Market Insight

2012 Year in Review: Risk Model Backtesting

Rachael Smith and Christopher Finger

Rachael.Smith@msci.com

Christopher.Finger@msci.com

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Abstract:

There is continuing industry demand for transparency and standards for risk model performance. Here we present results of a model backtesting exercise, using RiskManager, for a number of standard risk models applied to fixed income and equity portfolios during the period December 2011 to November 2012. This is a follow up to a similar exercise performed over the 2011 calendar year. Compared to 2011, this year has been less dramatic, with all models producing relatively stable forecasts. In terms of risk forecast performance, comparing ex-ante forecasts with ex-post returns, we find that most of the models produced acceptable forecasts for fixed income and equity portfolios, with some overstatement of risk from the most long-dated model.

Why This Matters:

- Indicates expected performance for clients testing similar portfolios and risk models.
- Offers insight into the relationship between clean and dirty returns for various indices, particularly topical given the recent *Basel Fundamental Review of the Trading Book*.

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Introduction

It is important for MSCI to assess the performance of its own models, but it is of broader importance to provide these results as a context for risk managers completing their own model assessments. In this report, 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 during 2012. The backtesting we perform includes VaR statistics and counting VaR exceedances. All the portfolios backtested and two of the risk models assessed are common to our 2011 report.[1] This year we include a new *hybrid* model that allows separate modeling of volatilities and correlations.

Description of the Backtesting Procedure

The models we assess are described as follows:

mc97 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 0.97.

hybrid This model is a new feature where the volatilities and correlations modeled using different risk settings. For this study, we use the *mc97* model for the volatilities and a historical five year trailing window of equally weighted daily historical returns for the correlations.

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

hist5y This model implements historical simulations 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 the model's performance formally, we run the standard analysis of counting VaR exceedances, that is, count the days when the portfolio loss exceeds the VaR forecast. The period December 1, 2011 to November 30, 2012 contained 262 trading days, so for 99 percent VaR, we expect 2.6 exceedances on average, with statistical fluctuation[2] ranging from zero to five. For 95 percent VaR, we expect 13 exceedances, with fluctuations between six and 20.

As in last year's study, we work with two different notions of return. The first, referred to as *clean returns*, is 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 what is implied by the changes in the modeled risk factors. The second notion, *dirty returns*, is the actual return from one day to the next, incorporating portfolio turnover, trading revenue, and actual market price changes.

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

[2] 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.

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Fixed Income Backtesting Results

We begin by considering the average, minimum and maximum VaR for all the fixed income indices to gain a general impression of the differences between the models. These statistics are shown in Tables 1 and 2. First of all, we observe that the *mc97* and *hybrid* models seem to have similar characteristics, but with subtle differences. Notably, the range for the *hybrid* model tends to be narrower or equivalent to the *mc97* model, indicating that it is more stable. In addition, the range of VaR produced by the *hist1y* and *hist5y* in most cases had half the range of the *mc97* and *hybrid* models, suggesting that these models were even more stable. For all the fixed income indices, the *mc97* and *hybrid* settings produce the lowest average VaR. The average VaR levels at 99 percent confidence are mostly between 50 and 100bp and between 30 and 80bp for the 95 percent confidence interval. The models are broadly in agreement, with the *hist1y* and *hist5y* having slightly higher VaR than the other two models. One exception is for the JPMorgan EMBI Global Diversified Index, where the *hist5y* average VaR is twice as large as any other risk assessment.

The exceedance statistics for the fixed income indices are presented for clean returns in Table 3 and for dirty returns in Table 4, with cases of too many exceedances highlighted in red, and too few exceedances highlighted in blue. For both the clean and dirty returns, at 99 percent VaR, the models all performed within the expected ranges. At 95 percent VaR for the clean returns, we see that for all indices, *hist5y* produced too few exceedances. Here the history used for the simulations included the volatile period of 2008 so it is not too surprising that this model over-forecast the volatility. The *hist1y* results were somewhat better than *hist5y* with half the indices having too few exceedances. The *mc97* model, with one exception, performed within the expected ranges for both clean and dirty returns. Though the results for the *hybrid* model are similar to those of *mc97*, in the cases where it differed, the *hybrid* model produced fewer exceedances.

We present the comparisons of VaR and return for the fixed income indices in Figures 1 through 6. In each plot, the VaR forecasts (at 95 and 99 percent confidence, on the gain and loss sides of the distribution) appear as black bands, the clean returns as blue dots, and the dirty returns as red crosses.

In contrast to last year, for all indices, the returns are much more stable. This is perhaps surprising in light of the ongoing Euro crisis. Though there was some pickup in volatility in the iBoxx EUR Corporates Index (Figure 4) in the spring of 2012, this was no more pronounced than any other point in the year. As a consequence of the stable returns, the risk forecasts were also quite stable. One exception to this is the *hist1y* model where the US indices (Barclays US Government Index and Barclays US Investment Grade Corporate Index in Figures 1 and 2), JPMorgan EMBI Global Diversified Index (Figure 6), and Citi World Government Bond Index (Figure 3) all had a sharp reduction in volatility in August 2012. When we consider last year's returns picture, we see why this is the case: the returns from August 2011, which were the reaction to the US downgrade, will be dropped out of the model in August 2012. Therefore this drop in volatility seems something of an artifact from the previous year.

In Figure 11 we show the scatter plots of clean and dirty returns for the fixed income indices. This is increasingly relevant given the recent *Basel Fundamental Review of the Trading Book,* which requires P&L attribution as a component of model validation, i.e. reconciling the actual P&L on a portfolio over time with the P&L explained only by the risk model factors.

Also, in contrast to 2011, the 2012 backtesting results do not appear to be much different across the two notions of returns. For example, for the iBoxx EUR Corporates Index, at 99 percent VaR and using the mc97 model, we observed in 2011 five exceedances for clean returns (within acceptable bounds) compared with nine exceedances (outside acceptable bounds) for dirty returns. In 2012, the models generally produce comparable results under both return notions.

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Looking more closely at the relationship between clean and dirty returns, we compare Figure 11 to its equivalent chart[3] from the 2011 report. Here, we find a few relationships that have significantly changed, as quantified in Table 15. Notably, for the iBoxx EUR Sovereign Index, the relationship has strengthened, with correlations rising from 0.69 to 0.96 and betas from 0.64 to 0.94. The opposite happened with iBoxx EUR Corporates Index, where the relationship weakened. Here correlations changed from 0.85 to 0.74 and beta from 0.96 to 0.67. Finally, we observe that the relationship for the JPMorgan EMBI Global Diversified Index also weakened, with correlations reducing from 0.64 to 0.58.

Equity Backtesting Results

Moving to the equity indices, we first consider the average, minimum and maximum VaR for the four equity indices, under the four model settings. These results are presented in Tables 1 and 2. For the equity indices, the *mc97* and *hybrid* settings produced similar results, in a tight range between 230 and 270 bps. The *hist1y* method produced somewhat larger levels between 350 and 400 bps, and the *hist5y* method extremely high levels of 430 to 540 bps. The *mc97* model has the widest range and *hist5y* has the narrowest, with *hist1y* between the two. Interestingly, the *hybrid* setting has similar or typically lower range than the *hist1y,* except for the MSCI Emerging Markets Index, where its range is closer to the result for the *mc97*. These results indicate that the *hybrid* model produces similar results to the *mc97*, just being slightly more stable.

The exceedance statistics for the equity indices are in Table 5. For 99 percent VaR, all models perform within the expected range. The statistics for 95 percent VaR show that both the *hist1y* and *hist5y* have fewer than expected exceedances for all indices. The *mc97* and *hybrid* models perform within the expected range, though with slight differences between the two: the *hybrid* setting typically producing fewer exceedances than the *mc97*.

We present the time series plots of VaR and returns in Figures 7 to 10. A first point to note is that for these indices, there was little difference between the clean and dirty returns (as mentioned last year). We see in the *hist1y* plots for all four indices that the VaR bands shrink in August 2012, due to the data from early August 2011 dropping out of the lookback window (the reaction to the US Government debt downgrade). We also notice that the VaR bands for the *hist5y* are very broad, as these still contain the 2008 data. The *hybrid* and *mc97* models behave similarly, with a slight volatility burst in June/July 2012, perhaps reflecting the deal amongst EU lenders to help struggling Eurozone banks.

Other backtesting statistics for both fixed income and equity indices, which assess the size as well as clustering of VaR exceedances, are described in Appendix C of the 2011 Year in Review report. As this has been a fairly benign year, we will not discuss these results, although we do include them, for completeness, in Tables 9 to 14.

Conclusion

For risk managers performing their own backtesting studies, our results provide a number of points of context. For all of the indices backtested here, there are few, if any, surprising daily returns, and little fluctuation in volatility throughout the year. For backtesting, the implication of this market behavior was that there were few VaR exceedances under any of the models. Indeed, we only found models producing too few exceedances, and none with too many. Moreover, there was relatively little

[3] We compare this with Figure 11, Finger and Abbasi (2012)

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differentiation across the models as a function of their responsiveness. Consistent with last year's study, the largest discrepancies in model results continue to derive from whether data from the crisis of 2008 is still being used for the current risk forecasts. For 2012, the next important differentiator is how the data from the last truly volatile period (August 2011) has been treated in the model chosen; with the one-year, equally weighted model (*hist1y*), the departure of this data from the historical window produced undesirable jumps downward in risk. Finally, we introduce a new *hybrid* model, and find it performs similarly to *mc97* but produces slightly more stable risk forecasts. For risk managers performing their own testing, we expect them to find similar results to those presented here, assuming their models and portfolios are similar to our test cases.

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Appendix A: Figures 1-11

Figure 1: Barclays US Government Index, Daily VaR (in basis points).

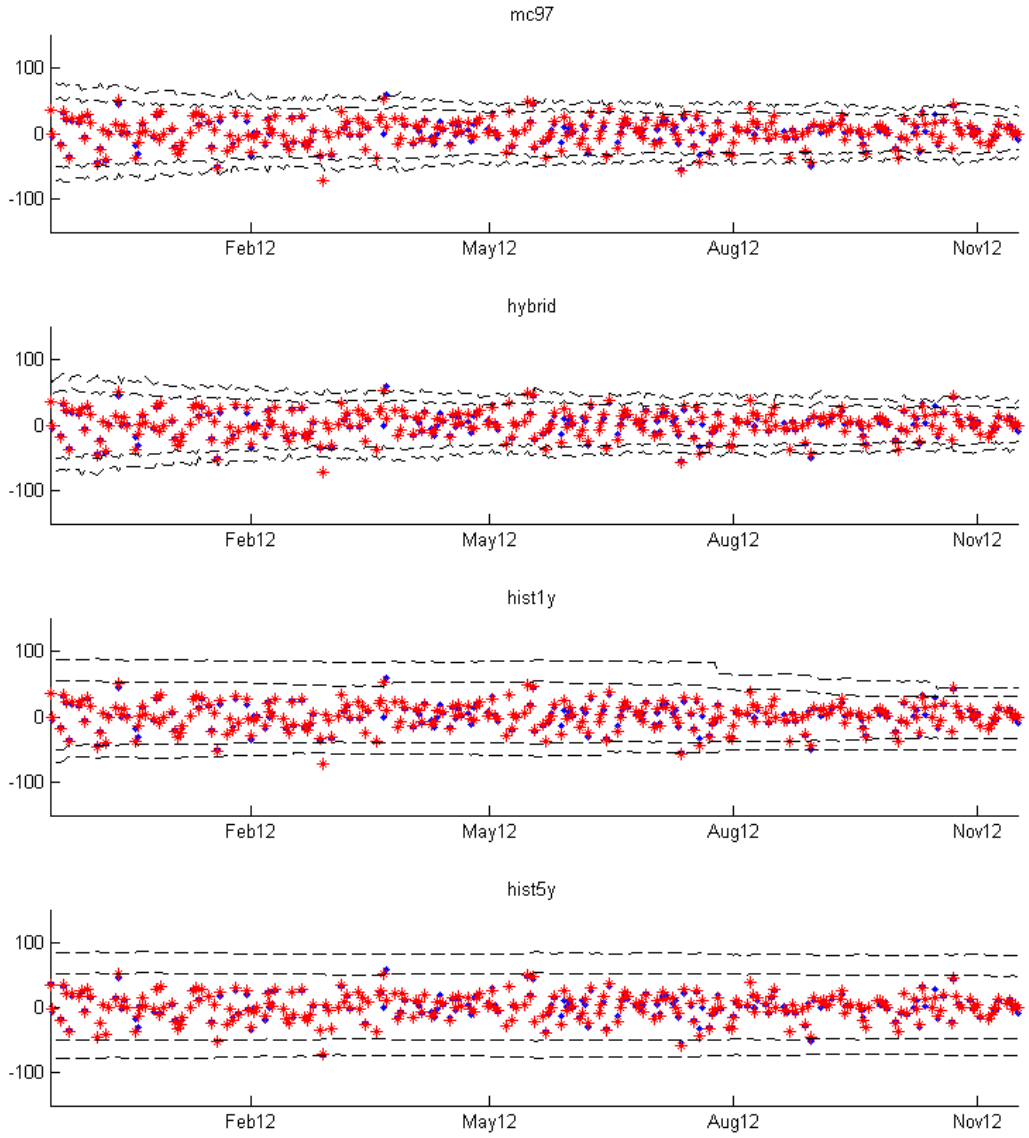

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Figure 2: Barclays US Investment Grade Corporate Index, Daily VaR (in basis points).

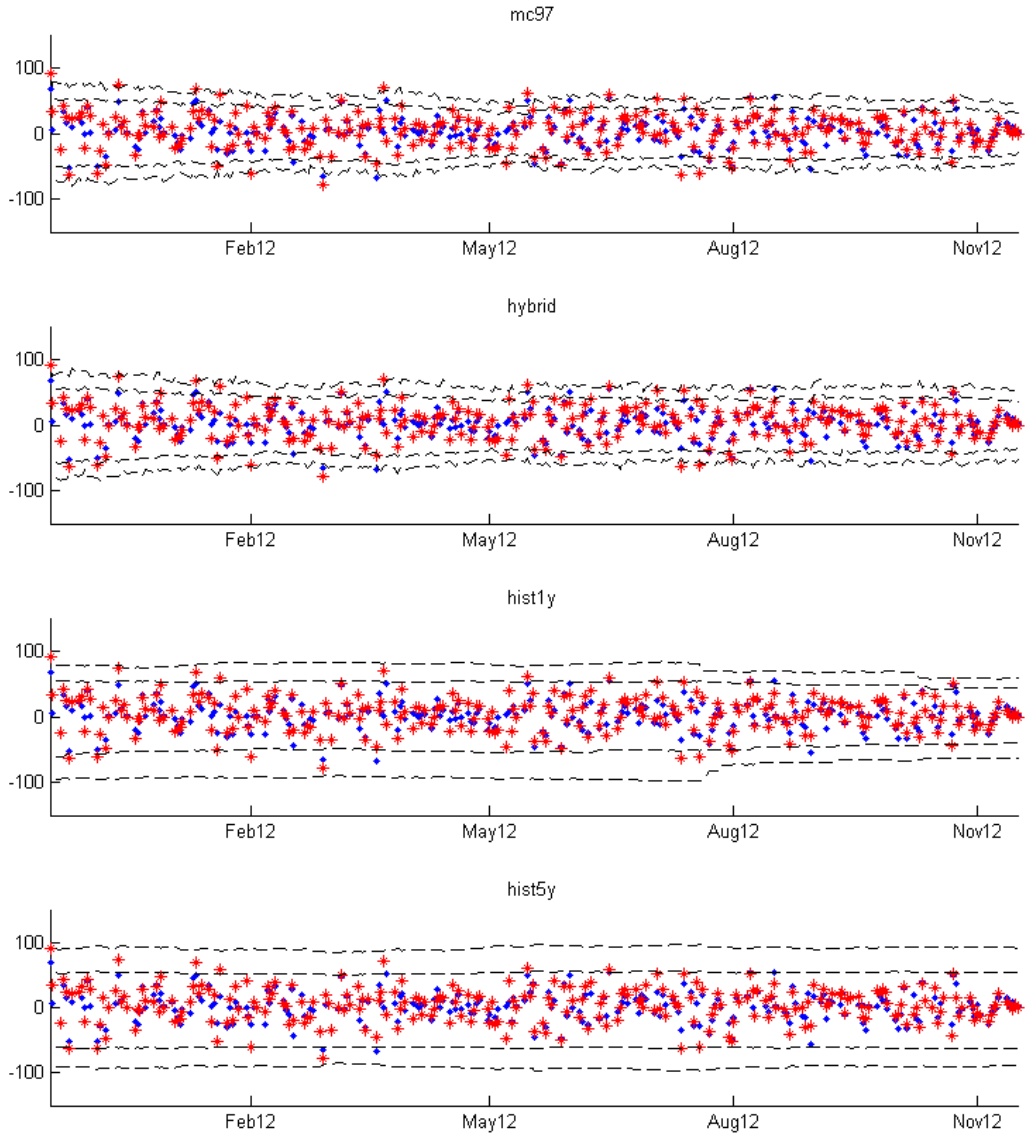

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Figure 3: Citi World Government Bond Index, Daily VaR (in basis points).

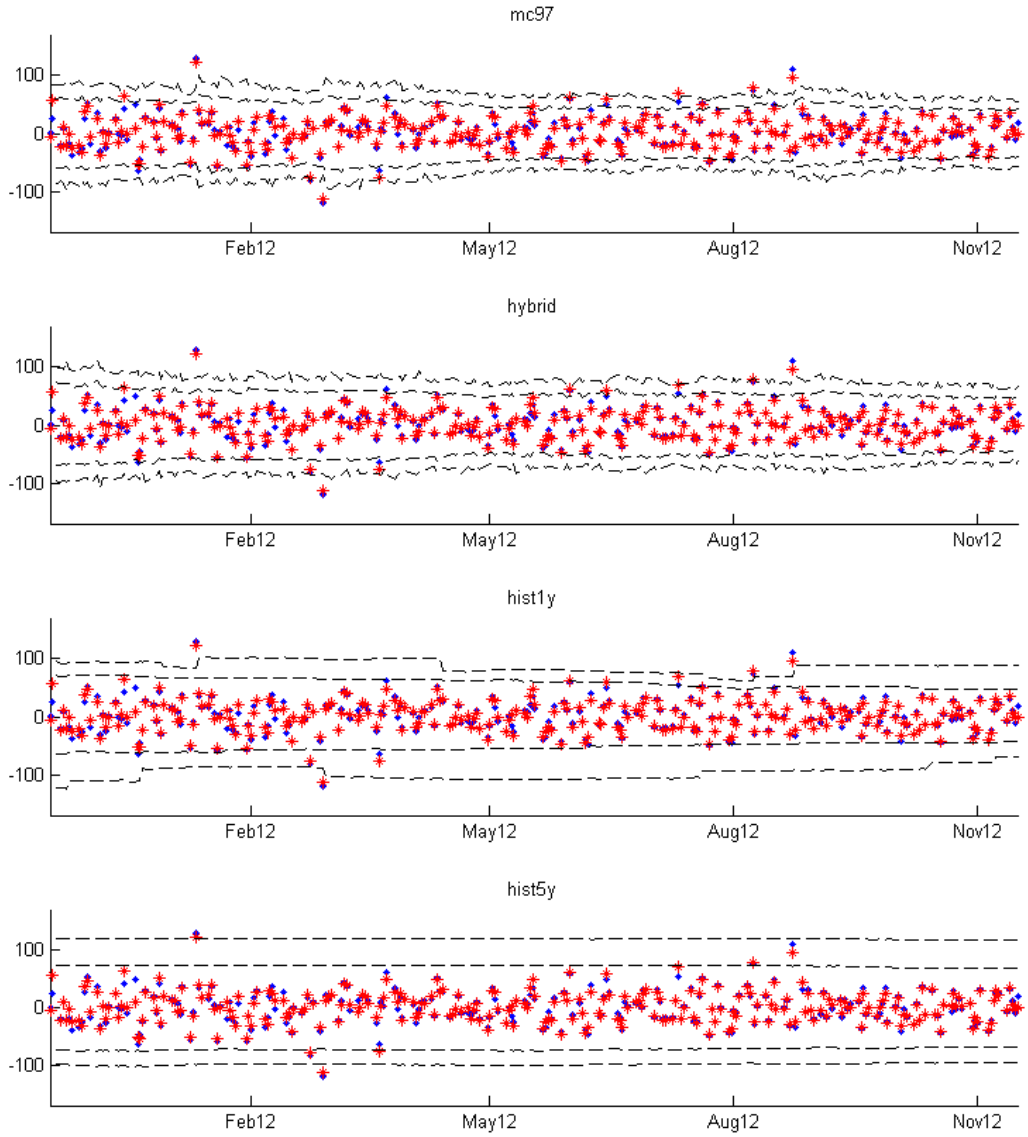

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Figure 4: iBoxx EUR Corporates Index, Daily VaR (in basis points).

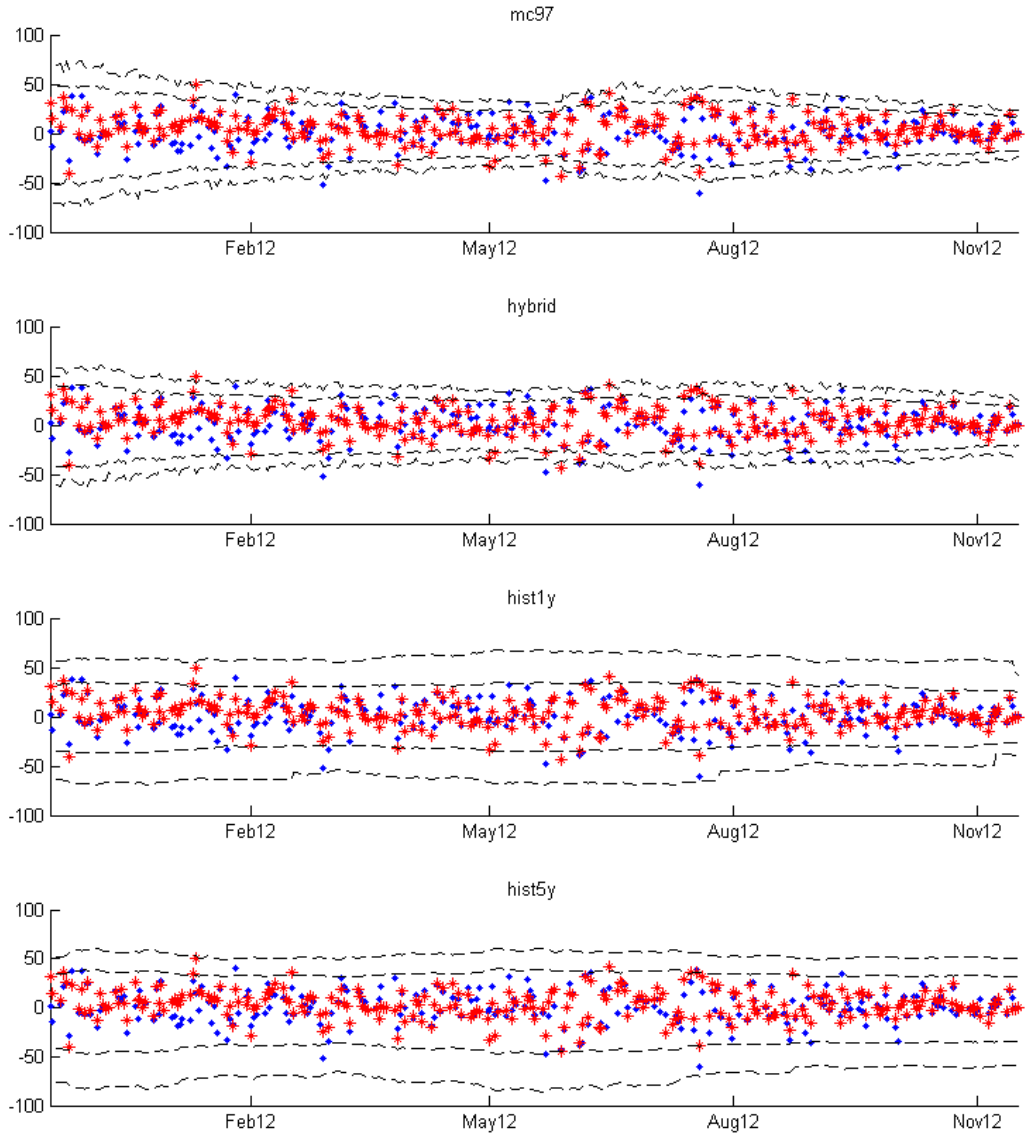

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Figure 5: iBoxx EUR Sovereign Index, Daily VaR (in basis points).

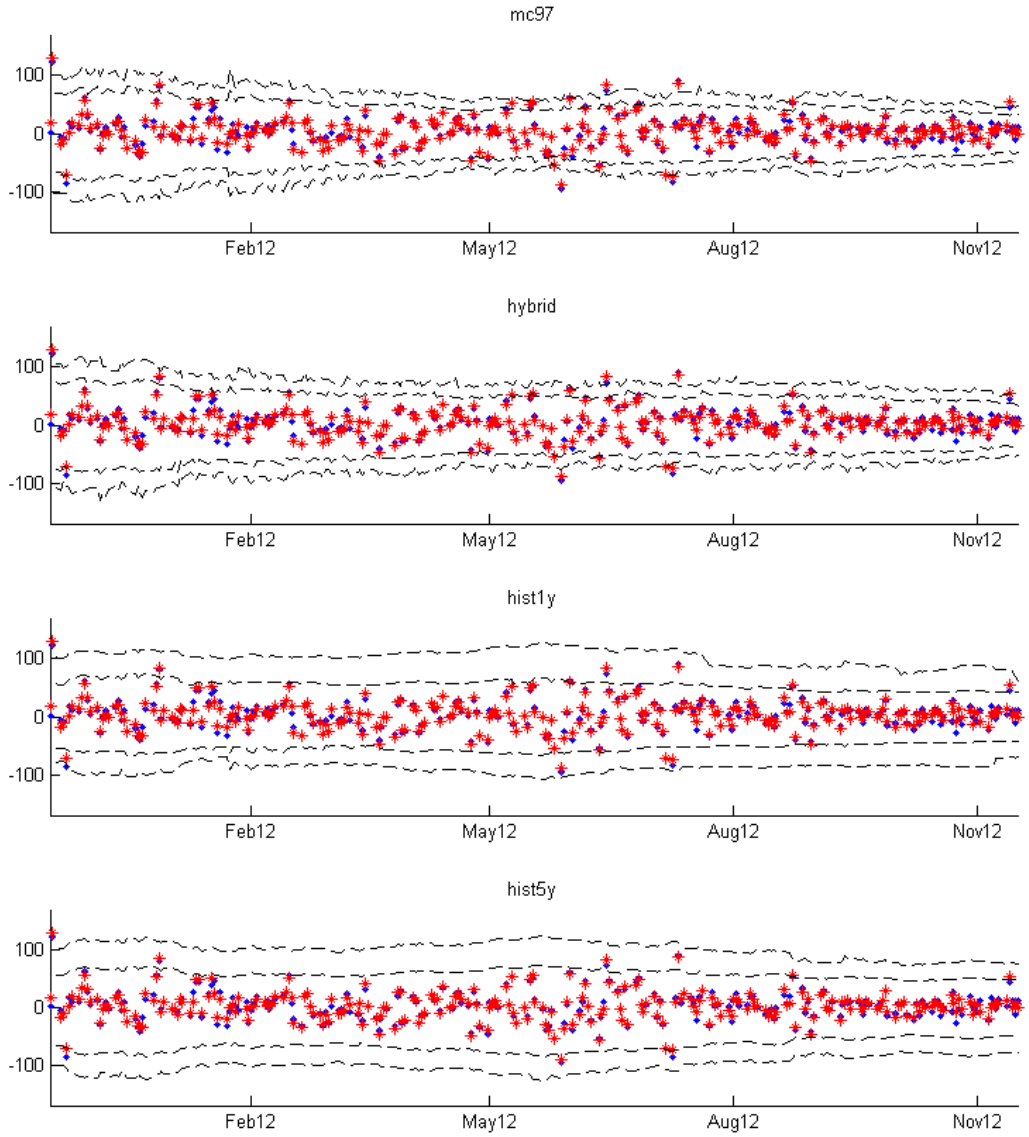

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Figure 6: JPMorgan EMBI Global Diversified Index, Daily VaR (in basis points).

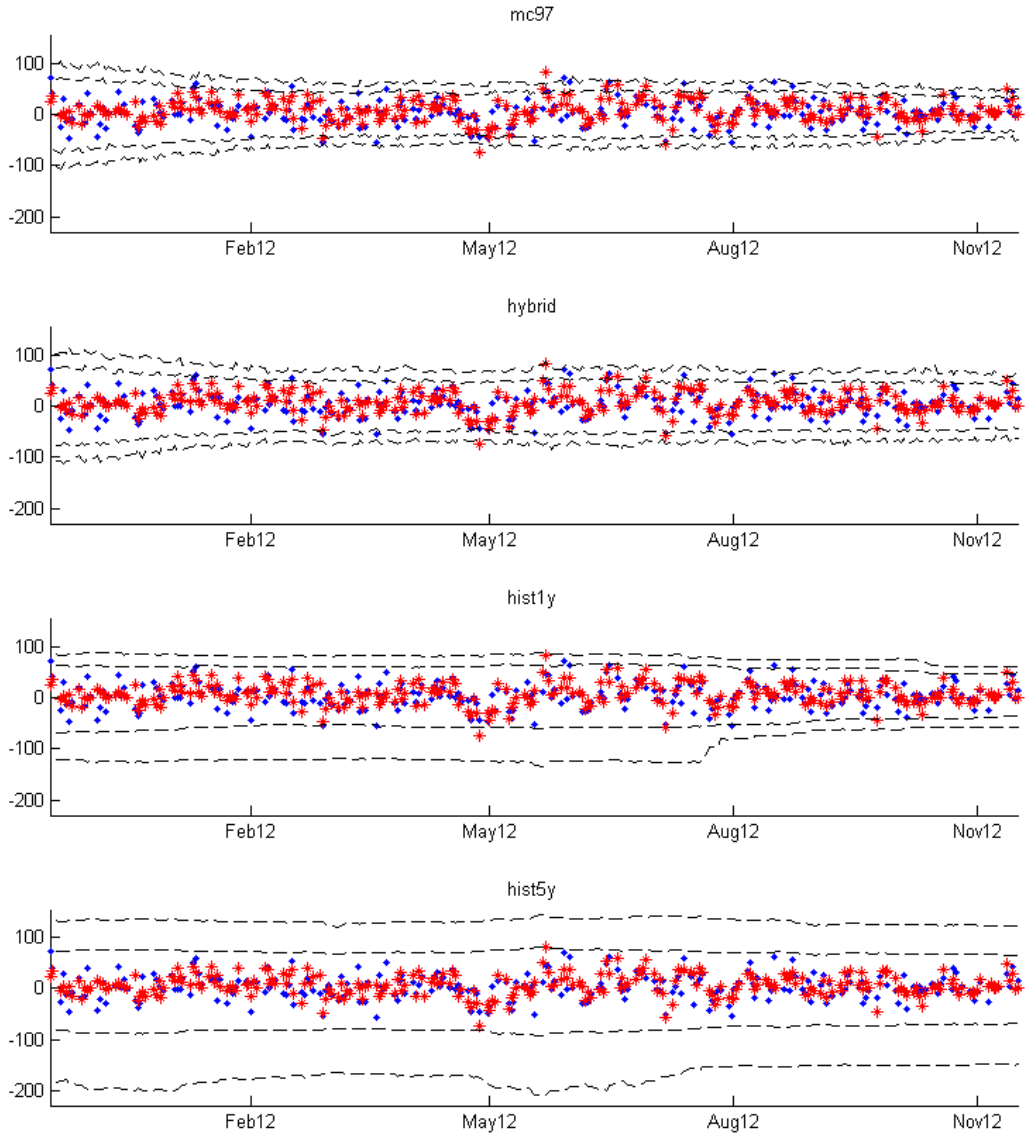

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Figure 7: MSCI EAFE Index, Daily VaR (in basis points).

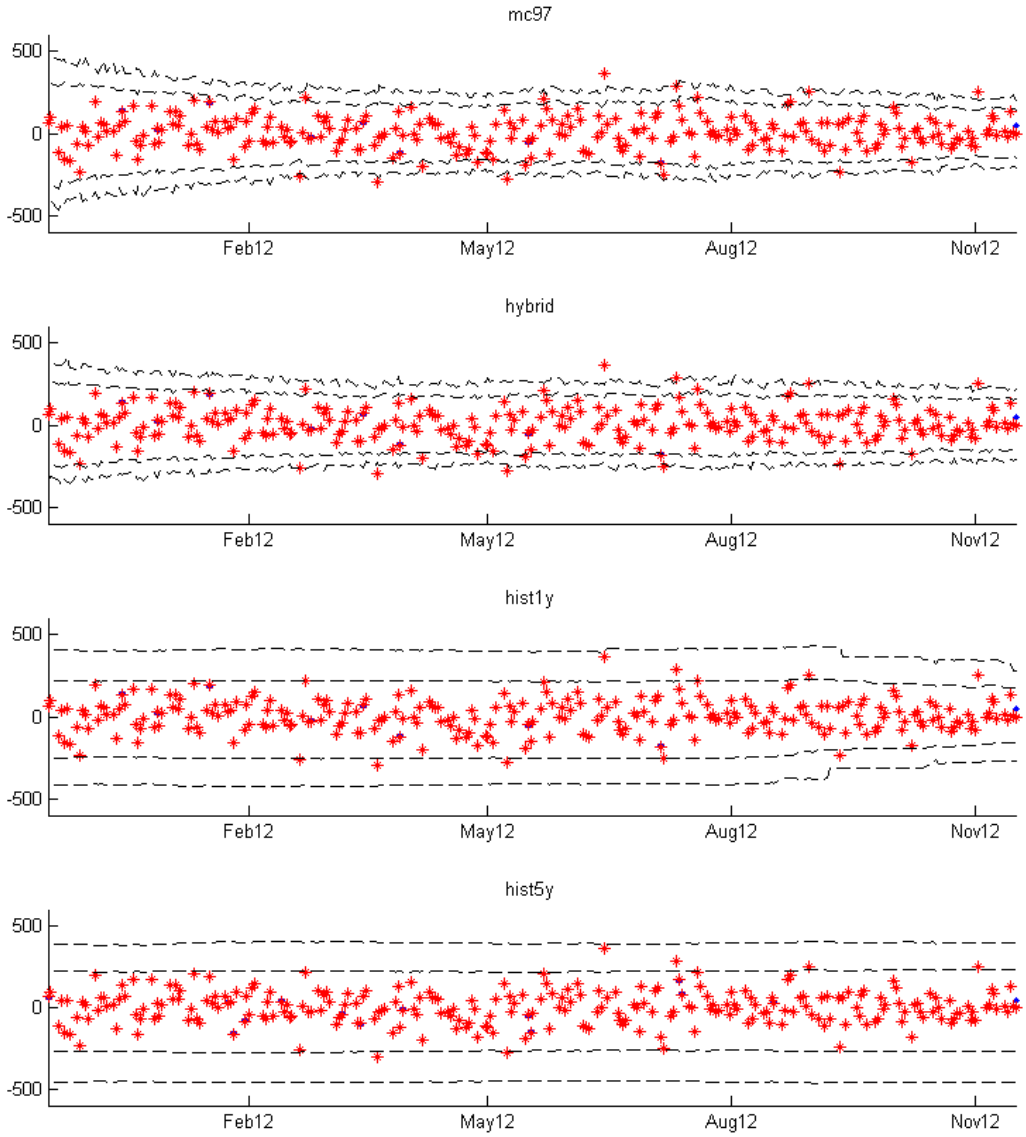

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Figure 8: MSCI Emerging Markets Index, Daily VaR (in basis points).

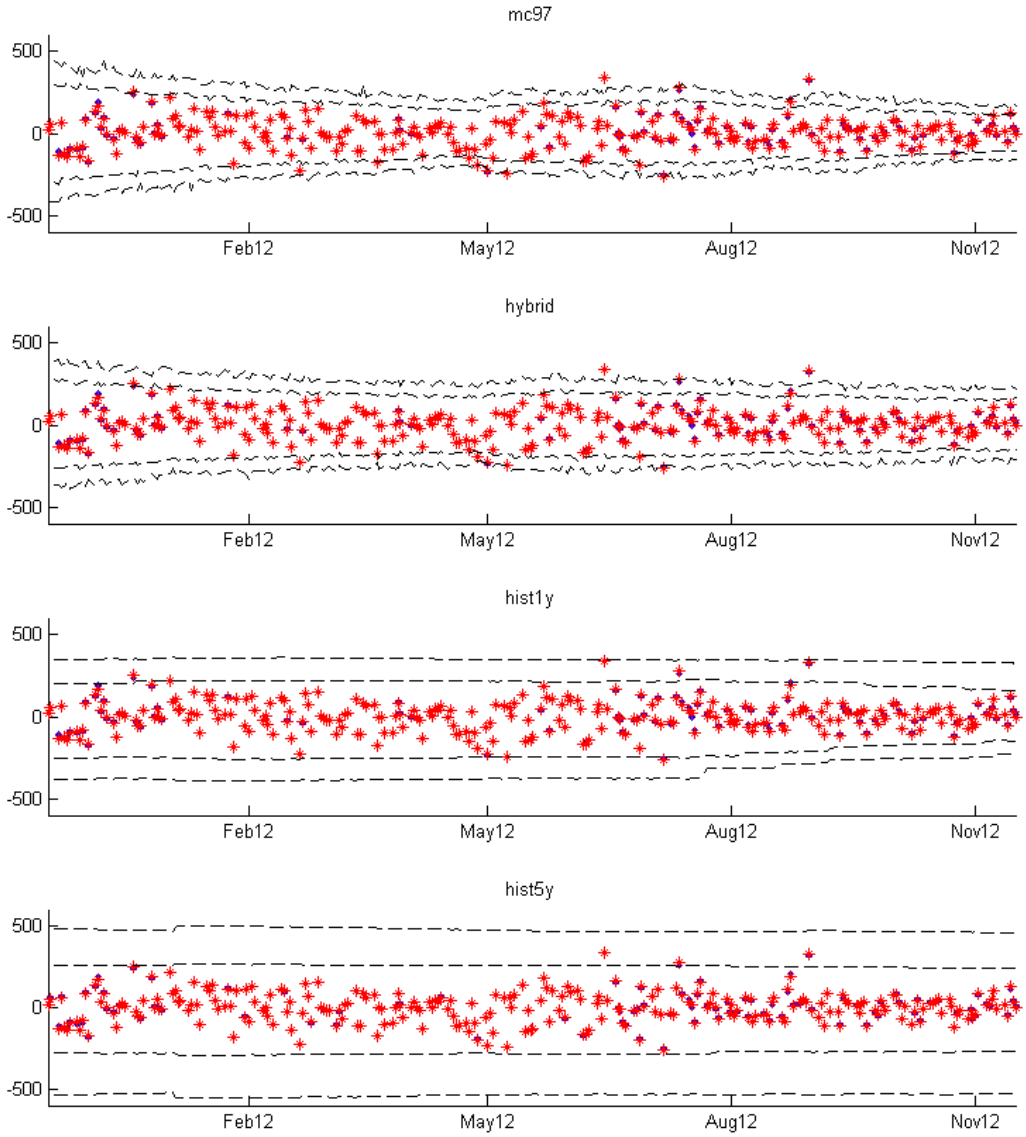

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Figure 9: MSCI World Index, Daily VaR (in basis points).

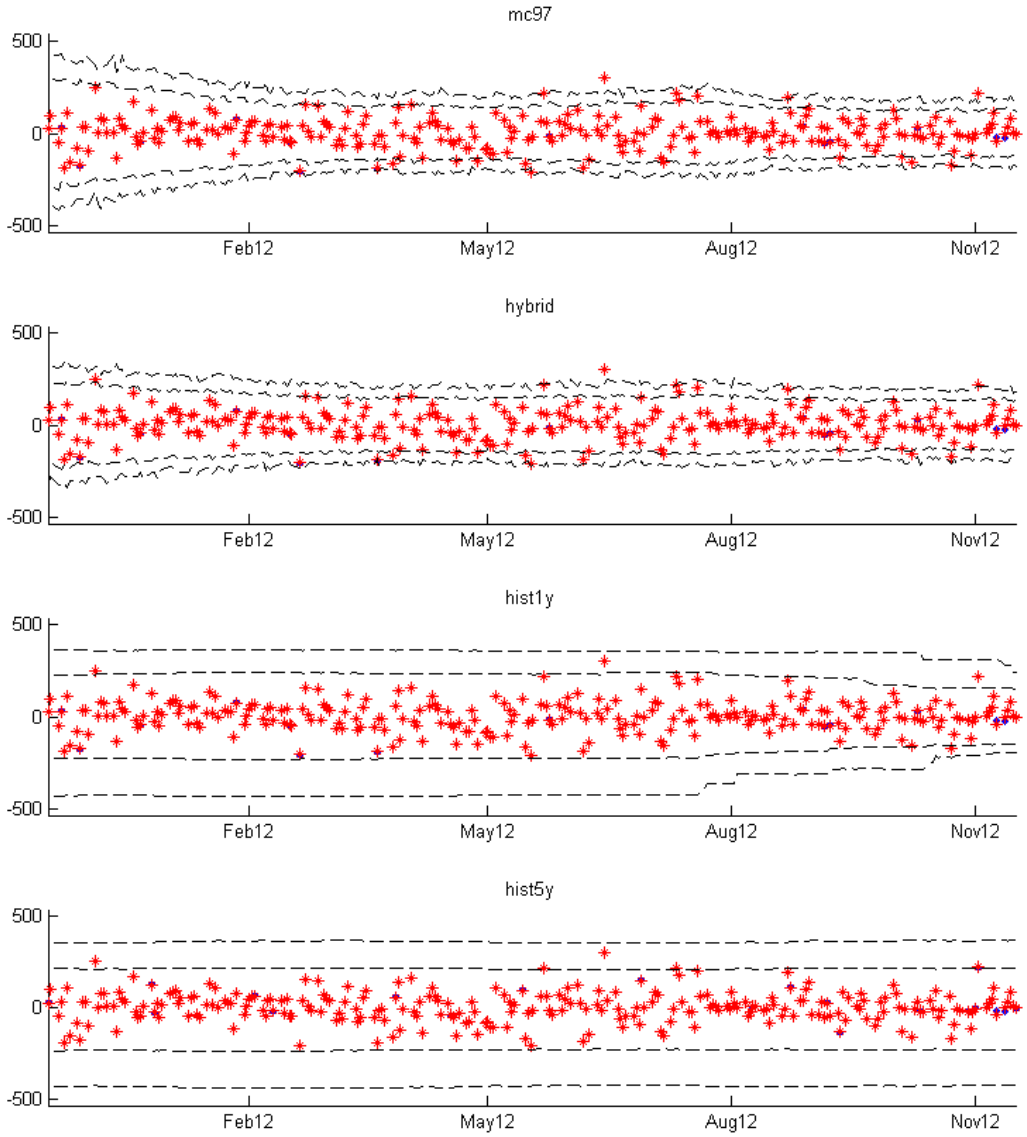

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Figure 10: MSCI USA Index, Daily VaR (in basis points).

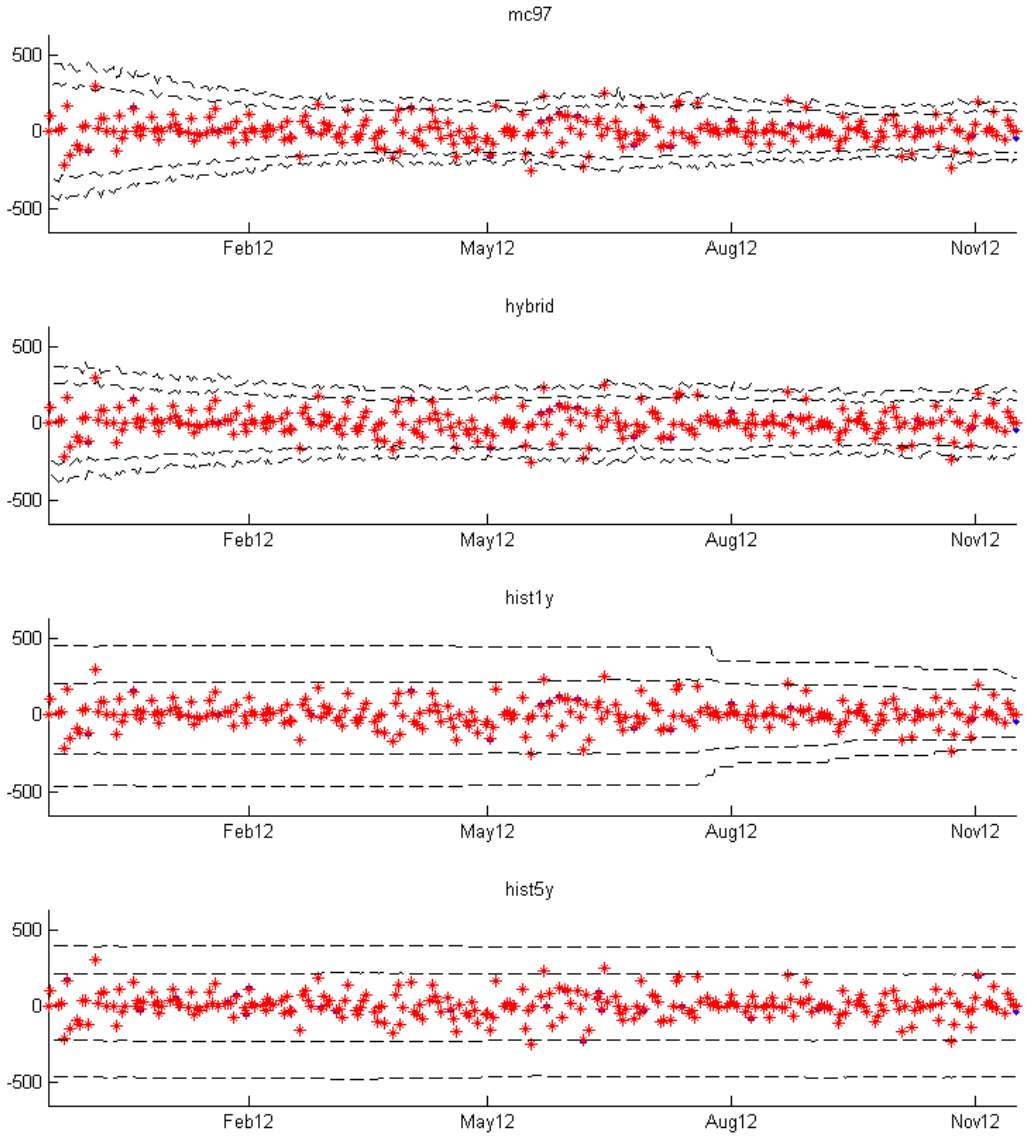

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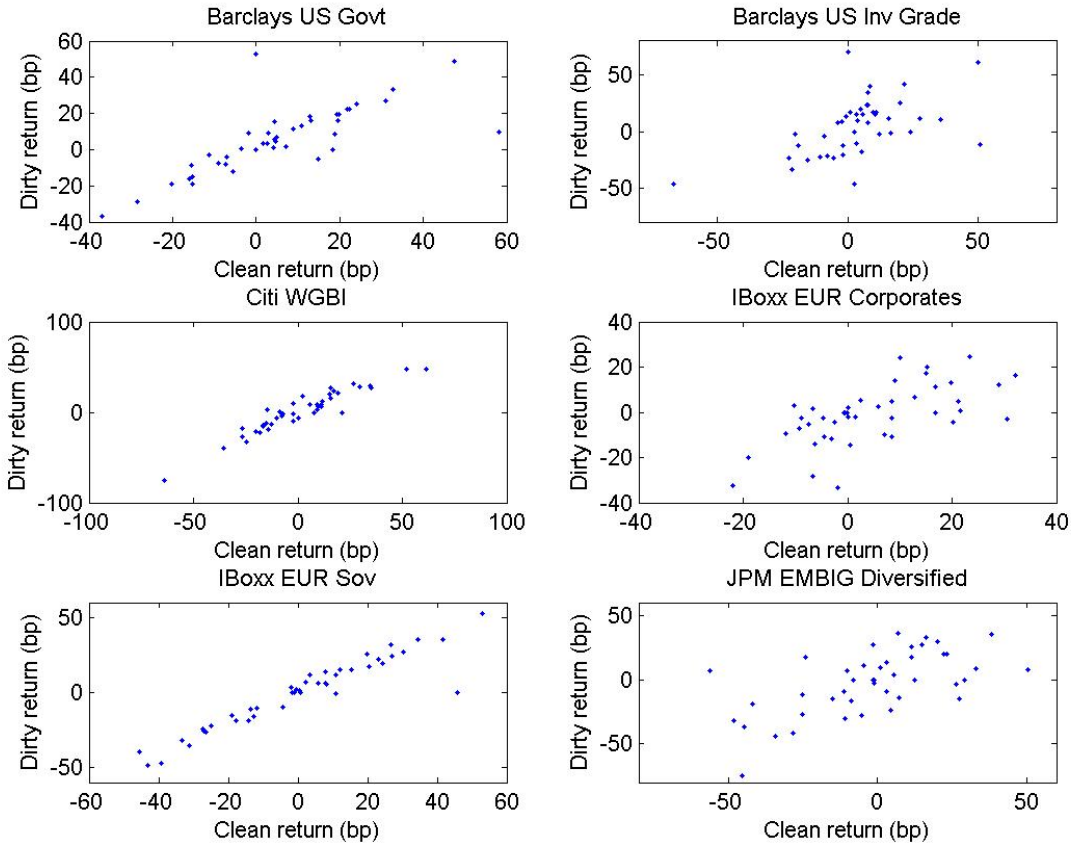
Figure 11: Clean and Dirty Returns, 2012, Fixed Income Indices.



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Appendix B: Tables 1-15

Table 1: Average, Maximum and Minimum 99 percent Daily VaR (in basis points) for 2012.

Index name	Methodology	Avg	Min	Max
Barclays US Govt	mc97	49	75	36
	hybrid	48	76	34
	hist1y	56	69	49
	hist5y	74	78	71
Barclays US Inv Grade	mc97	56	80	42
	hybrid	61	84	50
	hist1y	85	98	63
	hist5y	91	97	85
Citi WGBI	mc97	72	98	55
	hybrid	78	108	59
	hist1y	97	125	69
	hist5y	98	103	95
IBoxx EUR Sov	mc97	75	120	45
	hybrid	79	129	52
	hist1y	88	108	69
	hist5y	100	127	77
IBoxx EUR Corporates	mc97	43	76	24
	hybrid	41	62	28
	hist1y	60	70	38
	hist5y	72	86	58
JPM EMBIG Diversified	mc97	65	109	42
	hybrid	75	114	57
	hist1y	105	135	57
	hist5y	172	210	148
MSCI EAFE	mc97	267	468	184
	hybrid	257	369	200
	hist1y	390	427	261
	hist5y	455	463	446
MSCI EM	mc97	248	462	155
	hybrid	265	394	194
	hist1y	345	390	230
	hist5y	536	552	518
MSCI World	mc97	228	419	156
	hybrid	218	339	170
	hist1y	380	434	193
	hist5y	431	442	423
MSCI USA	mc97	229	447	144
	hybrid	241	384	172
	hist1y	400	466	227
	hist5y	465	478	456

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Table 2: Average, Maximum and Minimum 95 percent Daily VaR (in basis points) for 2012.

Index name	Methodology	Avg	Min	Max
Barclays US Govt	mc97	35	54	24
	hybrid	34	53	24
	hist1y	39	50	32
	hist5y	49	51	47
Barclays US Inv Grade	mc97	40	54	30
	hybrid	43	59	33
	hist1y	50	61	40
	hist5y	61	63	59
Citi WGBI	mc97	51	69	38
	hybrid	55	71	44
	hist1y	53	65	43
	hist5y	72	76	69
IBoxx EUR Sov	mc97	53	84	31
	hybrid	56	83	36
	hist1y	54	66	42
	hist5y	67	85	47
IBoxx EUR Corporates	mc97	30	56	17
	hybrid	29	44	20
	hist1y	32	37	26
	hist5y	40	48	34
JPM EMBIG Diversified	mc97	46	80	32
	hybrid	53	81	41
	hist1y	54	71	36
	hist5y	80	92	68
MSCI EAFE	mc97	189	335	137
	hybrid	182	261	144
	hist1y	237	257	160
	hist5y	268	276	260
MSCI EM	mc97	176	309	107
	hybrid	187	268	139
	hist1y	231	258	146
	hist5y	280	293	265
MSCI World	mc97	161	310	110
	hybrid	154	243	120
	hist1y	210	232	150
	hist5y	231	237	225
MSCI USA	mc97	162	322	105
	hybrid	170	271	132
	hist1y	227	255	140
	hist5y	227	233	223

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Table 3: VaR Exceedances in 2012, Fixed Income, Clean Returns.

	mc97	hybrid	hist1y	hist5y
99% VaR Exceedances				
Barclays US Govt	3	4	2	0
Barclays US Inv Grade	3	2	0	0
Citi WGBI	2	1	1	1
IBoxx EUR Sov	3	2	1	0
IBoxx EUR Corporates	5	5	0	0
JPM EMBIG Diversified	0	0	0	0
95% VaR Exceedances				
Barclays US Govt	13	14	7	4
Barclays US Inv Grade	11	8	3	2
Citi WGBI	6	4	6	2
IBoxx EUR Sov	6	6	4	3
IBoxx EUR Corporates	10	10	12	4
JPM EMBIG Diversified	9	3	3	0

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Table 4: VaR Exceedances in 2012, Fixed Income, Dirty Returns.

	mc97	hybrid	hist1y	hist5y
99% VaR Exceedances				
Barclays US Govt	3	4	2	0
Barclays US Inv Grade	5	3	0	0
Citi WGBI	1	1	1	1
IBoxx EUR Sov	4	2	0	0
IBoxx EUR Corporates	1	1	0	0
JPM EMBIG Diversified	2	1	0	0
95% VaR Exceedances				
Barclays US Govt	14	14	7	3
Barclays US Inv Grade	17	14	8	3
Citi WGBI	5	3	3	3
IBoxx EUR Sov	6	5	4	2
IBoxx EUR Corporates	7	7	5	0
JPM EMBIG Diversified	6	2	2	0

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Table 5: VaR Exceedances in 2012, Equity, Clean Returns.

	mc97	hybrid	hist1y	hist5y
99% VaR Exceedances				
MSCI EAFE	3	4	0	0
MSCI EM	3	1	0	0
MSCI World	3	1	0	0
MSCI USA	3	1	0	0
95% VaR Exceedances				
MSCI EAFE	9	10	4	2
MSCI EM	9	6	1	0
MSCI World	13	12	1	0
MSCI USA	11	7	3	3

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

Index Name	Methodology	Q1	Q2	Q3	Q4	Total
Barclays US Govt	mc97	1	0	2	0	3
	hybrid	1	0	2	1	4
	hist1y	1	0	1	0	2
	hist5y	0	0	0	0	0
Barclays US Inv Grade	mc97	1	1	1	0	3
	hybrid	1	1	0	0	2
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
Citi WGBI	mc97	2	0	0	0	2
	hybrid	1	0	0	0	1
	hist1y	1	0	0	0	1
	hist5y	1	0	0	0	1
IBoxx EUR Sov	mc97	0	1	2	0	3
	hybrid	0	1	1	0	2
	hist1y	0	0	0	1	1
	hist5y	0	0	0	0	0
IBoxx EUR Corporates	mc97	1	2	1	1	5
	hybrid	1	3	1	0	5
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
JPM EMBIG Diversified	mc97	0	0	0	0	0
	hybrid	0	0	0	0	0
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0

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Table 7: Exceedances by Quarter, Fixed Income, Dirty Returns, 99 percent Confidence Level.

Index Name	Methodology	Q1	Q2	Q3	Q4	Total
Barclays US Govt	mc97	1	0	2	0	3
	hybrid	1	0	2	1	4
	hist1y	1	0	1	0	2
	hist5y	0	0	0	0	0
Barclays US Inv Grade	mc97	2	1	2	0	5
	hybrid	1	0	2	0	3
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
Citi WGBI	mc97	1	0	0	0	1
	hybrid	1	0	0	0	1
	hist1y	1	0	0	0	1
	hist5y	1	0	0	0	1
IBoxx EUR Sov	mc97	0	2	2	0	4
	hybrid	0	1	1	0	2
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
IBoxx EUR Corporates	mc97	0	1	0	0	1
	hybrid	0	1	0	0	1
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
JPM EMBIG Diversified	mc97	0	1	1	0	2
	hybrid	0	1	0	0	1
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0

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Table 8: Exceedances by Quarter, Equity, Clean Returns, 99 percent Confidence Level.

Index Name	Methodology	Q1	Q2	Q3	Q4	Total
MSCI EAFE	mc97	1	2	0	0	3
	hybrid	0	2	2	0	4
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
MSCI EM	mc97	0	3	0	0	3
	hybrid	0	0	1	0	1
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
MSCI World	mc97	1	1	0	1	3
	hybrid	0	1	0	0	1
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0
MSCI USA	mc97	0	2	0	1	3
	hybrid	0	1	0	0	1
	hist1y	0	0	0	0	0
	hist5y	0	0	0	0	0

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Table 9: 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
Barclays US Govt	mc97	3	1.35	7.21	0.06	0.84
	hybrid	4	1.28	1.22	0.31	0.64
	hist1y	2	1.18	0.23	0.09	0.64
	hist5y	0			0.93	
Barclays US Inv Grade	mc97	3	1.15	0.09	0.06	0.40
	hybrid	2	1.12	-1.46	0.09	0.64
	hist1y	0			0.93	
	hist5y	0			0.93	
Citi WGBI	mc97	2	1.35	0.61	0.09	0.95
	hybrid	1	1.45	0.00	0.49	0.78
	hist1y	1	1.38		0.49	0.78
	hist5y	1	1.22		0.49	0.78
IBoxx EUR Sov	mc97	3	1.23	0.56	0.94	0.84
	hybrid	2	1.28	21.96	0.09	0.64
	hist1y	1	1.04		0.49	0.77
	hist5y	0			0.93	
IBoxx EUR Corporates	mc97	5	1.28	1.66	0.62	0.27
	hybrid	5	1.27	1.70	0.62	0.86
	hist1y	0			0.93	
	hist5y	0			0.93	
JPM EMBIG Diversified	mc97	0			0.93	
	hybrid	0			0.93	
	hist1y	0			0.93	
	hist5y	0			0.93	

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Table 10: 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
Barclays US Govt	mc97	13	1.30	0.42	0.09	0.53
	hybrid	14	1.31	0.61	0.07	0.36
	hist1y	7	1.30	0.39	0.86	0.74
	hist5y	4	1.17	-0.79	0.99	0.87
Barclays US Inv Grade	mc97	11	1.29	0.44	0.49	0.41
	hybrid	8	1.25	-0.07	0.77	0.79
	hist1y	3	1.30	3.70	1.00	0.40
	hist5y	2	1.08	-12.45	1.00	0.64
Citi WGBI	mc97	6	1.37	0.68	0.93	0.95
	hybrid	4	1.42	0.69	0.99	0.95
	hist1y	6	1.32	0.36	0.93	0.95
	hist5y	2	1.41	0.57	1.00	0.95
IBoxx EUR Sov	mc97	6	1.53	1.52	1.00	0.82
	hybrid	6	1.37	0.81	1.00	0.82
	hist1y	4	1.52	4.22	1.00	0.64
	hist5y	3	1.18	-2.73	1.00	0.39
IBoxx EUR Corporates	mc97	10	1.53	2.31	0.55	0.65
	hybrid	10	1.52	2.82	0.55	0.65
	hist1y	12	1.26	0.07	0.19	0.65
	hist5y	4	1.23	-0.16	0.99	0.64
JPM EMBIG Diversified	mc97	9	1.22	-0.82	0.73	0.91
	hybrid	3	1.14	-2.20	1.00	0.40
	hist1y	3	1.03	-20.80	1.00	0.40
	hist5y	0			1.00	

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Table 11: Backtesting Statistics, Fixed Income, Dirty 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
Barclays US Govt	mc97	3	1.32	1.71	0.06	0.84
	hybrid	4	1.26	0.91	0.31	0.64
	hist1y	2	1.18	0.30	0.09	0.64
	hist5y	0			0.93	
Barclays US Inv Grade	mc97	5	1.23	1.08	0.62	0.68
	hybrid	3	1.23	1.34	0.06	0.84
	hist1y	0			0.93	
	hist5y	0			0.93	
Citi WGBI	mc97	1	1.56	0.00	0.49	0.78
	hybrid	1	1.35	0.00	0.49	0.78
	hist1y	1	1.28		0.49	0.78
	hist5y	1	1.14		0.49	0.78
IBoxx EUR Sov	mc97	4	1.11	-0.35	1.00	0.87
	hybrid	2	1.15	0.08	0.09	0.64
	hist1y	0			0.93	
	hist5y	0			0.93	
IBoxx EUR Corporates	mc97	1	1.35	0.00	0.49	0.78
	hybrid	1	1.23	0.00	0.49	0.78
	hist1y	0			0.93	
	hist5y	0			0.93	
JPM EMBIG Diversified	mc97	2	1.14	-0.01	0.09	0.64
	hybrid	1	1.13	0.00	0.49	0.78
	hist1y	0			0.93	
	hist5y	0			0.93	

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Table 12: Backtesting Statistics, Fixed Income, Dirty 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
Barclays US Govt	mc97	14	1.29	0.43	0.58	0.92
	hybrid	14	1.32	0.73	0.58	0.74
	hist1y	7	1.30	0.49	0.86	0.74
	hist5y	3	1.23	-0.16	1.00	0.84
Barclays US Inv Grade	mc97	17	1.33	1.10	0.43	0.57
	hybrid	14	1.28	0.39	0.07	0.36
	hist1y	8	1.19	-1.13	0.77	0.77
	hist5y	3	1.11	-1.70	1.00	0.39
Citi WGBI	mc97	5	1.38	0.83	0.97	0.68
	hybrid	3	1.53	1.34	1.00	0.84
	hist1y	3	1.59	1.76	1.00	0.84
	hist5y	3	1.22	-0.20	1.00	0.84
IBoxx EUR Sov	mc97	6	1.47	1.33	1.00	0.98
	hybrid	5	1.35	0.82	1.00	0.94
	hist1y	4	1.37	2.48	1.00	0.64
	hist5y	2	1.05	-5.24	1.00	0.63
IBoxx EUR Corporates	mc97	7	1.32	0.60	0.86	1.00
	hybrid	7	1.27	0.20	0.86	1.00
	hist1y	5	1.13	-2.44	0.97	0.85
	hist5y	0			1.00	
JPM EMBIG Diversified	mc97	6	1.27	0.09	0.93	0.64
	hybrid	2	1.29	0.13	1.00	0.64
	hist1y	2	1.18	-0.75	1.00	0.63
	hist5y	0			1.00	

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Table 13: 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	mc97	3	1.14	-0.06	0.06	0.84
	hybrid	4	1.13	-0.21	0.31	0.87
	hist1y	0			0.93	
	hist5y	0			0.93	
MSCI EM	mc97	3	1.06	-3.71	0.06	0.99
	hybrid	1	1.02		0.49	0.78
	hist1y	0			0.93	
	hist5y	0			0.93	
MSCI World	mc97	3	1.05	-4.17	0.06	0.39
	hybrid	1	1.05		0.49	0.78
	hist1y	0			0.93	
	hist5y	0			0.93	
MSCI USA	mc97	3	1.31	1.09	0.06	0.84
	hybrid	1	1.09		0.49	0.78
	hist1y	0			0.93	
	hist5y	0			0.93	

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Table 14: 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	mc97	9	1.40	1.47	0.66	0.91
	hybrid	10	1.32	0.79	0.55	0.89
	hist1y	4	1.12	-3.05	0.99	0.64
	hist5y	2	1.07	-5.65	1.00	0.95
MSCI EM	mc97	9	1.29	0.41	0.66	0.99
	hybrid	6	1.28	0.36	0.93	0.82
	hist1y	1	1.02		1.00	0.78
	hist5y	0			1.00	
MSCI World	mc97	13	1.23	-0.58	0.49	0.96
	hybrid	12	1.20	-1.18	0.47	0.98
	hist1y	1	1.09		1.00	0.77
	hist5y	0			1.00	
MSCI USA	mc97	11	1.36	1.06	0.49	0.98
	hybrid	7	1.25	-0.03	0.86	0.99
	hist1y	3	1.17	-0.55	1.00	0.83
	hist5y	3	1.05	-6.16	1.00	0.84

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Table 15: Relationship Between Clean and Dirty Returns, 2012.

Index Name	Correlation	Beta
Barclays US Govt	0.95	0.98
Barclays US Inv Grade	0.84	1.02
Citi WGBI	0.96	0.94
Iboxx EUR Sov	0.96	0.94
Iboxx EUR Corporates	0.74	0.67
JPM EMBIG Diversified	0.58	0.53
MSCI EAFE	1.00	1.00
MSCI EM	1.00	1.01
MSCI World	1.00	1.00
MSCI USA	1.00	0.99

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[1] *As of June 30, 2011, based on eVestment, Lipper and Bloomberg data.*

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