Market Insight

2013 Year in Review: Risk Model Backtesting

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Abstract:

In this Market Insight, we present the results of an annual backtesting study, using RiskManager, applied to four standard risk models. The scope of the study includes fixed income and equity portfolios during the period January to December 2013. While the first half of 2013 was quiet, volatility increased after June 2013. For fixed income portfolios, comparing ex-ante risk forecasts with ex-post returns, the more reactive models showed some underestimation of risk in the turbulent period. The more stable historical model on average produced better forecasts (thanks to the 2008 crisis data being included). For equity portfolios, the least responsive model overestimated risk throughout 2013, while the more reactive models performed better. Looking back over the past three years of these backtesting studies, and accounting for both over and underestimation of risk, we see that different models have performed best in different years. This raises both immediate practical implications and longer term questions, which we discuss in the conclusion.

Why This Matters:

- There is continuing industry demand for transparent standards for risk model performance, and MSCI's annual backtesting of standard models provides a useful context for clients performing their own tests.
- There are various ways to test any model, and one should not reject a model because of poor performance during a particular year, since any period chosen to calibrate and assess a model will affect the results.
- MSCI's backtesting and exceedance statistics for the past three years enable comparisons across time and changing market regimes, and these results show the value of not relying on a single model alone.

Introduction

This is the third consecutive year that we have produced a backtesting paper that reviews the performance of standard risk models on a variety of fixed income and equity indices. One of the main aims, in addition to the general importance of MSCI assessing the performance of its own models, is to provide these results as a context for risk managers completing their own model assessments. In this Market Insight, we present the results of a backtesting exercise performed using RiskManager on a variety of fixed income and equity indices, utilizing four different risk models, all for the year 2013. The backtesting results include exceedance and backtesting statistics.

The first half of 2013 was relatively quiet and volatility started to increase in the second quarter. None of the models in this study performed equally well for the fixed income and equity portfolios. For the fixed income portfolios, comparing ex-ante forecasts with ex-post returns, we found that the more reactive models show some underestimation of risk in the turbulent period. By comparison, the more stable historical model on average produced acceptable forecasts: it slightly overestimated risk in the first few months of 2013, but overall the model benefited from keeping the 2008 crisis data in the rolling window of the sample. For equity portfolios, the stable models overestimated VaR throughout 2013, and the more reactive models performed better.

Description of the Backtesting Procedure

The models we tested are described as follows:

mc94 A model in which risk factor returns are generated from a Monte Carlo procedure using a Gaussian distribution, with volatilities and correlations forecast using an exponentially weighted moving average on historical daily returns, applying a decay factor of 0.94.

mc97 In this model, risk factor returns are generated in a similar fashion as the above model, but a decay factor of 0.97 is applied.

hist1y This is an implementation of historical simulation, using a trailing window of one year of equally weighted daily historical returns.

hist5y This model implements historical simulation on five years of weekly historical returns, scaled to produce a VaR for a one-day analysis horizon. We use overlapping returns to smooth out any weekly cyclical effects.

To test model performance formally, we run the standard analysis of counting VaR exceedances, that is, counting the days when the portfolio loss exceeded the VaR forecast. The period January 1, 2013 to December 31, 2013 contained 261 trading days, so for 99 percent VaR, we expect 2.6 exceedances per year, on average, with statistical fluctuation[1] ranging from zero to five. For 95 percent VaR, we expect 13 exceedances, with fluctuations between six and 20.

We work with *clean returns*, meaning the return on the portfolio under the assumptions of the risk model. To compute the clean return, we assume that there is no change in the portfolio composition, and that the price of each index constituent changes precisely by the changes in the modeled risk factors. This does not incorporate portfolio turnover, trading revenue, or actual market price changes.

[1] Statistical fluctuation is defined in all cases presented at a p-value of 99 percent, under the assumption that exceedances occur at the expected frequency (1 percent for 99 percent VaR and 5 percent for 95 percent VaR), and independently from one day to the next.

The portfolios we use to assess the models are as follows:

Fixed Income Portfolios	Equity Portfolios
JP Morgan GBI US Bond Index	MSCI EAFE Index
Citi US Broad Investment-Grade (USBIG) Bond Index	MSCI Emerging Markets Index
Citi World Government Bond Index (WGBI)	MSCI World Index
iBoxx EUR Corporates Index	MSCI USA Index
iBoxx EUR Sovereign Index	
JP Morgan EMBI Global Diversified Index	

Backtesting Statistics Used to Assess VaR and Return Data

Included in the appendix are a number backtesting statistics that assess important aspects of the VaR and return data, in particular, the timing and size of exceedances.

VaR Exceedance Timing

For models that react appropriately to changing market conditions, exceedances should be spread evenly throughout the year. The Chi-square test assesses the distribution of VaR exceedances across quarters, under the null hypothesis that VaR exceedances are likely to fall equally in each quarter. The Markov test, detailed in Christoffersen and Pelletier (2004), proposes a model wherein the probability of a VaR exceedance varies, depending on whether an exceedance occurred on the previous day.

VaR Exceedance Size

Under the assumption that portfolio returns are normally distributed, we tested whether the ratio of exceedance size to predicted VaR is significantly different from the normal benchmark. The expected size of a VaR exceedance, conditional on the exceedance occurring, is 1.15 times the VaR level for 99 percent VaR, and 1.25 times the VaR level for 95 percent VaR.

For each portfolio and model setting, we examined all of the VaR exceedances, and in each case computed the ratio of the portfolio loss to the VaR forecast. We then calculated the average ratio across all of the exceedance days, as well as the standard error of this estimate. The average exceedance ratios, as well as the difference between the average and the normal benchmark, are reported.

Fixed Income Backtesting Statistics

We begin this section by discussing the market and risk trends of 2013, making general observations about the model behavior throughout 2013, and finally focusing on the backtesting results.

In **Appendix A**, Figures 1 to 6 present the comparison of VaR and return for the six fixed income index portfolios (listed on page 3). These figures show the daily VaR estimate, both at the 95 percent and 99 percent confidence level, as black bands and the daily clean return as a blue dot.

The first half of 2013 was quiet, continuing from a relatively benign 2012. Volatility increased following various announcements by the Federal Reserve regarding tapering of quantitative easing (QE). The first hints that the Fed may reduce QE were in May 2013; at that time, only the US indices (JP Morgan GBI US Bond Index and Citi USBIG Bond Index) experienced increased volatility. Major reaction in the other markets did not occur until June 2013 when the Fed stated that QE may be reduced in 2013 and halted altogether in 2014. This coincided with the largest negative return for the non-US indices. The US indices experienced their largest negative return at the beginning of July 2013 when a strong US payroll report increased market confidence that the Fed would begin tapering. Compared to the first half of the year, returns in general remained more volatile for the remainder of 2013.

We see quite different behavior when comparing the four models over this period. The more reactive models (*mc94* and *mc97*) had the tightest VaR bands at the beginning of 2013 and these rapidly widened with the increased volatility at mid-year. The historical models had somewhat broader VaR bands earlier in the year and more muted reactions to the increased volatility. In general, the *hist5y* model produced stable risk forecasts, with some overestimation of risk in the first half of the year.

A summary of the behavior seen in Figures 1 to 6 is shown in **Appendix B**, Tables 1 and 2, which present the average, maximum, and minimum daily VaR at the 99 and 95 percent confidence level, respectively. The Monte Carlo models and *hist1y* have similar average VaR forecasts, but the range is wider for the more reactive *mc94* and *mc97* models. The *hist5y* model had the highest average VaR for most indices, due to higher VaR levels during the first half of the year.

The results also show that the VaR forecasts of historical models may exhibit artifacts caused by the time window used for VaR prediction. For instance, the results of the *hist1y* model for the iBoxx EUR Sovereigns illustrates the drawback of using data that covers different volatility regimes. Even while volatility rose in June 2013, the *hist1y* model produced decreasing risk forecasts for the iBoxx EUR Sovereigns. This was caused by the Eurozone crisis of May 2012 no longer being included in the one-year look-back. We see a similar effect when we consider the *hist5y* model for the JPM EMBI Global Diversified Index, where VaR forecasts sharply decreased in October 2013, as the turbulent period of October 2008 left the time window.

Table 3 contains the exceedance statistics for the fixed income indices, with cases of too many exceedances highlighted in red, and too few exceedances highlighted in blue. At 99 percent, the reactive models experienced too many exceedances, whereas the *hist5y* model performed within the expected range. The results for the *hist1y* model were in between the performance of the Monte Carlo models and the *hist5y model*, with too many exceedances for two indices. At 95 percent VaR, all models performed within the expected ranges, except the *hist1y* model for the JPM EMBIG Diversified index, which produced too many exceedances.

Table 5 provides more insight into these exceedances: the majority appeared in the second quarter of 2013, when the market shifted to the more volatile half of the year. The *mc94*, *mc97*, and *hist1y* models had relatively narrow bands in the first half of the year, and experienced exceedances when several large negative returns occurred in the second quarter, as the models did not react quickly enough. The *hist5y* model, on the other hand, produced higher VaR forecasts during the first half of 2013,

overestimating VaR in the first quarter, and suffered much less from the pickup in volatility. On average, it performed best, benefiting from having the 2008 crisis period in its time window.

Finally, we turn our attention to the backtesting statistics in Tables 7 and 8 in Appendix B. The statistics in the two rightmost columns are the p-values of the Chi-square and Christoffersen tests and cases where the null hypothesis is rejected at the 99 percent confidence level are highlighted. For both the 99 percent and the 95 percent confidence level, high p-values confirm our earlier observation of exceedance clustering. Tables 7 and 8 also reveal that, mostly for *mc94*, *mc97*, and *hist1y*, VaR exceedances were too large, i.e., when an exceedance occurred, the P&L seemed large relative to the normal distribution. Cases where the departure from the normal benchmark is greater than two standard errors are highlighted in red, but highlighted in blue when the size is smaller than expected.

Equity Backtesting Statistics

In Figures 7 to 10 of Appendix A, we observe that the equity indices experienced similar return patterns to the fixed income indices, with large negative returns occurring around June 2013. An exception is the MSCI USA index where the returns oscillated through lower and higher volatility throughout the year. The two most responsive models, *mc94* and *mc97,* quickly reacted to the changing volatility levels, unlike the other two models, *hist1y* and *hist5y*. These more stable models suffered some data artifacts due to the time window used. The *hist1y* model did not react much to the exceptional returns around June, and, somewhat counter-intuitively, the VaR bands slightly decreased. The *hist5y* model predicted constant and high VaR levels until October 2013, when the VaR decreased due to the October 2008 data leaving the sample. As a result, the *hist5y* 99 percent VaR forecasts significantly overestimated volatility in the first part of the year. For example, in the first five months of 2013, the average 99 percent VaR for MSCI World and MSCI EM was more than twice the size of the largest observed loss during this period. Tables 1 and 2 reflect these observations, with average *hist5y* VaR levels being almost twice as large as the average VaR levels of the other models.

Turning our attention to the exceedance statistics in Table 4, we observe that the models performed better for the equity indices than for the fixed income indices. At the 99 percent confidence level, only the *mc94* model produced too many exceedances for MSCI World and MSCI USA. At the 95 percent confidence level, the *hist5y* model produced too few exceedances. Table 6 illustrates that, for the equity indices, exceedances also clustered in the second quarter.

Finally, we present the backtesting statistics for the equity indices in Tables 9 and 10. The high p-values for the Chi-square test confirm that exceedances were not equally spread through the year. The average size of exceedances behaved more as expected, with only three occurrences of the VaR forecast being more than two standard deviations away from the normal benchmark at the 99 percent confidence level, and one occurrence at the 95 percent confidence level.

Backtest Comparison with Previous Years

It is worth comparing the backtesting results of 2013 with those of previous years. The comparison of 2013 with 2011 is particularly interesting, since the markets behaved similarly, moving from a quieter first half to a more turbulent second half. [2]

For the fixed income portfolios, the differences between the results for 2011 and 2013 have been most pronounced. Though the market behavior was relatively similar, at 99 percent confidence the models

[2] Finger, C. and M Abbasi, (2012), Market Report, 2011 – Year in Review: Risk Model Backtesting.

that performed best are opposite. In 2013, the reactive models showed too many exceedances and the *hist5y* had exceedances within the expected range. This is a contrast to 2011 where the models that used the longest history experienced too few exceedances, while the most reactive models performed well.

The equity portfolios tell the opposite story: the reactive models performed better in 2013 and worse in 2011. In 2013, the *mc94* model produced slightly too many exceedances at the 99 percent confidence level for two of the indices whereas in 2011 both the *mc94* and *mc97* experienced too many exceedances for all equity indices at the 99 percent confidence level. In 2011 the long dated models performed within expected range at the 95 percent confidence level for almost all portfolios, yet in 2013 all portfolios experienced too few exceedances.

Comparing with 2012 backtesting results[3] is less insightful, since the markets remained very benign throughout the entire year. However, the stable model overestimated risk in this calm environment, and for both fixed income and equity portfolios the stable model experienced too few exceedances.

Table 11 in Appendix B contains the average exceedances of the fixed income indices by model and per year at the 99 percent confidence level. The averages were taken over the fixed income indices included in the past three annual backtesting papers. The final column is the average across three years for each model (although the 2011 results use the three-year model rather than the *hist5y*). For all three years there has been a clear ranking of exceedances, where the stable model produced the fewest exceedances and the reactive models had the most. The range in average number of exceedances across models was noticeably tighter in 2011 and 2012 than in 2013. In 2013, the exceedances experienced by the most reactive models were a multiple of five of the most stable model. We note that the fixed income indices, for the 95 percent confidence level, produced too few exceedances in 2011 and 2012 for the most stable model.

Conclusion

The results presented in this paper provide context for risk managers who are performing their own backtesting studies. Our backtests present the performance of four models for a collection of fixed income and equity portfolios. As we use index portfolios, any changes in VaR are due to the model choice, and the reaction of the model to the market environment, rather than combined effects between market environment and a changing portfolio.

This year, events in the US had a major impact on markets. For the fixed income portfolios, the more reactive models such as *mc94* and *mc97* produced too many exceedances. The *hist5y* model overall performed well and produced exceedances within expected ranges. For all the equity indices, the models in general performed better, although the *hist5y* model overestimated VaR in the first half of the year, which led to too few exceedances.

Taking a slightly longer perspective, we see that different models have performed better in different years. This raises both practical and research-related questions.

In the short term, the practical question is how to work with the models that we have. That is, how should risk professionals manage the tradeoffs between stability and responsiveness, or between protracted overestimation of risk and underestimation at the start of a turbulent period? Some market participants have implemented policies or limit schemes based on multiple risk models, hoping to capture the best of different model assumptions.

[3] Smith, R. and C Finger, (2013), Market Insight, 2012 Year in Review: Risk Model Backtesting.

Beyond the short term, we would like to establish an agenda to better understand and improve model performance. First on this agenda is the question of whether the reactive models react at the appropriate pace; they do seem to track risk well in quiet periods, and sometimes react appropriately to the onset of turbulence. It could be that an adjustment to their reactivity could help; on the other hand, the answer could lie in the distributional assumptions employed in these models, suggesting filtered historical simulations as a possible alternative.

Delving deeper, we would like to understand whether volatility and correlation forecasts tend to perform better or worse in concert. Could distinct model settings for the two produce better forecasts globally? We look forward to pursuing these questions in a series of follow-up studies.

Appendix A: Figures 1-10

Figure 1: JP Morgan GBI United States Bond Index, Daily VaR (in basis points).

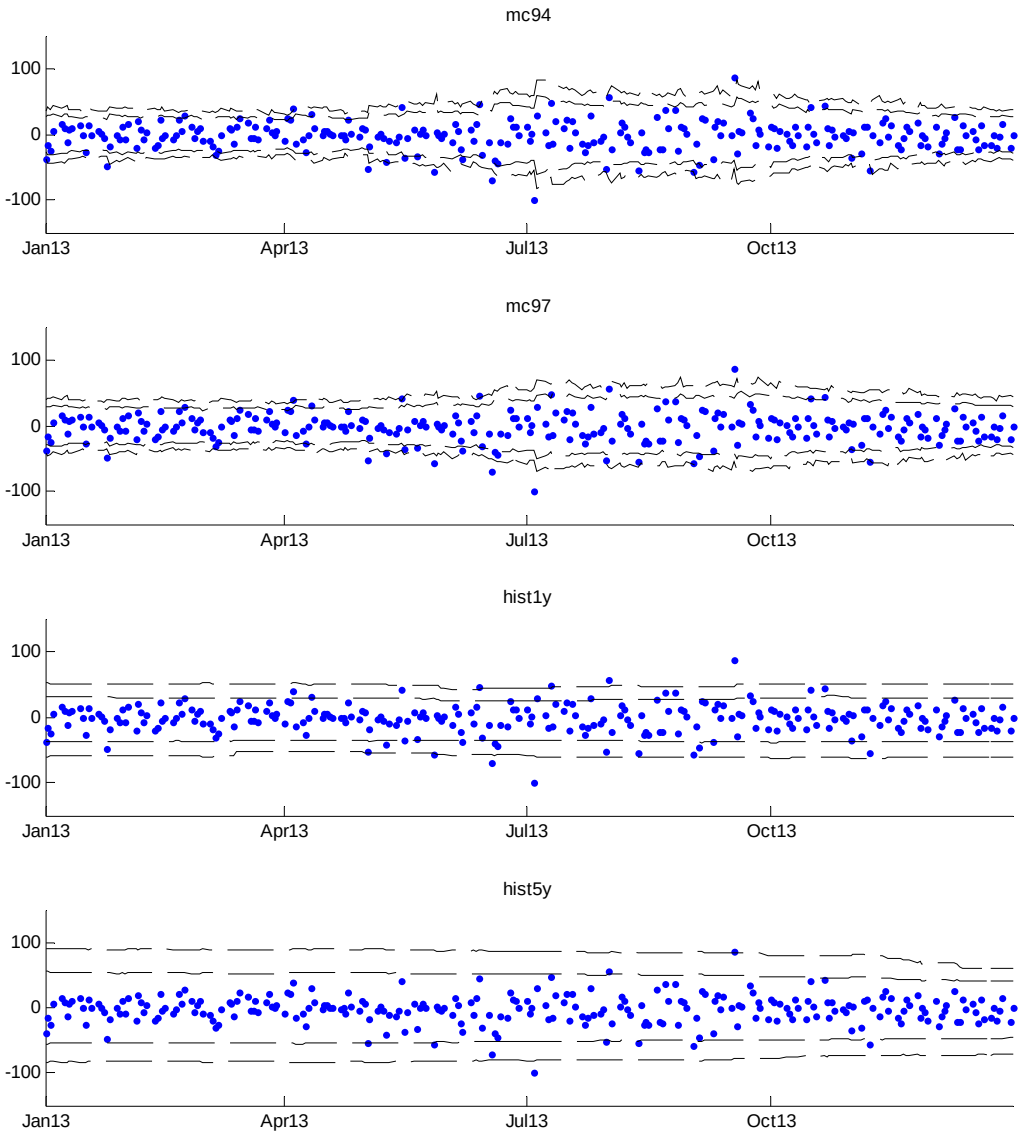


Figure 2: Citi US Broad Investment-Grade (USBIG) Bond Index, Daily VaR (in basis points).

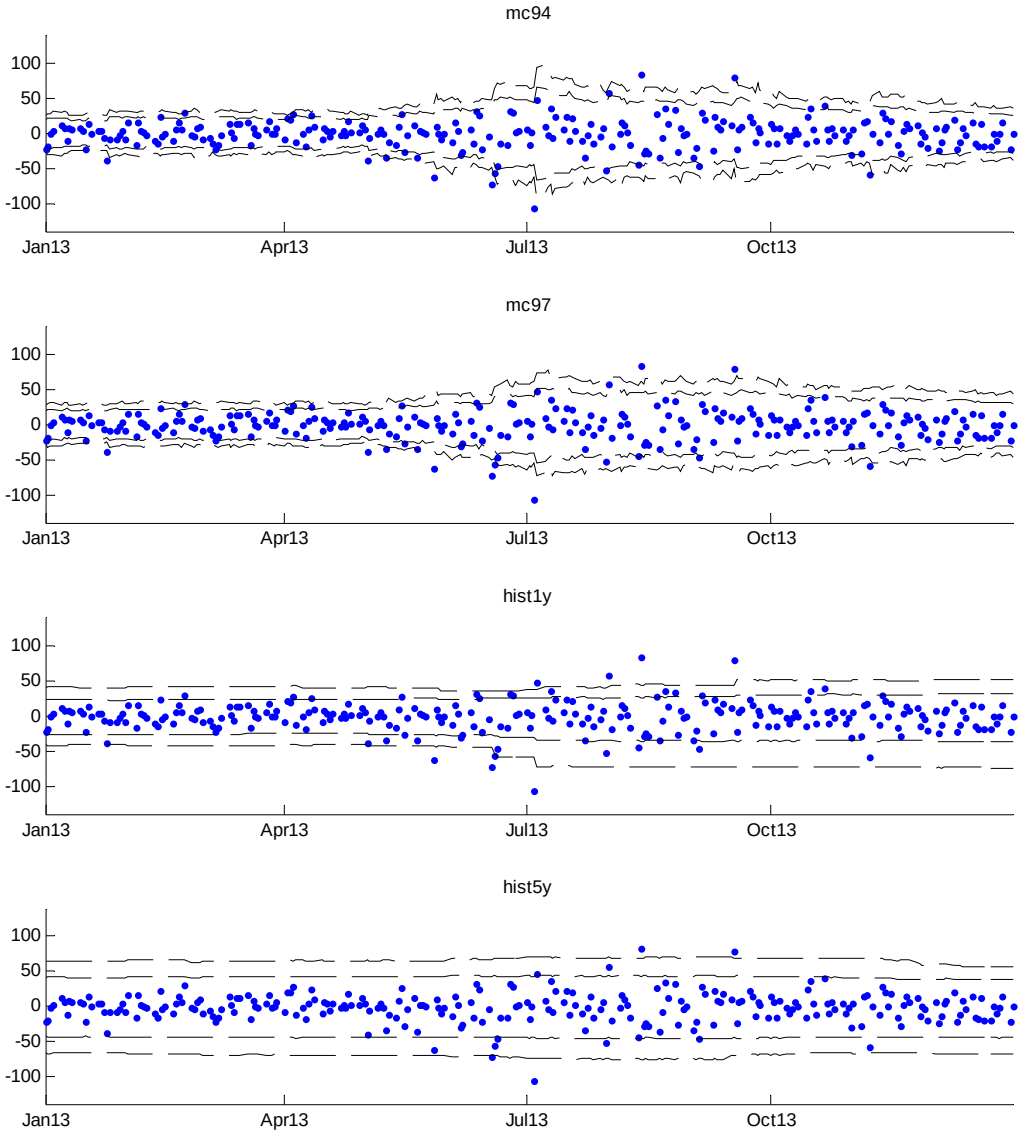


Figure 3: Citi World Government Bond Index, Daily VaR (in basis points).

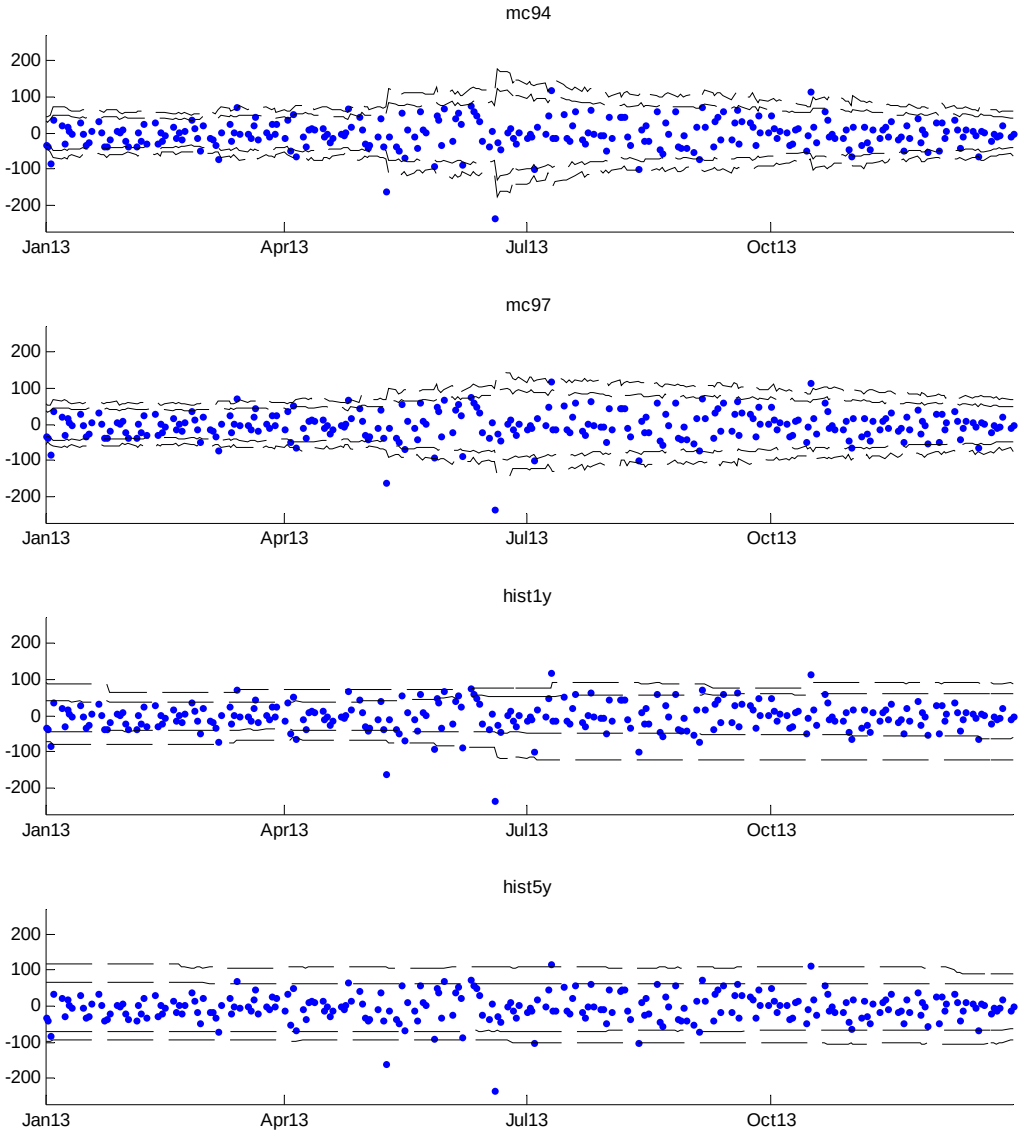


Figure 4: iBoxx EUR Corporates Index, Daily VaR (in basis points).

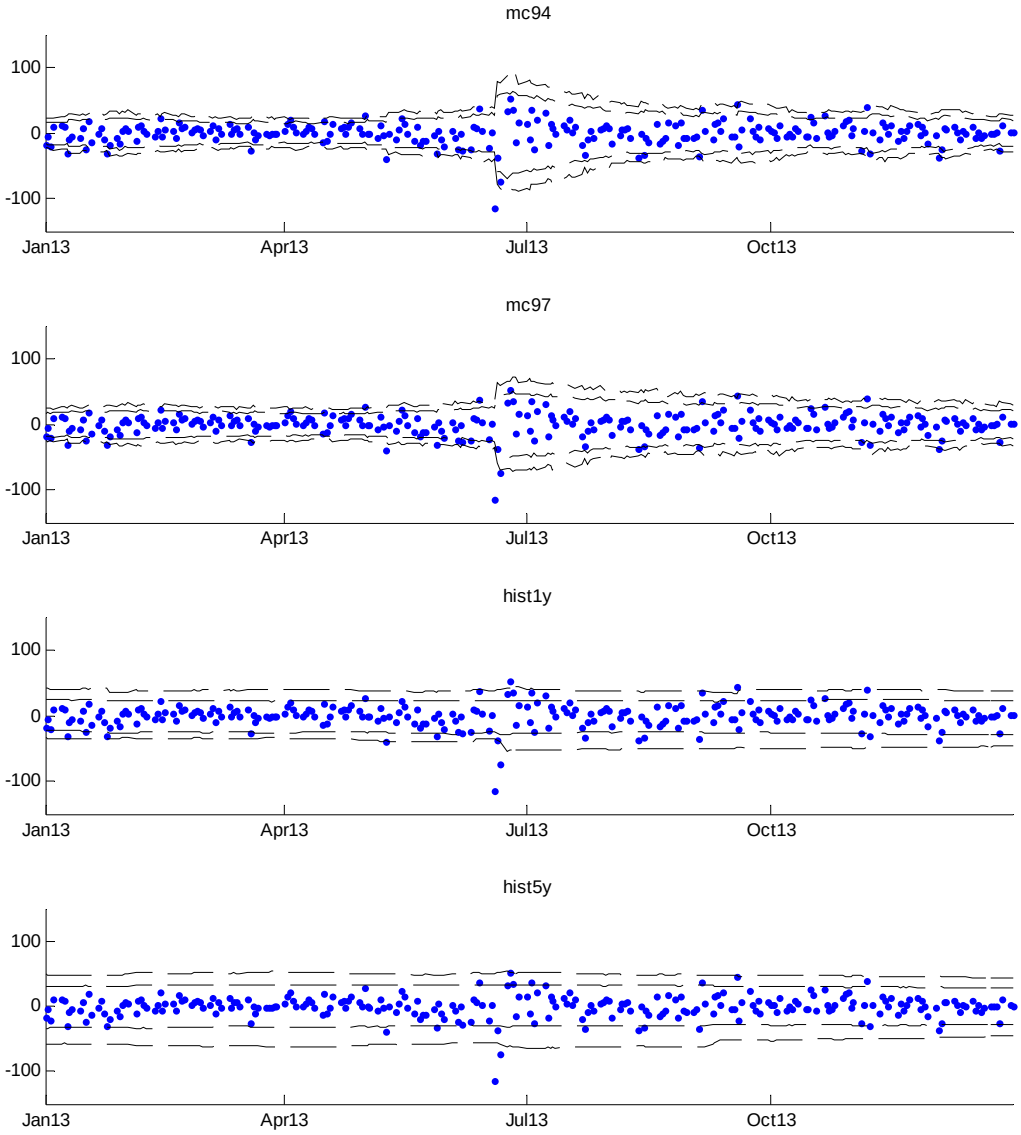


Figure 5: iBoxx EUR Sovereign Index, Daily VaR (in basis points).

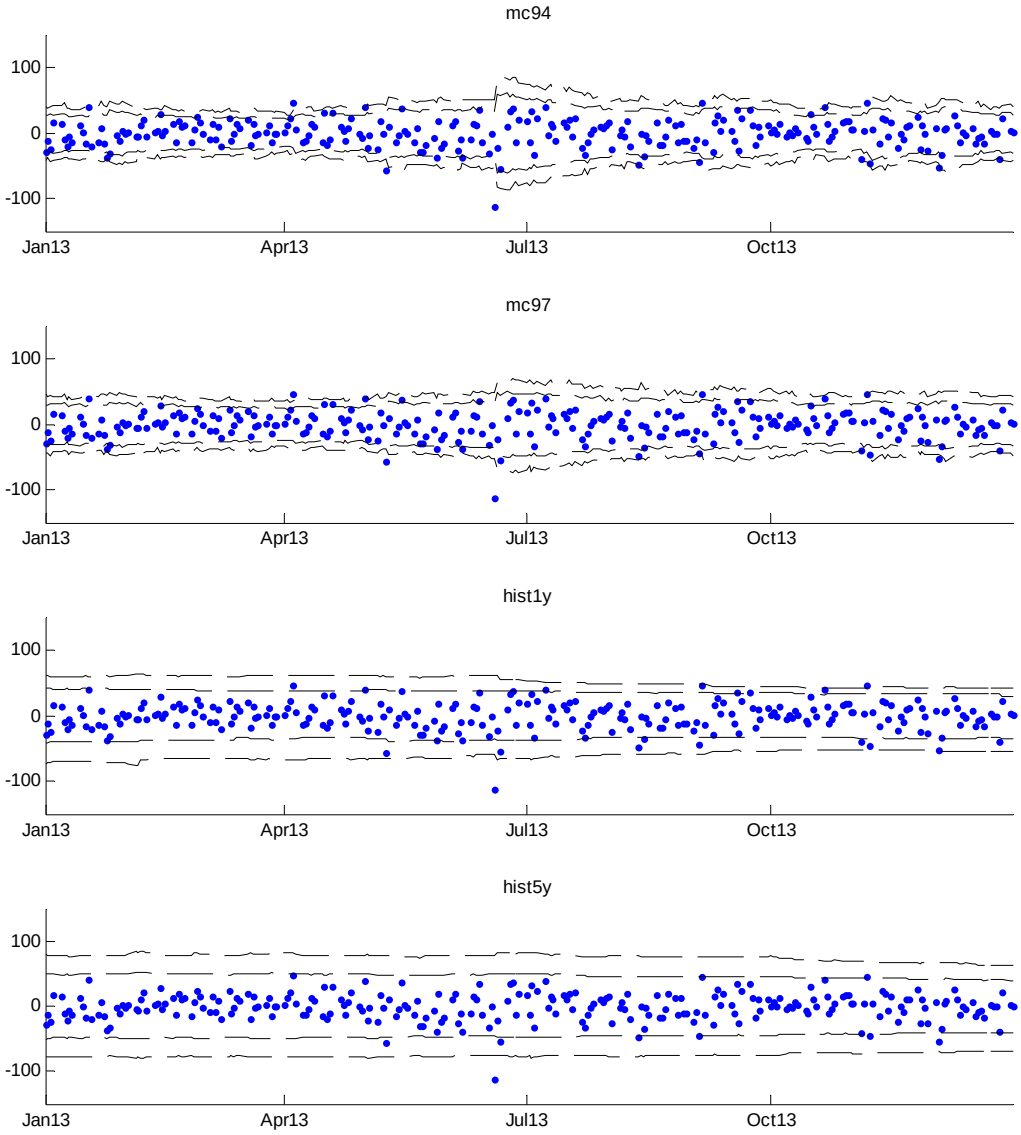


Figure 6: JPMorgan EMBI Global Diversified Index, Daily VaR (in basis points).

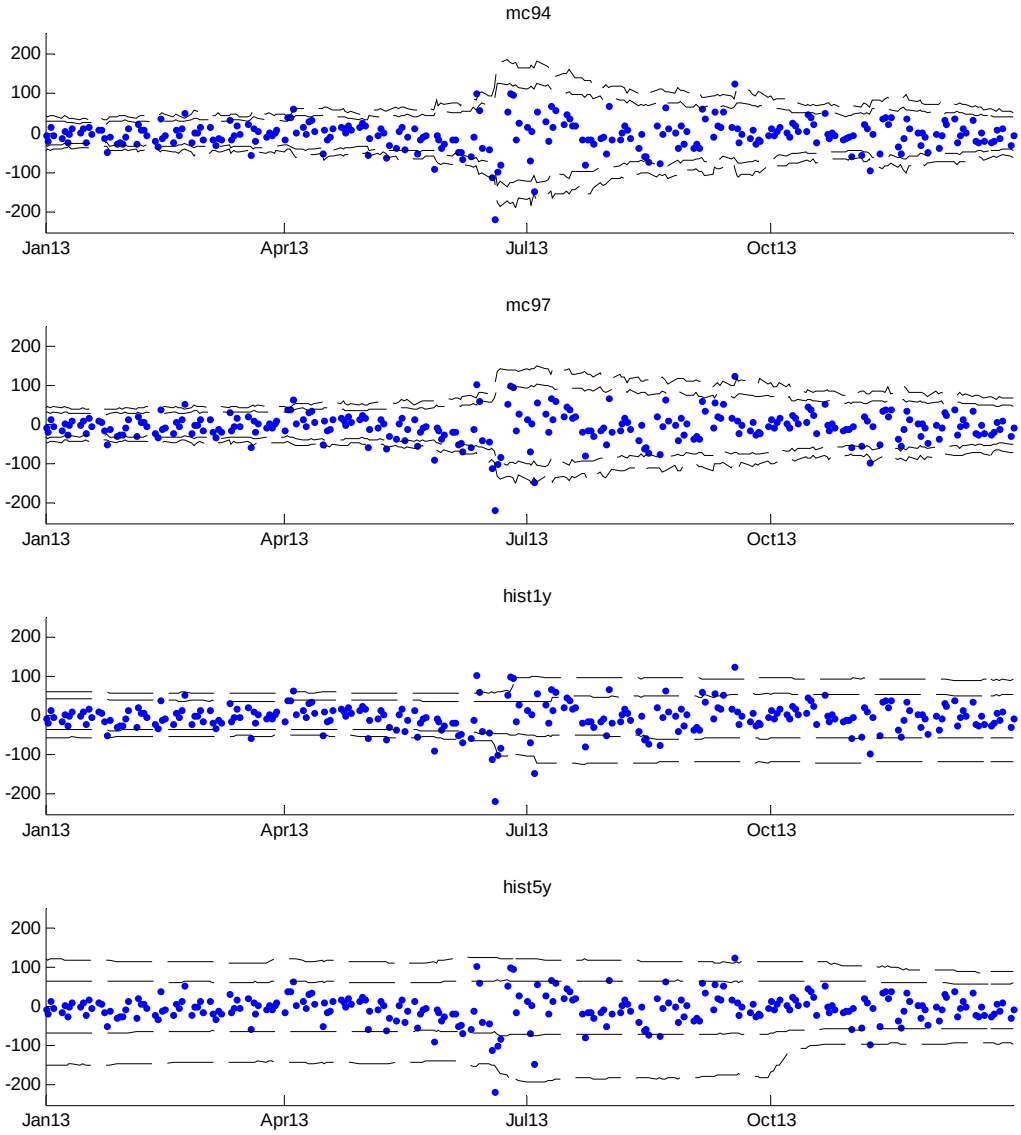


Figure 7: MSCI EAFE Index, Daily VaR (in basis points).

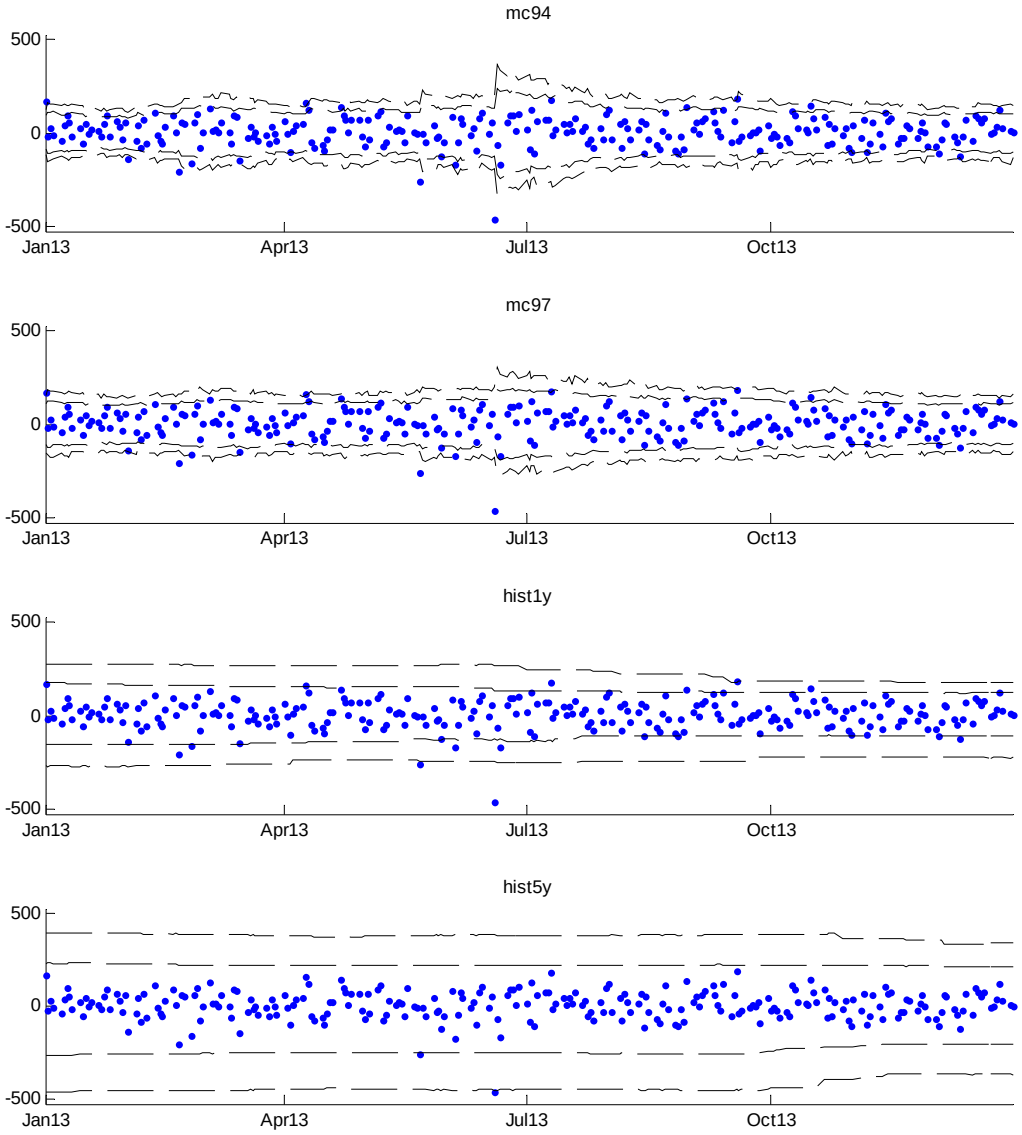


Figure 8: MSCI Emerging Markets Index, Daily VaR (in basis points).

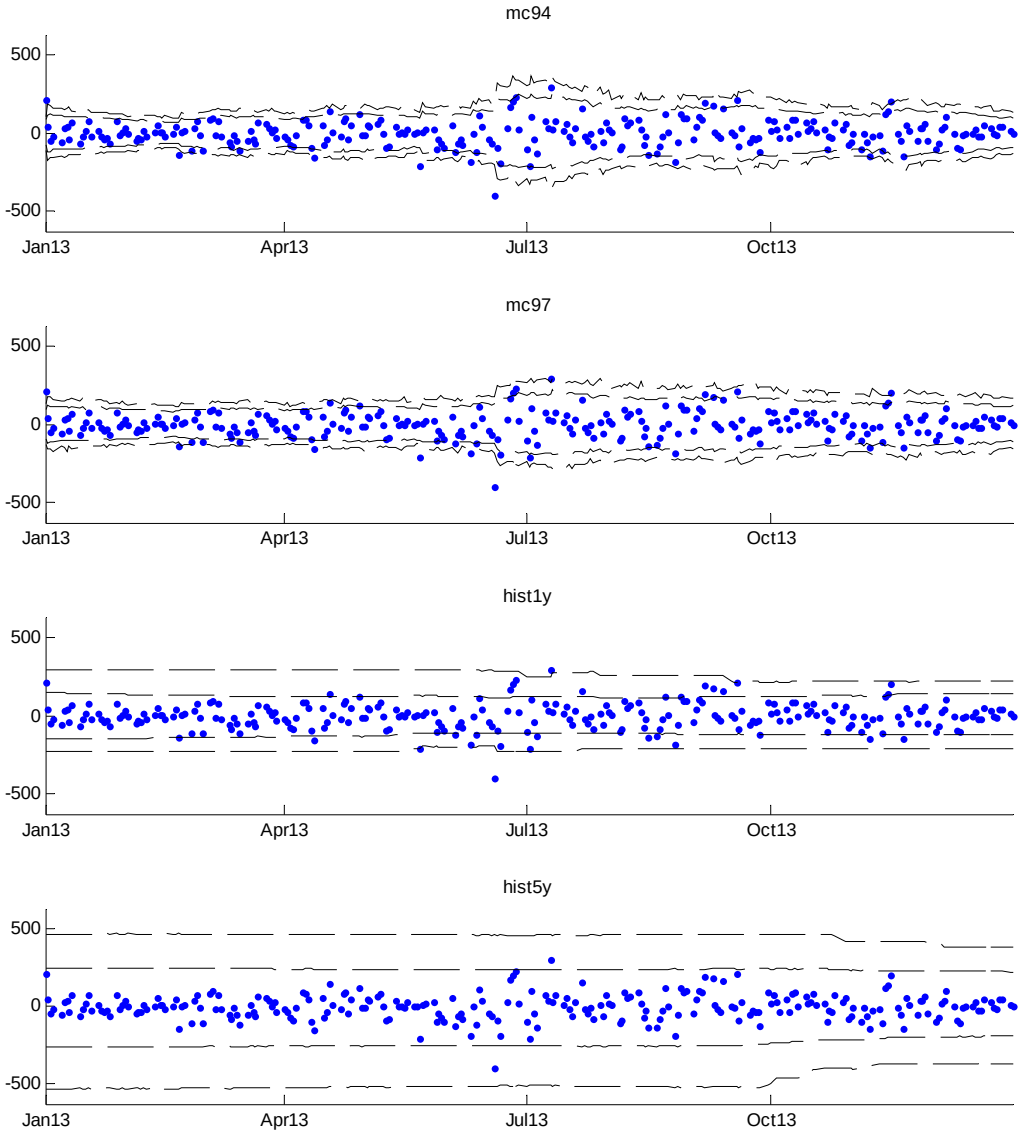


Figure 9: MSCI World Index, Daily VaR (in basis points).

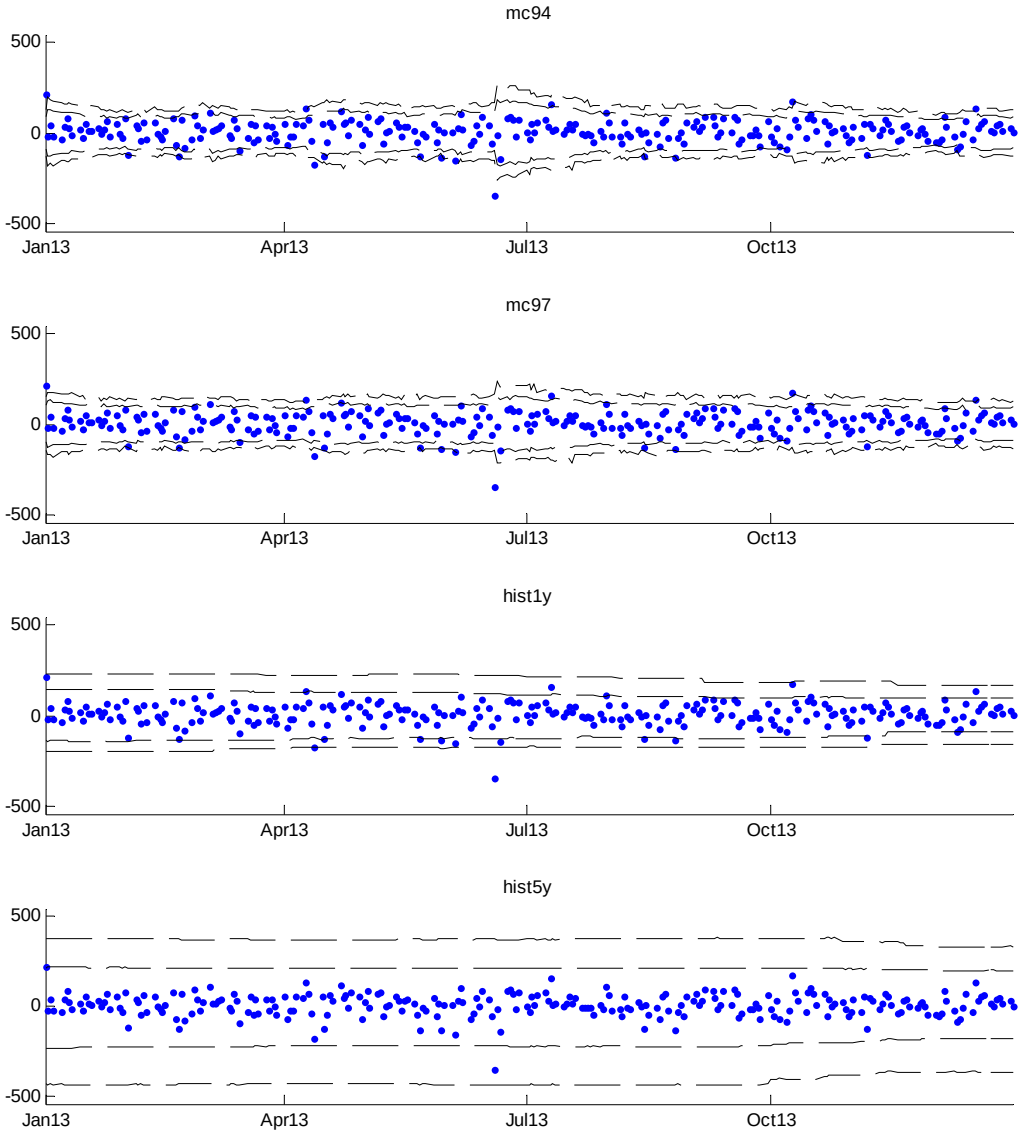
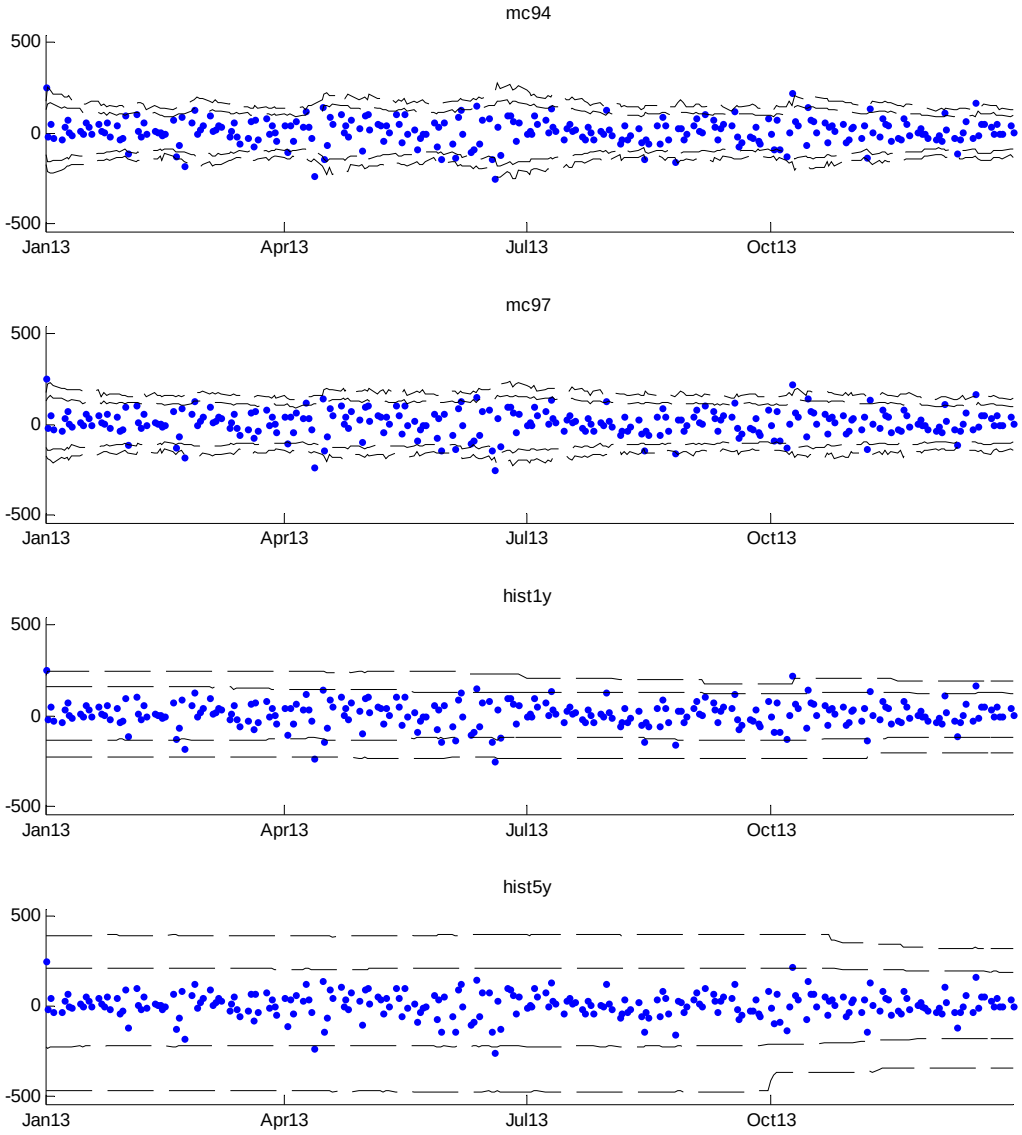


Figure 10: MSCI USA Index, Daily VaR (in basis points).



Appendix B: Tables 1-15

Table 1: Average, Maximum and Minimum 99 percent Daily VaR (in basis points) for 2013.

Index name	Methodology	Avg	Min	Max
Citi USBIG	mc94	46	23	92
	mc97	46	25	73
	hist1y	58	41	75
	hist5y	70	67	77
Citi WGBI	mc94	85	44	177
	mc97	85	48	140
	hist1y	100	58	123
	hist5y	98	93	104
iBoxx EUR Corporates	mc94	37	20	93
	mc97	37	22	71
	hist1y	43	33	54
	hist5y	57	46	65
iBoxx EUR Sov	mc94	47	27	87
	mc97	47	33	74
	hist1y	61	52	76
	hist5y	75	68	81
JPM EMBIG Diversified	mc94	78	33	188
	mc97	78	38	150
	hist1y	88	48	125
	hist5y	143	93	192
JPM GBI US Bond Index	mc94	49	29	82
	mc97	49	32	70
	hist1y	59	52	63
	hist5y	80	71	84
MSCI EAFE	mc94	171	112	335
	mc97	176	135	276
	hist1y	246	225	274
	hist5y	437	365	465
MSCI EM	mc94	180	93	350
	mc97	182	116	285
	hist1y	218	197	231
	hist5y	489	366	533
MSCI World	mc94	142	97	255
	mc97	145	103	213
	hist1y	175	161	197
	hist5y	417	360	438
MSCI USA	mc94	160	113	252
	mc97	163	126	226
	hist1y	228	202	235
	hist5y	440	339	477

Table 2: Average, Maximum and Minimum 95 percent Daily VaR (in basis points) for 2013.

Index name	Methodology	Avg	Min	Max
Citi USBIG	mc94	33	17	67
	mc97	32	18	55
	hist1y	31	25	37
	hist5y	45	43	47
Citi WGBI	mc94	60	31	129
	mc97	60	33	104
	hist1y	47	38	63
	hist5y	68	63	70
iBoxx EUR Corporates	mc94	26	14	69
	mc97	26	15	51
	hist1y	26	23	30
	hist5y	31	28	35
iBoxx EUR Sov	mc94	33	21	61
	mc97	33	24	50
	hist1y	36	32	42
	hist5y	46	40	51
JPM EMBIG Diversified	mc94	55	23	134
	mc97	55	26	107
	hist1y	47	34	60
	hist5y	64	55	74
JPM GBI US Bond Index	mc94	34	21	61
	mc97	34	22	51
	hist1y	37	34	40
	hist5y	52	46	56
MSCI EAFE	mc94	121	77	246
	mc97	124	96	196
	hist1y	128	106	159
	hist5y	245	206	268
MSCI EM	mc94	127	65	233
	mc97	128	80	196
	hist1y	125	108	146
	hist5y	245	193	266
MSCI World	mc94	100	66	185
	mc97	102	79	150
	hist1y	122	91	140
	hist5y	215	180	232
MSCI USA	mc94	113	81	180
	mc97	115	93	159
	hist1y	128	118	137
	hist5y	213	177	230

Table 3: VaR Exceedances in 2013, Fixed Income, Clean Returns.

	mc94	mc97	hist1y	hist5y
99% VaR Exceedances				
Citi USBIG	7	8	4	2
Citi WGBI	5	5	6	2
iBoxx EUR Corporates	9	7	3	2
iBoxx EUR Sov	7	5	2	1
JPM EMBIG Diversified	8	10	10	1
JPM GBI US Bond Index	8	7	3	1
95% VaR Exceedances				
Citi USBIG	16	17	16	8
Citi WGBI	17	14	19	10
iBoxx EUR Corporates	19	18	16	11
iBoxx EUR Sov	12	13	11	6
JPM EMBIG Diversified	16	16	27	10
JPM GBI US Bond Index	18	19	15	7

Table 4: VaR Exceedances in 2013, Equity, Clean Returns.

	mc94	mc97	hist1y	hist5y
99% VaR Exceedances				
MSCI EAFE	4	3	2	1
MSCI EM	5	5	2	0
MSCI World	9	4	2	0
MSCI USA	6	5	2	0
95% VaR Exceedances				
MSCI EAFE	11	10	10	2
MSCI EM	13	14	16	1
MSCI World	13	13	9	1
MSCI USA	15	14	10	2

Table 5: Exceedances by Quarter, Fixed Income, Clean Returns, 99 percent Confidence Level.

Index name	Methodology	Q1	Q2	Q3	Q4	Total
Citi USBIG	mc94	1	4	1	1	7
	mc97	1	5	1	1	8
	hist1y	0	3	1	0	4
	hist5y	0	1	1	0	2
Citi WGBI	mc94	2	2	0	1	5
	mc97	2	3	0	0	5
	hist1y	1	5	0	0	6
	hist5y	0	2	0	0	2
iBoxx EUR Corporates	mc94	3	3	1	2	9
	mc97	3	4	0	0	7
	hist1y	0	3	0	0	3
	hist5y	0	2	0	0	2
iBoxx EUR Sov	mc94	0	2	2	3	7
	mc97	0	2	1	2	5
	hist1y	0	1	0	1	2
	hist5y	0	1	0	0	1
JPM EMBIG Diversified	mc94	2	5	0	1	8
	mc97	2	6	1	1	10
	hist1y	1	8	1	0	10
	hist5y	0	1	0	0	1
JPM GBI US Bond Index	mc94	1	4	2	1	8
	mc97	1	4	1	1	7
	hist1y	0	2	1	0	3
	hist5y	0	0	1	0	1

Table 6: Exceedances by Quarter, Equity, Clean Returns, 99 percent Confidence Level.

Index name	Methodology	Q1	Q2	Q3	Q4	Total
MSCI EAFE	mc94	2	2	0	0	4
	mc97	1	2	0	0	3
	hist1y	0	2	0	0	2
	hist5y	0	1	0	0	1
MSCI EM	mc94	1	4	0	0	5
	mc97	1	4	0	0	5
	hist1y	0	2	0	0	2
	hist5y	0	0	0	0	0
MSCI World	mc94	2	4	2	1	9
	mc97	0	4	0	0	4
	hist1y	0	2	0	0	2
	hist5y	0	0	0	0	0
MSCI USA	mc94	1	3	2	0	6
	mc97	1	2	2	0	5
	hist1y	0	2	0	0	2
	hist5y	0	0	0	0	0

Table 7: Backtesting Statistics, Fixed Income, Clean Returns, 99 percent Confidence Level.

Index name	Methodology	VaR Excessions	Avg Exceedances / VaR	Avg Exceedances SE diff from Normal	Christoffersen test p-value	Quarter dist Chi2 p-value w/ cont
Citi USBIG	mc94	7	1.48	5.07	0.94	0.86
	mc97	8	1.44	3.05	0.99	0.95
	hist1y	4	1.50	2.26	0.91	0.95
	hist5y	2	1.23	0.44	0.09	0.63
Citi WGBI	mc94	5	1.66	2.29	0.62	0.68
	mc97	5	1.68	2.06	0.62	0.94
	hist1y	6	1.59	1.53	0.83	1.00
	hist5y	2	2.08	2.38	0.09	0.95
iBoxx EUR Corporates	mc94	9	1.37	1.16	0.99	0.48
	mc97	7	1.49	1.20	0.94	0.98
	hist1y	3	2.04	1.45	0.06	0.99
	hist5y	2	1.67	1.31	0.09	0.95
iBoxx EUR Sov	mc94	7	1.27	0.81	0.94	0.73
	mc97	5	1.38	1.08	0.62	0.66
	hist1y	2	1.46	0.70	0.09	0.63
	hist5y	1	1.51	0.00	0.48	0.78
JPM EMBIG Diversified	mc94	8	1.35	2.11	0.99	0.97
	mc97	10	1.31	1.41	1.00	0.97
	hist1y	10	1.42	1.53	1.00	1.00
	hist5y	1	1.46	0.00	0.48	0.78
JPM GBI US Bond Index	mc94	8	1.34	1.81	0.98	0.78
	mc97	7	1.39	2.11	0.94	0.86
	hist1y	3	1.33	0.94	0.06	0.84
	hist5y	1	1.23	0.00	0.48	0.77

Table 8: Backtesting Statistics, Fixed Income, Clean Returns, 95 percent Confidence Level.

Index name	Methodology	VaR Excessions	Avg Exceedances / VaR	Avg Exceedances SE diff from Normal	Christoffersen test p-value	Quarter dist Chi2 p-value w/ cont
Citi USBIG	mc94	16	1.57	2.50	0.95	0.83
	mc97	17	1.54	2.14	0.97	0.98
	hist1y	16	1.65	2.46	0.55	1.00
	hist5y	8	1.42	1.10	0.98	0.92
Citi WGBI	mc94	17	1.54	1.71	0.97	0.57
	mc97	14	1.65	1.89	0.07	0.80
	hist1y	19	1.83	2.48	0.94	0.91
	hist5y	10	1.55	1.23	0.55	0.63
iBoxx EUR Corporates	mc94	19	1.53	1.80	0.98	0.42
	mc97	18	1.54	1.59	0.60	0.64
	hist1y	16	1.56	1.40	0.55	0.64
	hist5y	11	1.53	1.05	0.84	0.93
iBoxx EUR Sov	mc94	12	1.56	1.92	0.97	0.48
	mc97	13	1.50	1.54	0.09	0.64
	hist1y	11	1.47	1.24	0.48	0.85
	hist5y	6	1.37	0.53	0.93	0.81
JPM EMBIG Diversified	mc94	16	1.55	2.84	0.28	0.94
	mc97	16	1.61	2.64	0.55	1.00
	hist1y	27	1.64	2.61	1.00	1.00
	hist5y	10	1.57	1.48	0.99	0.99
JPM GBI US Bond Index	mc94	18	1.49	2.19	0.99	0.43
	mc97	19	1.47	1.99	0.98	0.99
	hist1y	15	1.45	1.72	0.55	0.98
	hist5y	7	1.24	-0.08	0.86	0.91

Table 9: Backtesting Statistics, Equity, Clean Returns, 99 percent Confidence Level.

Index name	Methodology	VaR Excessions	Avg Exceedances / VaR	Avg Exceedances SE diff from Normal	Christoffersen test p-value	Quarter dist Chi2 p-value w/ cont
MSCI EAFE	mc94	4	1.72	2.12	0.32	0.87
	mc97	3	1.90	2.30	0.06	0.84
	hist1y	2	1.48	0.80	0.09	0.95
	hist5y	1	1.02	0.00	0.48	0.78
MSCI EM	mc94	5	1.48	1.92	0.62	0.99
	mc97	5	1.47	1.56	0.62	0.99
	hist1y	2	1.51	0.74	0.09	0.95
	hist5y	0	0.00	0.00	0.93	0.00
MSCI World	mc94	9	1.24	0.67	0.99	0.66
	mc97	4	1.46	0.97	0.32	1.00
	hist1y	2	1.52	0.74	0.09	0.95
	hist5y	0	0.00	0.00	0.93	0.00
MSCI USA	mc94	6	1.24	1.02	0.83	0.81
	mc97	5	1.24	0.84	0.62	0.67
	hist1y	2	1.07	-2.28	0.09	0.95
	hist5y	0	0.00	0.00	0.93	0.00

Table 10: Backtesting Statistics, Equity, Clean Returns, 95 percent Confidence Level.

Index name	Methodology	VaR Excessions	Avg Exceedances / VaR	Avg Exceedances SE diff from Normal	Christoffersen test p-value	Quarter dist Chi2 p-value w/ cont
MSCI EAFE	mc94	11	1.66	1.68	0.48	0.86
	mc97	10	1.67	1.53	0.55	0.90
	hist1y	10	1.50	0.95	0.55	0.46
	hist5y	2	1.42	0.42	1.00	0.95
MSCI EM	mc94	13	1.52	1.81	0.49	0.75
	mc97	14	1.47	1.37	0.56	0.80
	hist1y	16	1.49	1.51	0.28	0.96
	hist5y	1	1.55	0.00	1.00	0.78
MSCI World	mc94	13	1.58	1.95	0.49	0.82
	mc97	13	1.49	1.49	0.49	0.82
	hist1y	9	1.33	0.41	0.65	0.99
	hist5y	1	1.57	0.00	1.00	0.78
MSCI USA	mc94	15	1.45	1.97	0.15	0.86
	mc97	14	1.39	1.37	0.07	0.91
	hist1y	10	1.36	0.92	0.55	0.97
	hist5y	2	1.11	-5.50	1.00	0.95

Table 11: Average exceedances per year, Fixed Income, Clean Returns, 99 percent Confidence Level.

	2011 *	2012	2013	Average
mc94	4.2	3.3	7.3	4.9
mc97	3.8	2.7	7.0	4.5
hist1y	2.0	0.7	4.7	2.4
hist5y	1.2	0.2	1.5	0.9

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[1] *As of March 31, 2013, as reported on July 31, 2013 by eVestment, Lipper and Bloomberg* *Jan 2014*