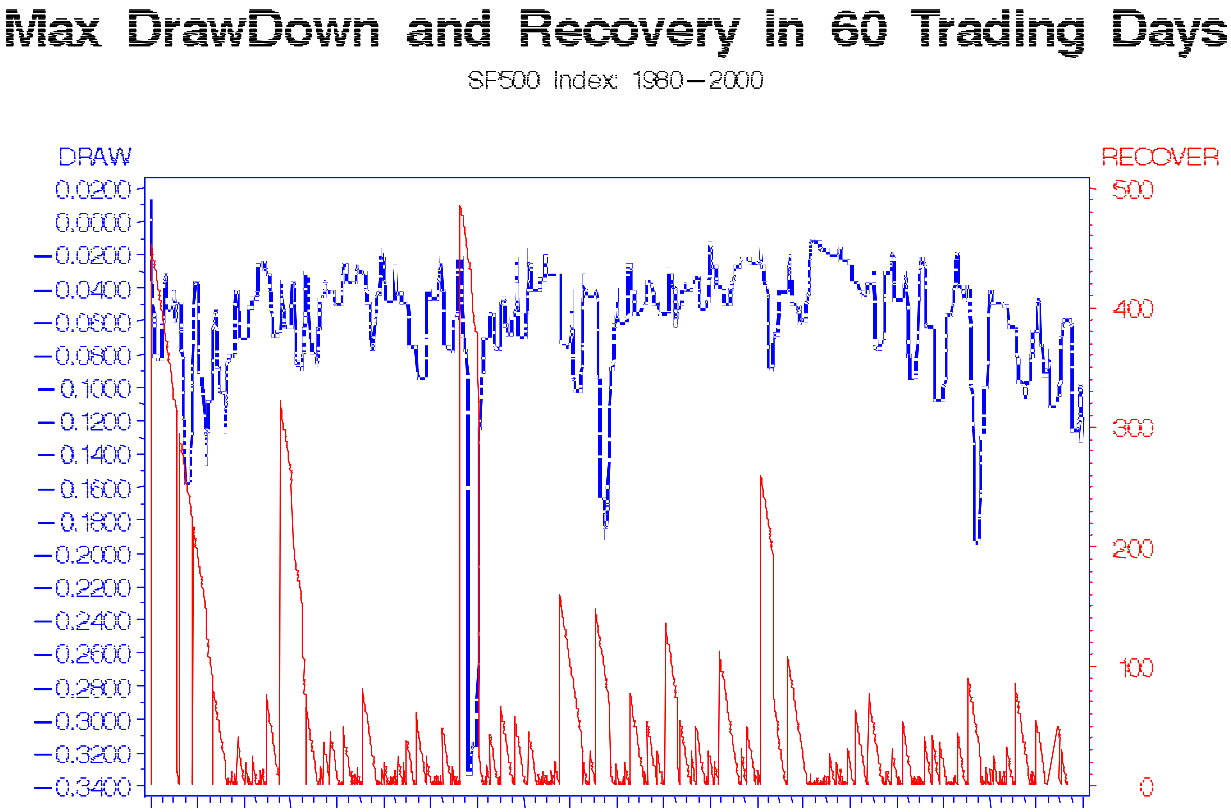
Table 2 describes the quantiles of the distribution. For monitoring purposes we will focus on the 1st and 99th quantiles which provide a 98% observation interval around the data (-0.012, -0.29).

Table 2. Quantiles of the maximum quarterly drawdown of the S&P500 Index from 1980 to 2000.

Quantile	Estimate
100% Max	0.0119554
99%	-0.0122718
95%	-0.0216696
90%	-0.0265504
75% Q3	-0.0392829
50% Median	-0.0505389
25% Q1	-0.0754761
10%	-0.1020601
5%	-0.1255877
1%	-0.2985402
0% Min	-0.3323633

Figure 3 shows the drawdown plotted against the time to recovery from the peak.

Figure 3. S&P500 percent maximum drawdown (blue) and days to recovery 9red) in rolling quarters from 1980 to 2000.



The density function of the recovery period shows that there are plenty of drawdown events that require a year or more to recover. Figure 4 shows the temporal relationship between these events. It seems as if drawdown of 15% to 20% takes about a year to recover, except for the crash in 1997 which took little recovery time. Deeper drawdown, greater than 20%, which only occurred in 1987, required almost 2 years of recovery time.

Figure 4. Density function of recovery time of S&P500 Index from 1980 to 2000.

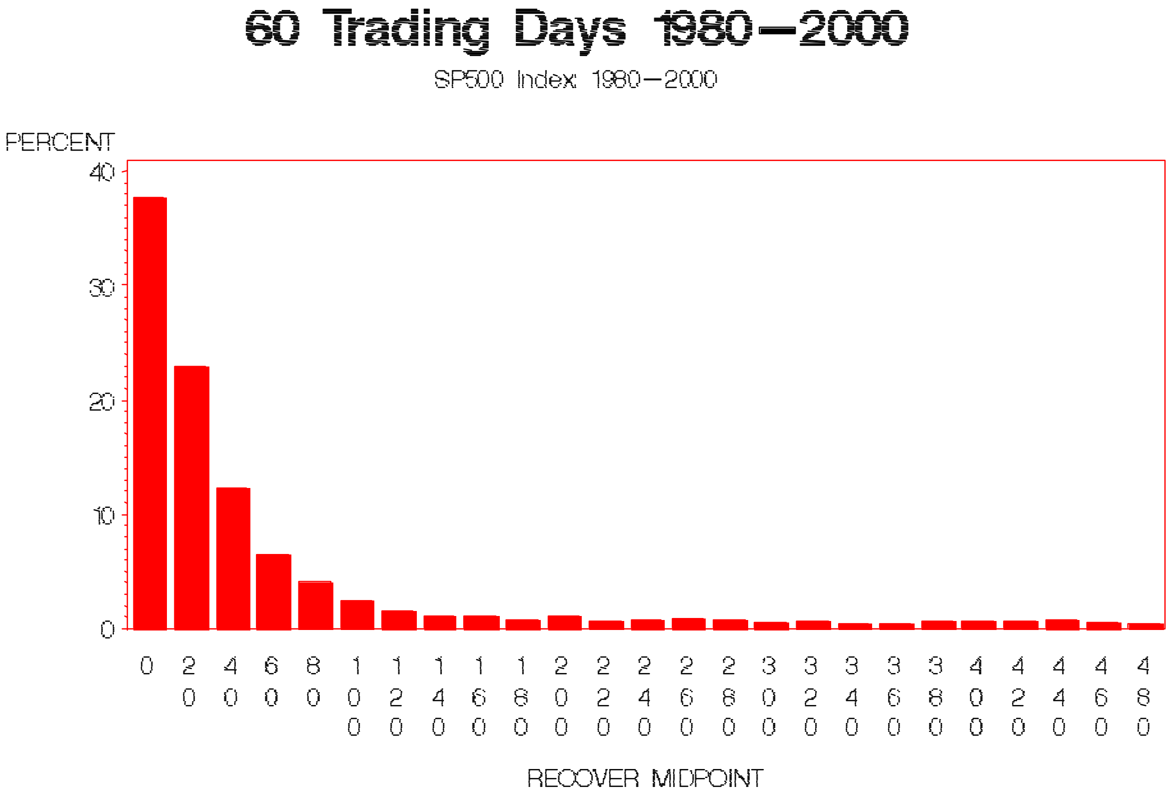


Table 3. Descriptive statistics of the recovery time of the S&P500 Index from 1980 to 2000.

N	4908
Mean	57.643643
Std Deviation	97.9578726
Skewness	2.55813449
Coeff Variation	169.936991
Variance	9595.7448
Kurtosis	6.05581948
Std Error Mean	1.39825721

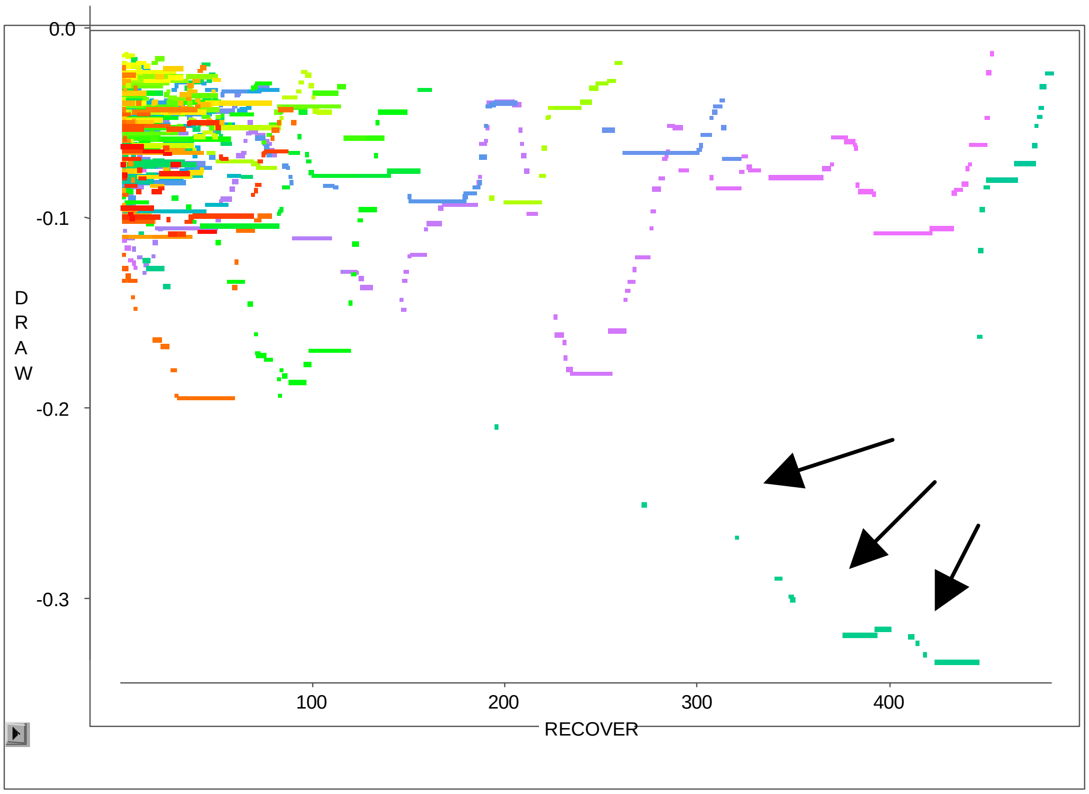
Table 4 provides the quantiles which have more positive and negative extremes. Overall, the maximum recovery time was 485 days or nearly two years.

Table 4. Quantiles of the recovery of the Index from 1980 to 2000.

Quantile	Estimate
100% Max	485.0
99%	445.0
95%	311.0
90%	183.0
75% Q3	55.0
50% Median	18.5
25% Q1	4.0
10%	1.0
5%	1.0
1%	1.0
0% Min	1.0

Figure 5 cuts to the heart of the matter. While the two measures, drawdown and recovery are not well correlated, the greatest drawdowns are associated with some of the greatest recovery periods as pointed out by the arrows in the lower right hand portion of figure 5.

Figure 5. Drawdown by recovery for the S&P500 index in rolling quarters from 1980 to 2000 (time is graded color).



VALUE AT RISK (VAR)

Value At Risk (VAR) is calculated in one of three ways:

1. Historical return & parametric inference
2. Historical correlations & parametric inference
3. Monte Carlo & parametric inference.

The code that follows can be used to calculate VAR using the first two methods.

```
PROC IML;
USE MATRIXV;
READ VAR _NUM_ INTO V;
 PRINT V;
 USE MATRIXC;
READ ALL VAR _NUM_ INTO C;
 PRINT C;
 X = V*C;
 PRINT X;
 W=T(V);
 PRINT W;
 Y = X*W;
 PRINT Y;
 Z = SQRT(Y);
 PRINT Z;

 CREATE VARDIV FROM Z[COLNAME="VAR"];
 APPEND FROM Z;
```

Figure 6. Daily asset value with tomorrow's lower boundary 95% confidence interval of VAR($) estimated from the undiversified analysis (method I: red) and diversified analysis (method II: green).

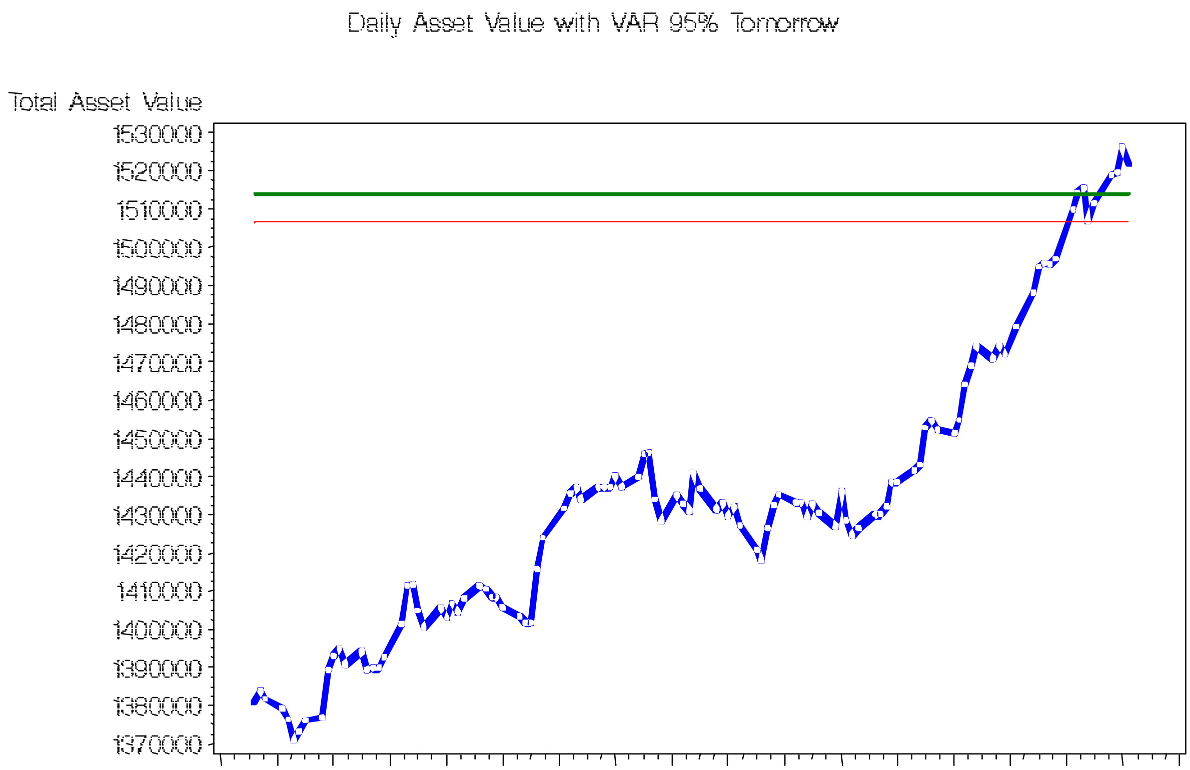
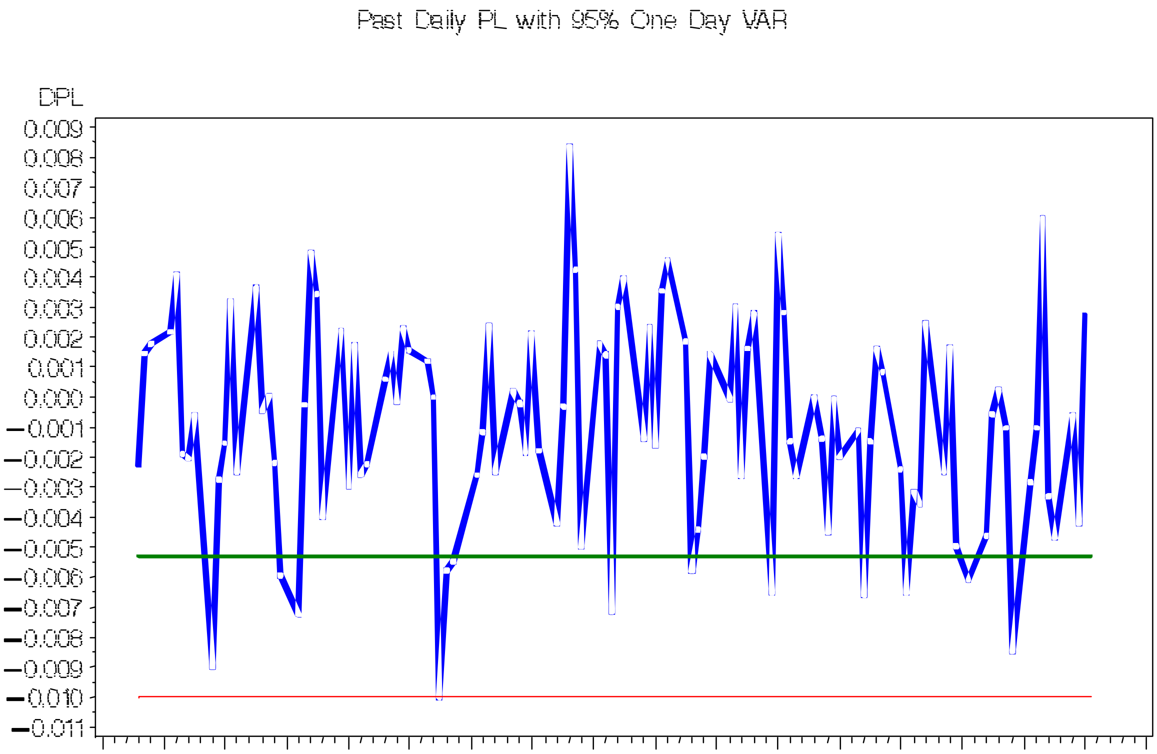


Figure 7. Log(daily return) with the lower boundary 95% confidence interval of VAR(%) boundaries estimated from the undiversified analysis (method I: red) and diversified analysis (method II: green).



Several conclusions can be made from figure 7. Mostly one notices that the undiversified asset approach leads to many exceptions, and this presentation will include discussion of the Kupiec test which quantifies the probability of exceptions.

CRASH KAPPA

Extreme markets require extreme calculations. In order to predict behavior during extreme market conditions, one needs to constrain the sample to extreme conditions. This can be done with the Crash Kappa, where the analytic sample is confined to those days of +/- 3% change. The code for such estimates will be described in detail during the presentation.

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