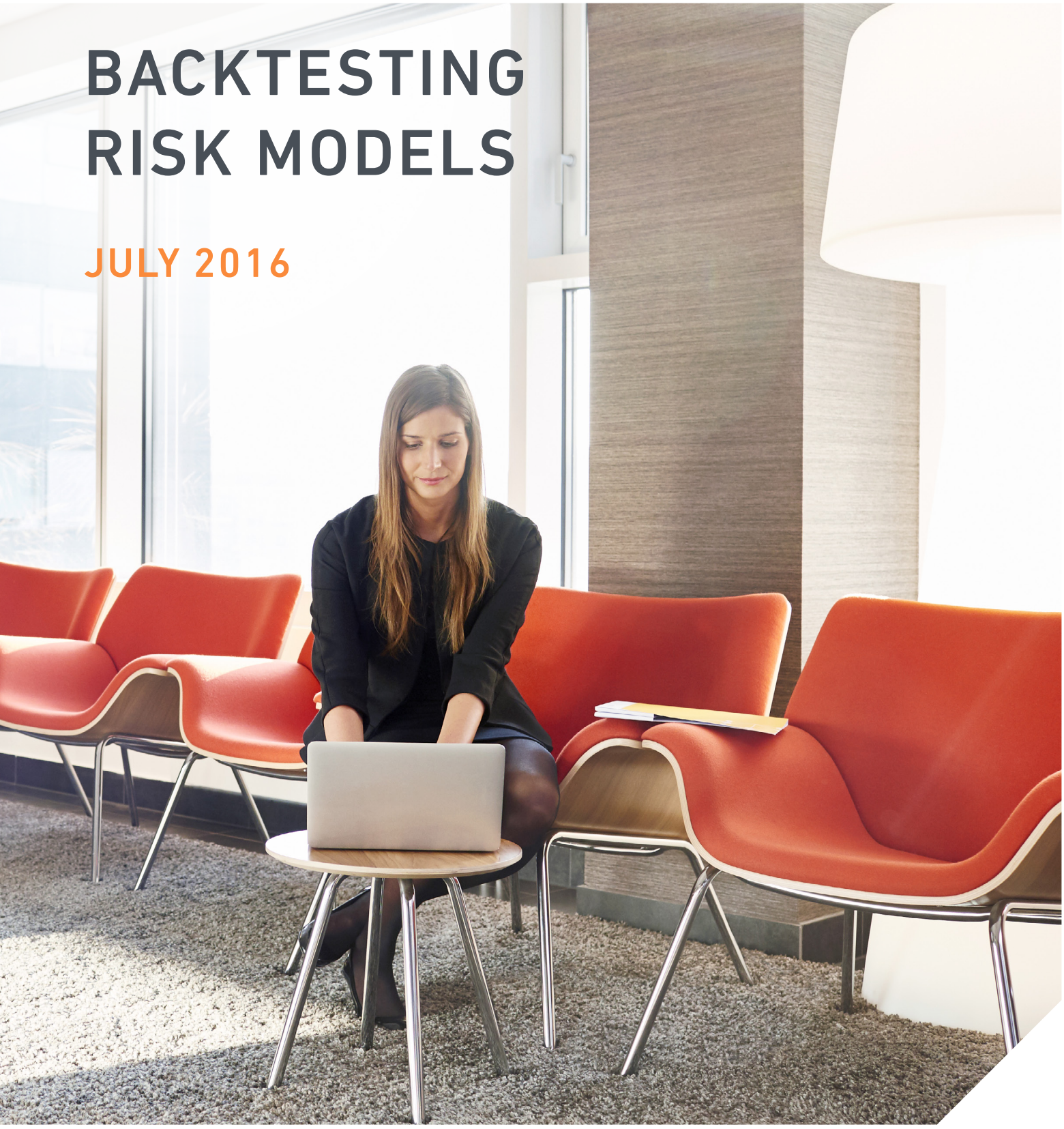
BACKTESTING RISK MODELS

JULY 2016



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EXECUTIVE SUMMARY

In this half-year update of the Backtesting Review, MSCI began by analyzing how each of four types of simulation models available in *RiskMetrics* RiskManager—Monte Carlo, historical, filtered historical and weighted historical—performed over the year ended June 30, 2016. These models were tested on 10 indexes, representing different segments of the U.S. and global equity and bond markets.

Risk measures, such as Expected Shortfall and Value at Risk, are designed to calculate the risk level of a portfolio. But some risk models may work better than others for different asset classes and for different periods of time. We ranked four types of models using the MSCI Model Scorecard, an innovative tool that measures how well a model has predicted risk, either with Expected Shortfall (ES) or Value at Risk (VaR).

We also performed a traditional VaR backtest, by counting the number of times the realized loss of the index exceeded the VaR forecasts for the four models. A model that has too many "VaR exceedances" has underestimated risk, while a model with too few exceedances overestimated it. This analysis was complemented by a number of conditional backtesting measures, designed to detect inappropriate clustering of VaR exceedances. In addition to the traditional VaR backtest, we conducted a formal backtest of Expected Shortfall, based on a framework recently developed by MSCI. We validated the entire forecast distribution through the realized p-values.

Our July 2016 model backtests found:

- When any risk model failed the VaR and ES backtests, it was usually the result of either a mild underestimation (yellow zone in Exhibits 5-8) or a mild overestimation of risk (light blue zone). Only in one instance did a severe underestimation of risk occur—the mc_fhist5y97 model failed the backtest for 99% VaR for the MSCI Emerging Market index.
- As in the previous backtesting report (January 2016), we observed that, as we calculated VaR or ES at higher confidence levels and got deeper into the tails of the distribution, the Gaussian assumption may not have been appropriate. This was when the filtered historical models tended to perform better. At lower confidence levels, however, this seemed less of an issue and the Monte Carlo based models also performed well.
- Although it was difficult to generalize about each model's performance over different indexes, the MSCI Scorecard suggested that the historical models tended to perform better for the higher confidence levels, whereas the Monte Carlo models performed more strongly at the lower confidence level.

Description of the Backtesting Procedure

RISK MODELS

In this paper, we formally backtested eight models, divided into four categories:

1 Monte Carlo simulation

2 Historical simulation

3 Filtered historical simulation

4 Weighted historical simulation

This year we have changed the selection of risk models compared to the backtesting paper published mid-July 2015.

Instead of using filtered historical models with a lookback period of one year, we incorporated a lookback period of five years. By doing so, we are able to include a greater number of observations in the tails of the distribution. Hence, the filtered historical model was able to combine the advantages of using an empirical distribution to capture fat tails, having enough observations in the tail due to the long lookback period and being reactive to regime changes due to the filtering. Furthermore, we replaced the weighted historical model with a decay factor of 0.97 with a filtered historical model which is less reactive (hist_fhist5y995).

The detailed descriptions of the models are as follows:

MC94	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	Similar model as the above, but with a decay factor of 0.97.
HIST1Y	Historical simulation, using a one-year trailing window of equally weighted daily historical returns.
HIST5YO	Historical simulation based on five years of weekly historical returns, scaled back to produce VaR and ES for a one-day analysis horizon. Overlapping returns are used to smooth out any weekly cyclical effects.
HIST_FHIST5Y97	In this model, historical returns are scaled down by a volatility estimate at the time of observation, and scaled up by the current volatility estimate. The volatility is estimated with an exponentially weighted moving average with a decay factor of 0.97. This method is also referred to as filtering historical returns. The filtered returns are then used for a five-year historical simulation, with equally weighted returns.
MC_FHIST5Y97	This model is similar to the previous one, but applies Monte Carlo simulation using a Gaussian distribution, with volatilities and correlations estimated on a five-year window of equally weighted filtered returns.
HIST_FHIST5Y995	Same as HIST_FHIST5Y97, but with a decay factor of 0.995.
WHIST995	Historical simulation in which the weight of each observation depends on its age. The weight is determined with a decay factor of 0.995.

RISK MEASURES

In this study we backtest both Value at Risk (VaR) and Expected Shortfall (ES). We calculate and test VaR at a 99% and a 95% confidence level, whereas for ES we look at the 97.5% and 87.5% confidence levels. Note that, under the assumption of normality, 99% VaR is approximately equal to 97.5% ES, whereas 95% VaR is similar to 87.5% ES.

INDEXES

We test all models on 10 indexes, which are standard equity and fixed income indexes. We work with clean returns, i.e., the return of the index under the changes of mark-to-market as computed by our modeled pricing functions. To compute the clean return, we assume that there is no change in index composition and that the price of each index constituent changes precisely by the changes in the modeled risk factors. This does not incorporate index turnover, trading revenue or actual market price changes.

The indexes we use to assess model performance are the following:

FIXED INCOME INDEXES	EQUITY INDEXES
CITI US BROAD INVESTMENT-GRADE BOND INDEX (CITIUSBIG)	MSCI EAFE INDEX (MSEAFE)
CITI WORLD GOVERNMENT BOND INDEX (CITIWGBI)	MSCI EMERGING MARKETS INDEX (MSEM)
JP MORGAN EMBI GLOBAL DIVERSIFIED INDEX (JPMEMBIG)	MSCI WORLD INDEX (MSWORLD)
JP MORGAN GBI US BOND INDEX (JPMGBI)	MSCI USA INDEX (MSUSA)
IBOXX EUR CORPORATES INDEX (IBOXXCORP)	
IBOXX EUR SOVEREIGN INDEX (IBOXXSOV)	

BACKTESTING STATISTICS

Unconditional VaR Backtest

To backtest VaR, we use the standard analysis of counting exceedances to VaR, meaning that we count the number of days when the index loss exceeded the VaR forecast. The number of exceedances is expected to be equal to the number of trading days, multiplied by one minus the confidence level. For example, with 260 trading days, we expect 13 exceedances to 95% VaR. Too many observed exceedances imply the model underestimates risk, whereas too few exceedances indicate an overly conservative risk model. We use a traffic light system to highlight the models, according to the following convention:

- Red: the model severely underestimates risk (hypothesis test with a significance level of 0.01%).
- Yellow: the model mildly underestimates risk (5% significance level)
- Light blue: the model mildly overestimates risk (5% significance level)
- Dark blue: the model severely overestimates risk (0.01% significance level)

The significance levels refer to a one-sided hypothesis test based on the binomial distribution, to detect anomalous high (low) numbers of exceptions for under- (respectively over-) estimation of risk. The results are reported in Exhibits 5 and 6.

Unconditional ES Backtest

We also backtested expected shortfall, based on the methodology proposed by Acerbi and Székely (2014). In fact, we used a variant the Z-statistic, i.e. Z_2^*, and critical values based on resampling (see Acerbi, Verbraken and Szekely (2015)). This statistic is expected to yield zero values for a perfect model, negative values for a model underestimating risk and positive values for a conservative model. We applied the same traffic light color-coding outlined above for the ES backtesting results, with the same significance levels; results are displayed in Exhibits 7 and 8.

Conditional VaR Coverage

For models that react appropriately to changing market conditions, exceedances should be spread evenly throughout the year. However, the unconditional VaR and ES backtests assess the VaR and ES forecasts over the course of the entire period, but these tests fail to detect the clustering of VaR exceedances. Therefore, Exhibits 9 and 10 report conditional coverage backtesting statistics for VaR at the 99%, 97.5%, 95%, and 87.5% confidence levels.

We use a standard chi-square independence test to assess the distribution of VaR exceedances across quarters. Under the null hypothesis, VaR exceedances are evenly spread across quarters, and any deviation from an equal distribution will lead to a higher value for the test statistic and a low corresponding p-value. The Markov test, detailed in Christoffersen and Pelletier (2004), proposes a model where the probability of a VaR exceedance varies, depending on whether an exceedance occurred on the previous day. We report the p-values for these tests and highlight those models which fail the test at a 1% significance level.

Realized p-values

Another way of testing how accurately the model performs is to look at the realized p-values. On each day in the backtesting period, we look at the forecast distribution and obtain the cumulative probability of the observed P&L on that day, i.e., the realized p-value. In a large sample, the realized p-values should be distributed uniformly between zero and one, if the model predictions were correct. We assess whether this condition holds with a Kolmogorov-Smirnov statistic.

The p-value of this hypothesis test is reported in the third column of Exhibits 9 and 10, highlighting results beyond the 1% significance level. Note that this statistic looks at the entire forecast distribution and not just at the tails as do VaR and ES.

MODEL SELECTION

Besides backtesting the risk models, we also used the MSCI Model Scorecard to assess their relative performance for VaR and ES forecasting (see Exhibits 11–14). With a scoring function based on the concept of elicitability, we ranked the forecast performance of each model for every given index[1]. Better models produced smaller scores. Note that scores cannot be compared across indexes, because the values they produce are index-specific and can therefore only be used for a relative ranking of models forecasting the same index, and not for an absolute assessment of the quality of any prediction. For this reason, even the best model in the selection can fail a backtest. It should also be noted that a large score may result for either underestimation or overestimation of risk.

Discussion

MARKET ENVIRONMENT

To assess the level of market turbulence in the 12-months ending June 2016, we looked at the forecast of a reactive Monte Carlo VaR model (mc94) for each index (see Exhibits 15-24). The picture varied for different fixed income indexes. For several indexes, there was increased volatility at the beginning of December 2015, when a statement by ECB President Mario Draghi on quantitative easing upset the markets. Around mid-March 2016, we saw turbulence in the Citi WGBI, due to expectations of an interest rate hike by the Federal Reserve. And at the end of June 2016, the time of the U.K. Brexit referendum, we saw a sharp rise in the volatility bands for the JPM GBI Index.

Overall, we saw average 99% VaR levels between 38 and 113 basis points, depending on the index and risk model. Based on the normal distribution, 97.5% ES would be approximately the same as 99% VaR. However, in our results, we saw that 97.5% ES was slightly lower than 99% VaR, with average 97.5% ES ranging from 32 to 92 bps. We saw a similar trend for 95% VaR versus 87.5% ES, where average 95% VaR ranged between 24 and 76 bps and 87.5% ES between 15 and 49 bps (see Exhibits 1 and 2).

For the equity indexes, we saw three periods of increased volatility. The first occurred around the end of August 2015, when concerns about a China slowdown triggered market turmoil. We observed a second rise in volatility at the beginning of 2016: Renewed worries about the Chinese economy and the oil price led to a strong market correction, although this was not as severe as in August 2015. We saw a third hike in volatility on June 24, the day after the Brexit referendum. The VaR forecast for the MSCI EAFE index reacted particularly sharply, with VaR levels roughly doubling in one day (see Exhibit 24).

Average 99% VaR levels ranged from 199bps to 302bps, whereas average 97.5% ES ranged from 168bps to 228bps. For 95% VaR and 87.5% ES we observed ranges of 132bps to 189bps and 76bps to 132bps respectively over the past year (see Exhibits 3 and 4).

[1] We used the scoring function described in Acerbi and Szekely (2014), with w=4.

FIXED INCOME BACKTESTING RESULTS

The fixed income backtesting statistics for 95% VaR showed that none of the models underestimated or overestimated risk at a 0.01% significance level. At a 5% significance level, there were a few cases of mild overestimation of risk, most of which occurred for the JPM EMBIG index. We did not observe any overestimation of risk for the two Monte Carlo models (mc94 and mc97), for which volatility bands narrow quickly when market volatility decreases.

For 99% VaR we saw a similar pattern, with no violations at either significance level, although we should note that overestimation of risk cannot be detected for 99% VaR, since a VaR model with no exceedances still falls within the 95% confidence bounds (see Exhibits 5 and 6).

For 97.5% ES, the backtests showed that all models passed the test for the fixed income indexes. The backtest for 87.5% ES looked slightly less good, with a mild overestimation of risk for the JPM EMBIG index in particular, although this also applied to Citi USBIG. Again, we saw the Monte Carlo models performing well, with no overestimation of risk for any of the indexes (see Exhibits 7 and 8).

Finally, we looked at the conditional coverage statistics for the fixed income indexes. There were no red flags for the clustering statistics at any confidence level, but the mc97 and hist5yo models for the iBoxx Corporates index failed the Kolmogorov-Smirnov test (see Exhibit 9).

FIXED INCOME MODEL RANKING

The MSCI Scorecard ranked the models based on their VaR and ES predictions. As for the backtesting results in the previous report (January 2016), we saw that the ranking depended on the confidence level. The standard Monte Carlo models tended to rank higher for 95% VaR, whereas the standard and weighted historical models performed better for 99% VaR. We observed a similar phenomenon for 87.5% and 97.5% ES.

This may suggest that, at lower confidence levels, Monte Carlo models that are reactive but assume a normal distribution do well. At higher confidence levels, the assumption of a normal distribution may not be as appropriate, so that historical models, which are based on an empirical distribution, tended to perform better. It should be emphasized, though, that the model selection statistics indicated that there was no "best" model. The preferable model choice depended on the index (see Exhibits 11-14).

EQUITY BACKTESTING RESULTS

We saw a mild underestimation of 95% VaR for several equity indexes. This particularly applied to MSCI EAFE and MSCI Emerging Markets, for which five models mildly underestimated risk. For 99% VaR the results looked slightly worse, with mild underestimation of risk for many of the indexes and mc_fhist5y97 severely underestimating risk for the MSCI Emerging Market index. It is notable that the Monte Carlo models (mc94, mc97 and mc_fhist5y97) failed the backtest for all indexes, with just one exception. This suggests that a Gaussian assumption for equity returns may not have been appropriate for estimating VaR at a 99% confidence level (see Exhibits 5 and 6). The ES backtesting statistics looked better, with only hist1y and whist995 mildly underestimating 87.5% ES for MSCI EAFE, while mc_fhist5y97 mildly underestimated 97.5% ES for MSCI Emerging Markets (see Exhibits 7 and 8).

Among the conditional backtesting statistics for equities, the hist1y model failed the chi-squared test, implying that its exceedances clustered in time. The Kolmogorov-Smirnov statistic suggested that the hist5yo model did not capture the current return distribution well for the MSCI World and MSCI USA indexes. This is a recurring observation for the hist5yo model, which has a long look-back period and includes return data that may no longer be relevant (see Exhibit 10).

EQUITY MODEL RANKING

For equities, we observed that for 99% VaR, hist5yo—a historical model with a long look-back period—clearly performed best among all models, followed by the other historical and filtered historical models, with the exception of mc_fhist5y97, which is based on a normal distribution. In addition, mc94 and mc97, which are both Monte Carlo models based on a normal distribution, also performed poorly. This once again indicates that a normal distribution may not be an optimal assumption for estimating 99% VaR for equity portfolios. For 95% VaR, however, the Monte Carlo models ranked higher, as did hist5yo; the filtered historical models followed these.

The weighted historical model and the historical model with a one-year look-back period ranked lowest. The conclusions are less straightforward for the ranking of the expected shortfall models. At the 97.5% confidence level, hist5yo again performed best for most indexes, but mc94 also did well. The worst model was clearly the Monte Carlo that uses filtered returns (mc_fhist5y97). Here the picture for 87.5% shortfall looks similar to that for 95% VaR (see Exhibits 11-14).

CONCLUSION

In this semi-annual publication, we show the results of a systematic one-year backtest of four categories of standard risk models available in RiskManager. We report standard VaR backtesting results, complemented with a backtest of Expected Shortfall; we also include results from the MSCI Model Scorecard, which ranks the different models in terms of predictive performance.

Our results indicate that,

- When the risk models failed the VaR and ES backtests, this was usually the result of either a mild underestimation (yellow zone in Exhibits 5-8) or a mild overestimation of risk (light blue zone). Severe underestimation of risk was only observed in one instance (mc_fhist5y97 for the MSCI Emerging Market index).
- As in the previous backtesting report (January 2016), we observed that, as we calculated VaR or ES at higher confidence levels and got deeper into the tails of the distribution, the Gaussian assumption may not have been appropriate. This was when the filtered historical models tended to perform better. At lower confidence levels, however, this seemed less of an issue, and the Monte Carlo based models also performed well.
- Although it was difficult to generalize about each model's performance over different indexes, the MSCI Scorecard indicated that the historical models tended to perform better for the higher confidence levels, whereas the Monte Carlo models did well at lower confidence levels.

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Carlo Acerbi joined MSCI in 2009 and currently leads MSCI research on risk methodologies and liquidity. In the past he worked as a risk manager and as a financial engineer for major Italian banks, and as a senior expert in the risk practice of McKinsey & Co. He received a PhD in Theoretical Physics (SISSA – ISAS Trieste) before turning to finance in 1997.

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Since December 2013, Thomas has been a member of MSCI's research team. Among other things, he contributes to the development of new risk methodologies for the *Barra* and *RiskMetrics* models, with a special focus on the ongoing evolution of banking regulation.

He is also responsible for the publication of the *RiskMetrics* periodicals *Risk Monitor* and *Year In Review*; the latter is a regular, extensive risk models backtest report. Prior to joining MSCI, Thomas obtained a PhD in applied economics at the KU Leuven, Belgium. He is also a CFA charterholder and holds a Master in Civil Engineering from the KU Leuven.

EXHIBIT 1 Average, Minimum, and Maximum 99% VaR and 97.5% ES Over the Past Year, for Fixed Income Indexes (in basis points)

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
CITIUSBIG	MC94	49	76	34	41	62	29
CITIUSBIG	MC97	50	71	37	42	58	33
CITIUSBIG	HIST1Y	61	66	53	51	55	42
CITIUSBIG	HIST5YO	58	63	53	46	51	42
CITIUSBIG	HIST_FHIST5Y97	54	71	45	43	55	36
CITIUSBIG	MC_FHIST5Y97	49	65	38	41	57	31
CITIUSBIG	HIST_FHIST5Y995	55	61	50	46	52	40
CITIUSBIG	WHIST995	58	65	52	49	53	43
CITIWGBI	MC94	98	164	62	83	129	55
CITIWGBI	MC97	99	140	71	84	109	59
CITIWGBI	HIST1Y	113	118	100	92	97	81
CITIWGBI	HIST5YO	96	97	94	74	77	70
CITIWGBI	HIST_FHIST5Y97	103	131	86	82	106	67
CITIWGBI	MC_FHIST5Y97	91	118	71	76	101	59
CITIWGBI	HIST_FHIST5Y995	102	111	97	78	89	70
CITIWGBI	WHIST995	106	118	96	88	94	79
JPMEMBIG	MC94	66	95	45	56	79	40
JPMEMBIG	MC97	68	100	49	58	82	43
JPMEMBIG	HIST1Y	84	92	78	68	78	55
JPMEMBIG	HIST5YO	108	120	98	77	90	73
JPMEMBIG	HIST_FHIST5Y97	81	103	72	64	83	56
JPMEMBIG	MC_FHIST5Y97	71	93	59	60	79	49
JPMEMBIG	HIST_FHIST5Y995	90	105	80	71	83	65
JPMEMBIG	WHIST995	84	91	75	69	75	59

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
JPMGBI	MC94	60	93	40	51	79	34
JPMGBI	MC97	61	81	48	52	69	41
JPMGBI	HIST1Y	70	75	66	60	66	55
JPMGBI	HIST5YO	68	72	63	53	55	50
JPMGBI	HIST_FHIST5Y97	63	81	52	52	66	44
JPMGBI	MC_FHIST5Y97	58	76	46	49	64	39
JPMGBI	HIST_FHIST5Y995	63	66	61	53	57	49
JPMGBI	WHIST995	67	71	63	58	60	55
IBOXXCORP	MC94	40	65	24	33	56	19
IBOXXCORP	MC97	41	54	28	34	49	23
IBOXXCORP	HIST1Y	49	57	41	36	41	31
IBOXXCORP	HIST5YO	55	60	52	40	43	38
IBOXXCORP	HIST_FHIST5Y97	43	54	33	34	43	25
IBOXXCORP	MC_FHIST5Y97	38	51	26	32	45	22
IBOXXCORP	HIST_FHIST5Y995	40	44	37	32	34	29
IBOXXCORP	WHIST995	46	52	39	35	37	33
IBOXXSOV	MC94	60	89	41	51	74	34
IBOXXSOV	MC97	62	81	46	53	67	39
IBOXXSOV	HIST1Y	79	86	70	62	68	51
IBOXXSOV	HIST5YO	76	81	71	53	56	51
IBOXXSOV	HIST_FHIST5Y97	66	89	47	52	70	39
IBOXXSOV	MC_FHIST5Y97	60	91	40	51	74	35
IBOXXSOV	HIST_FHIST5Y995	64	68	55	50	53	45
IBOXXSOV	WHIST995	77	83	69	57	63	50

EXHIBIT 2 Average, Minimum, and Maximum 95% VaR and 87.5% ES Over the Past Year, for Fixed Income Indexes (in basis points)

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
CITIUSBIG	MC94	34	52	24	24	37	18
CITIUSBIG	MC97	35	48	27	25	34	19
CITIUSBIG	HIST1Y	42	47	34	27	30	20
CITIUSBIG	HIST5YO	35	38	33	24	26	22
CITIUSBIG	HIST_FHIST5Y97	36	49	29	24	31	19
CITIUSBIG	MC_FHIST5Y97	34	48	27	24	32	18
CITIUSBIG	HIST_FHIST5Y995	35	38	32	22	25	20
CITIUSBIG	WHIST995	39	45	34	25	29	21
CITIWGBI	MC94	70	106	47	49	72	33
CITIWGBI	MC97	70	91	50	49	63	36
CITIWGBI	HIST1Y	76	81	67	46	53	35
CITIWGBI	HIST5YO	57	59	53	38	40	36
CITIWGBI	HIST_FHIST5Y97	65	82	53	42	53	34
CITIWGBI	MC_FHIST5Y97	64	85	51	45	61	34
CITIWGBI	HIST_FHIST5Y995	59	67	55	37	43	33
CITIWGBI	WHIST995	70	78	67	43	47	36
JPMEMBIG	MC94	47	68	34	33	47	24
JPMEMBIG	MC97	49	70	37	34	48	26
JPMEMBIG	HIST1Y	54	65	44	34	40	26
JPMEMBIG	HIST5YO	60	68	57	38	43	36
JPMEMBIG	HIST_FHIST5Y97	52	64	45	33	40	29
JPMEMBIG	MC_FHIST5Y97	50	69	41	35	46	29
JPMEMBIG	HIST_FHIST5Y995	56	65	50	35	40	31
JPMEMBIG	WHIST995	53	58	47	33	37	30

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
JPMGBI	MC94	42	62	28	30	44	20
JPMGBI	MC97	43	57	34	30	41	24
JPMGBI	HIST1Y	52	58	44	30	33	27
JPMGBI	HIST5YO	42	44	40	29	30	27
JPMGBI	HIST_FHIST5Y97	42	53	35	28	35	23
JPMGBI	MC_FHIST5Y97	41	55	33	29	37	23
JPMGBI	HIST_FHIST5Y995	41	43	39	27	29	25
JPMGBI	WHIST995	48	52	42	29	30	28
IBOXXCORP	MC94	28	47	16	20	34	11
IBOXXCORP	MC97	29	41	20	20	29	13
IBOXXCORP	HIST1Y	30	35	24	17	22	13
IBOXXCORP	HIST5YO	31	34	28	18	20	17
IBOXXCORP	HIST_FHIST5Y97	26	35	19	16	21	12
IBOXXCORP	MC_FHIST5Y97	27	38	18	19	25	13
IBOXXCORP	HIST_FHIST5Y995	24	26	23	15	16	14
IBOXXCORP	WHIST995	29	32	25	16	19	14
IBOXXSOV	MC94	43	64	28	30	45	21
IBOXXSOV	MC97	44	57	31	31	40	23
IBOXXSOV	HIST1Y	46	52	38	31	37	26
IBOXXSOV	HIST5YO	41	44	39	25	27	23
IBOXXSOV	HIST_FHIST1Y97	42	58	31	27	37	20
IBOXXSOV	MC_FHIST5Y97	43	63	30	30	44	21
IBOXXSOV	HIST_FHIST5Y995	42	45	38	24	27	23
IBOXXSOV	WHIST995	44	46	40	28	30	26

EXHIBIT 3 Average, Minimum, and Maximum 99% VaR and 97.5% ES Over the Past Year, for Equity Indexes (in basis points)

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
MSEAFE	MC94	239	515	150	201	460	129
MSEAFE	MC97	236	421	166	198	357	143
MSEAFE	HIST1Y	248	312	202	203	233	165
MSEAFE	HIST5YO	283	291	276	222	235	209
MSEAFE	HIST_FHIST5Y97	286	354	239	228	289	188
MSEAFE	MC_FHIST5Y97	237	331	191	200	266	153
MSEAFE	HIST_FHIST5Y995	274	306	233	213	239	177
MSEAFE	WHIST995	242	298	199	192	216	155
MSEM	MC94	269	406	162	225	339	132
MSEM	MC97	266	344	183	223	297	147
MSEM	HIST1Y	269	336	175	209	251	150
MSEM	HIST5YO	302	312	279	220	229	201
MSEM	HIST_FHIST5Y97	248	291	210	206	233	179
MSEM	MC_FHIST5Y97	225	283	172	190	226	152
MSEM	HIST_FHIST5Y995	261	288	219	213	224	183
MSEM	WHIST995	266	325	184	204	228	150
MSWORLD	MC94	206	358	122	173	309	103
MSWORLD	MC97	206	296	132	173	252	113
MSWORLD	HIST1Y	257	309	174	179	208	127
MSWORLD	HIST5YO	252	266	234	181	191	170
MSWORLD	HIST_FHIST5Y97	224	276	176	183	225	142
MSWORLD	MC_FHIST5Y97	199	277	146	168	224	123
MSWORLD	HIST_FHIST5Y995	232	263	186	174	195	138
MSWORLD	WHIST995	233	274	166	170	193	122

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
MSUSA	MC94	230	424	119	193	351	96
MSUSA	MC97	232	334	140	195	281	119
MSUSA	HIST1Y	284	326	183	202	241	162
MSUSA	HIST5YO	255	262	237	175	187	162
MSUSA	HIST_FHIST5Y97	259	317	189	198	247	141
MSUSA	MC_FHIST5Y97	214	283	145	181	239	123
MSUSA	HIST_FHIST5Y995	243	265	201	193	217	155
MSUSA	WHIST995	269	312	191	197	219	159

EXHIBIT 4 Average, Minimum, and Maximum 95% VaR and 87.5% ES Over the Past Year, for Equity Indexes (in basis points)

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
MSEAFE	MC94	168	378	110	118	270	73
MSEAFE	MC97	166	299	120	116	207	85
MSEAFE	HIST1Y	154	188	116	93	119	69
MSEAFE	HIST5YO	164	176	158	106	110	102
MSEAFE	HIST_FHIST5Y97	173	213	143	107	134	89
MSEAFE	MC_FHIST5Y97	168	218	133	117	151	95
MSEAFE	HIST_FHIST5Y995	162	182	137	94	106	79
MSEAFE	WHIST995	148	185	118	88	106	69
MSEM	MC94	189	291	113	132	196	83
MSEM	MC97	188	247	120	131	171	84
MSEM	HIST1Y	170	205	119	110	131	72
MSEM	HIST5YO	170	185	151	106	114	98

INDEX NAME	METHODOLOGY	AVG VAR	MAX VAR	MIN VAR	AVG ES	MAX ES	MIN ES
MSEM	HIST_FHIST5Y97	164	186	144	107	119	92
MSEM	MC_FHIST5Y97	159	189	131	111	137	88
MSEM	HIST_FHIST5Y995	161	179	136	103	113	85
MSEM	WHIST995	162	196	117	104	115	76
MSWORLD	MC94	145	259	84	101	185	60
MSWORLD	MC97	145	200	95	101	148	66
MSWORLD	HIST1Y	141	166	106	85	99	65
MSWORLD	HIST5YO	138	144	130	90	95	82
MSWORLD	HIST_FHIST5Y97	151	185	119	88	112	64
MSWORLD	MC_FHIST5Y97	140	178	104	98	127	73
MSWORLD	HIST_FHIST5Y995	137	151	113	76	86	60
MSWORLD	WHIST995	132	165	98	81	98	63
MSUSA	MC94	162	294	82	113	211	57
MSUSA	MC97	164	235	101	114	172	70
MSUSA	HIST1Y	158	186	130	98	116	75
MSUSA	HIST5YO	133	140	123	81	85	76
MSUSA	HIST_FHIST5Y97	155	195	113	94	122	64
MSUSA	MC_FHIST5Y97	151	198	102	106	136	70
MSUSA	HIST_FHIST5Y995	147	166	121	84	97	67
MSUSA	WHIST995	151	180	118	93	117	71

EXHIBIT 5 Backtesting Statistics for 99% Value at Risk

MODEL	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	3	3	3	3	3	3	6	7	7	6
MC97	1	3	3	1	2	2	5	7	7	6
HIST1Y	1	2	2	1	1	1	7	7	4	5
HIST5YO	1	4	0	1	1	1	4	4	4	5
HIST_FHIST5Y97	1	2	2	1	2	1	4	7	5	5
MC_FHIST5Y97	3	5	3	2	3	2	8	10	9	9
HIST_FHIST5Y995	1	2	1	2	3	2	3	6	4	7
WHIST995	1	2	2	1	1	1	7	7	4	5

Legend

- Underestimation of risk (p-value = 0.01%)
- Underestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 0.01%)

EXHIBIT 6 Backtesting Statistics for 95% Value at Risk

MODEL	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	11	10	9	11	11	10	22	18	20	16
MC97	8	11	8	10	8	9	21	19	18	13
HIST1Y	4	10	6	6	7	6	23	23	18	16
HIST5YO	9	16	5	9	6	9	19	18	17	26
HIST_FHIST5Y97	9	14	5	11	11	10	18	21	15	16
MC_FHIST5Y97	8	12	5	12	11	10	17	24	17	16
HIST_FHIST5Y995	9	15	5	12	15	8	20	23	18	23
WHIST995	6	10	6	8	7	8	25	25	22	20

Legend

- Underestimation of risk (p-value = 0.01%)
- Underestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 0.01%)

EXHIBIT 7 Backtesting Statistics for 97.5% Expected Shortfall

MODEL	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	0.04	0.01	-0.03	-0.01	-0.03	-0.05	-0.20	-0.21	-0.19	-0.15
MC97	0.03	0.01	0.02	0.03	0.04	0.03	-0.18	-0.18	-0.19	-0.19
HIST1Y	0.11	0.01	0.06	0.08	0.04	0.07	-0.12	-0.22	-0.14	-0.12
HIST5YO	0.09	-0.08	0.11	0.06	0.10	0.05	-0.06	-0.08	-0.07	-0.18
HIST_FHIST5Y97	0.06	-0.02	0.06	0.03	0.02	0.04	-0.10	-0.17	-0.13	-0.14
MC_FHIST5Y97	0.00	-0.06	0.05	0.00	-0.01	0.01	-0.24	-0.32	-0.21	-0.22
HIST_FHIST5Y995	0.09	-0.07	0.09	0.06	-0.03	0.04	-0.07	-0.13	-0.16	-0.13
WHIST995	0.09	0.01	0.06	0.06	0.02	0.05	-0.17	-0.20	-0.16	-0.12

Legend

- Underestimation of risk (p-value = 0.01%)
- Underestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 0.01%)

EXHIBIT 8 Backtesting Statistics for 87.5% Expected Shortfall

MODEL	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	0.09	0.10	0.12	0.07	0.05	0.04	-0.15	-0.11	-0.13	-0.10
MC97	0.12	0.13	0.14	0.08	0.08	0.09	-0.13	-0.13	-0.13	-0.06
HIST1Y	0.16	0.11	0.19	0.12	0.07	0.13	-0.25	-0.22	-0.16	-0.13
HIST5YO	0.14	-0.03	0.21	0.07	0.09	0.01	-0.10	-0.15	-0.10	-0.22
HIST_FHIST5Y97	0.11	0.03	0.15	0.05	-0.01	-0.01	-0.12	-0.20	-0.15	-0.16
MC_FHIST5Y97	0.11	0.03	0.16	0.05	0.02	0.05	-0.14	-0.24	-0.14	-0.14
HIST_FHIST5Y995	0.09	-0.01	0.17	0.04	-0.03	-0.01	-0.17	-0.20	-0.20	-0.19
WHIST995	0.15	0.06	0.17	0.09	0.03	0.09	-0.27	-0.23	-0.22	-0.16

Legend

- Underestimation of risk (p-value = 0.01%)
- Underestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 5%)
- Overestimation of risk (p-value = 0.01%)

EXHIBIT 9 Conditional Coverage Statistics for Fixed Income Indexes

			99% VaR		97.5% VaR		95% VaR		87.5% VaR	
Indexes	Model	KS	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq
CITIUSBIG	MC94	0.10	0.07	0.34	0.45	0.63	0.47	0.72	0.84	0.71
CITIUSBIG	MC97	0.04	0.47	0.43	0.24	0.58	0.74	0.45	0.94	0.80
CITIUSBIG	HIST1Y	0.03	0.47	0.43	0.88	0.60	0.99	0.30	0.99	0.52
CITIUSBIG	HIST5YO	0.35	0.47	0.43	0.69	0.32	0.69	0.32	0.99	0.52
CITIUSBIG	HIST_FHIST5Y97	0.24	0.47	0.43	0.45	0.30	0.63	0.34	0.90	0.85
CITIUSBIG	MC_FHIST5Y97	0.14	0.07	0.34	0.15	0.40	0.74	0.45	0.97	0.63
CITIUSBIG	HIST_FHIST5Y995	0.35	0.47	0.43	0.69	0.32	0.69	0.32	0.77	0.32
CITIUSBIG	WHIST995	0.14	0.47	0.43	0.69	0.32	0.92	0.40	0.97	0.63
CITIWGBI	MC94	0.04	0.07	0.32	0.15	0.14	0.53	0.27	0.86	0.32
CITIWGBI	MC97	0.02	0.07	0.32	0.15	0.38	0.47	0.18	0.97	0.33
CITIWGBI	HIST1Y	0.29	0.08	0.60	0.15	0.12	0.53	0.19	0.86	0.34
CITIWGBI	HIST5YO	0.15	0.34	0.60	0.73	0.19	0.32	0.78	0.14	0.51
CITIWGBI	HIST_FHIST5Y97	0.49	0.08	0.60	0.36	0.20	0.58	0.77	0.36	0.31
CITIWGBI	MC_FHIST5Y97	0.07	0.64	0.58	0.36	0.20	0.46	0.41	0.74	0.39
CITIWGBI	HIST_FHIST5Y995	0.20	0.08	0.60	0.73	0.19	0.67	0.71	0.14	0.51
CITIWGBI	WHIST995	0.65	0.08	0.60	0.15	0.12	0.53	0.19	0.74	0.29
JPMEMBIG	MC94	0.15	0.07	0.34	0.20	0.50	0.62	0.32	0.99	0.35
JPMEMBIG	MC97	0.11	0.07	0.34	0.23	0.33	0.73	0.45	1.00	0.37
JPMEMBIG	HIST1Y	0.04	0.08	0.60	0.44	0.62	0.92	0.63	1.00	0.34
JPMEMBIG	HIST5YO	0.02	-	-	0.88	0.60	0.96	0.33	1.00	0.38
JPMEMBIG	HIST_FHIST5Y97	0.15	0.08	0.60	0.44	0.62	0.96	0.33	0.97	0.30
JPMEMBIG	MC_FHIST5Y97	0.04	0.07	0.34	0.44	0.62	0.96	0.33	0.99	0.30
JPMEMBIG	HIST_FHIST5Y995	0.13	0.46	0.40	0.69	0.34	0.96	0.33	0.98	0.32
JPMEMBIG	WHIST995	0.07	0.08	0.60	0.44	0.62	0.92	0.63	0.99	0.30

			99% VaR		97.5% VaR		95% VaR		87.5% VaR	
Indexes	Model	KS	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq
JPMGBI	MC94	0.07	0.07	0.34	0.14	0.64	0.46	0.94	0.68	0.99
JPMGBI	MC97	0.06	0.46	0.43	0.22	0.59	0.49	0.78	0.60	0.94
JPMGBI	HIST1Y	0.25	0.46	0.43	0.68	0.33	0.97	0.08	0.77	0.81
JPMGBI	HIST5YO	0.26	0.46	0.43	0.43	0.30	0.68	0.61	0.33	0.86
JPMGBI	HIST_FHIST5Y97	0.17	0.46	0.43	0.22	0.59	0.30	0.85	0.33	0.86
JPMGBI	MC_FHIST5Y97	0.04	0.07	0.61	0.14	0.92	0.15	0.79	0.47	0.83
JPMGBI	HIST_FHIST5Y995	0.23	0.07	0.61	0.43	0.30	0.15	0.79	0.14	0.89
JPMGBI	WHIST995	0.46	0.46	0.43	0.43	0.30	0.82	0.31	0.47	0.95
IBOXXCORP	MC94	0.02	0.07	0.79	0.83	0.30	0.31	0.51	0.85	0.76
IBOXXCORP	MC97	0.01	0.08	0.55	0.69	0.79	0.83	0.43	0.89	0.82
IBOXXCORP	HIST1Y	0.78	0.46	0.42	0.44	0.58	0.92	0.04	0.61	0.48
IBOXXCORP	HIST5YO	0.00	0.46	0.42	0.88	0.55	0.97	0.12	0.45	0.78
IBOXXCORP	HIST_FHIST5Y97	0.11	0.08	0.55	0.44	0.58	0.31	0.42	0.17	0.81
IBOXXCORP	MC_FHIST5Y97	0.02	0.07	0.79	0.44	0.58	0.31	0.42	0.75	0.78
IBOXXCORP	HIST_FHIST5Y995	0.42	0.07	0.79	0.62	0.04	0.19	0.40	0.10	0.86
IBOXXCORP	WHIST995	0.62	0.46	0.42	0.23	0.30	0.92	0.04	0.40	0.69
IBOXXSOV	MC94	0.05	0.07	0.79	0.20	0.70	0.52	0.90	0.46	0.36
IBOXXSOV	MC97	0.03	0.08	0.60	0.44	0.58	0.62	0.96	0.79	0.82
IBOXXSOV	HIST1Y	0.44	0.46	0.42	0.69	0.32	0.92	0.07	0.91	0.35
IBOXXSOV	HIST5YO	0.12	0.46	0.42	0.44	0.12	0.62	0.56	0.16	0.63
IBOXXSOV	HIST_FHIST5Y97	0.48	0.46	0.42	0.44	0.58	0.52	0.90	0.16	0.37
IBOXXSOV	MC_FHIST5Y97	0.02	0.08	0.60	0.23	0.56	0.52	0.90	0.36	0.73
IBOXXSOV	HIST_FHIST5Y995	0.74	0.08	0.60	0.44	0.12	0.73	0.43	0.26	0.72
IBOXXSOV	WHIST995	0.62	0.46	0.42	0.44	0.12	0.73	0.43	0.62	0.89

EXHIBIT 10 Conditional Coverage Statistics for Equity Indexes

			99% VaR		97.5% VaR		95% VaR		87.5% VaR	
Indexes	Model	KS	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq
MSEAFE	MC94	0.32	0.95	0.54	0.99	0.50	0.99	0.19	1.00	0.27
MSEAFE	MC97	0.30	0.92	0.54	0.99	0.23	0.99	0.27	0.98	0.05
MSEAFE	HIST1Y	0.09	0.97	0.18	0.94	0.28	1.00	0.03	1.00	0.03
MSEAFE	HIST5YO	0.01	0.91	0.50	0.95	0.26	0.97	0.08	0.97	0.02
MSEAFE	HIST_FHIST5Y97	0.12	0.34	0.57	0.94	0.21	0.99	0.07	0.99	0.02
MSEAFE	MC_FHIST5Y97	0.33	1.00	0.19	1.00	0.16	0.99	0.09	0.98	0.03
MSEAFE	HIST_FHIST5Y995	0.15	0.07	0.78	0.95	0.26	0.99	0.06	1.00	0.03
MSEAFE	WHIST995	0.06	1.00	0.42	0.95	0.23	1.00	0.15	1.00	0.04
MSEM	MC94	0.49	0.94	0.29	0.98	0.40	0.71	0.78	0.53	0.39
MSEM	MC97	0.37	0.94	0.29	0.81	0.08	0.97	0.14	0.84	0.13
MSEM	HIST1Y	0.08	0.97	0.18	0.97	0.01	0.99	0.01	1.00	0.04
MSEM	HIST5YO	0.14	0.34	0.57	0.72	0.09	0.65	0.01	0.97	0.19
MSEM	HIST_FHIST5Y97	0.03	0.94	0.29	0.89	0.17	0.91	0.24	0.97	0.27
MSEM	MC_FHIST5Y97	0.34	1.00	0.09	0.99	0.10	0.99	0.19	0.97	0.37
MSEM	HIST_FHIST5Y995	0.03	0.84	0.36	0.81	0.06	0.98	0.04	0.98	0.13
MSEM	WHIST995	0.05	0.97	0.18	0.94	0.02	1.00	0.04	1.00	0.08
MSWORLD	MC94	0.48	1.00	0.42	0.95	0.50	0.97	0.63	0.95	0.41
MSWORLD	MC97	0.29	1.00	0.18	0.95	0.50	0.99	0.49	0.87	0.38
MSWORLD	HIST1Y	0.28	0.91	0.12	0.99	0.02	0.87	0.13	0.98	0.36
MSWORLD	HIST5YO	0.01	0.91	0.12	0.94	0.28	0.97	0.08	0.93	0.31
MSWORLD	HIST_FHIST5Y97	0.20	0.92	0.29	0.99	0.16	0.88	0.28	0.98	0.36
MSWORLD	MC_FHIST5Y97	0.45	1.00	0.28	0.99	0.16	0.86	0.16	0.95	0.24
MSWORLD	HIST_FHIST5Y995	0.11	0.91	0.12	1.00	0.05	0.97	0.05	1.00	0.51
MSWORLD	WHIST995	0.12	1.00	0.12	0.99	0.04	0.98	0.04	1.00	0.53

			99% VaR		97.5% VaR		95% VaR		87.5% VaR	
Indexes	Model	KS	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq	pChristoff	pChiSq
MSUSA	MC94	0.24	1.00	0.12	0.94	0.21	0.86	0.73	0.92	0.83
MSUSA	MC97	0.12	1.00	0.12	0.95	0.12	0.93	0.38	0.92	0.43
MSUSA	HIST1Y	0.71	1.00	0.04	0.94	0.09	0.86	0.21	0.96	0.03
MSUSA	HIST5YO	0.00	0.92	0.04	1.00	0.37	1.00	0.13	0.99	0.31
MSUSA	HIST_FHIST5Y97	0.26	1.00	0.04	0.99	0.08	0.86	0.30	0.97	0.15
MSUSA	MC_FHIST5Y97	0.14	1.00	0.03	0.99	0.21	0.86	0.24	0.98	0.08
MSUSA	HIST_FHIST5Y995	0.21	1.00	0.04	0.95	0.12	1.00	0.12	0.99	0.23
MSUSA	WHIST995	0.39	1.00	0.04	0.94	0.09	0.97	0.32	0.98	0.06

EXHIBIT 11 MSCI Model Scorecard for 99% VaR

	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	0.66	1.15	0.89	0.82	0.71	0.93	5.22	5.10	4.36	4.59
MC97	0.60	1.14	0.86	0.74	0.68	0.90	5.18	5.20	4.54	4.69
HIST1Y	0.63	1.28	0.90	0.75	0.67	0.96	5.14	4.83	4.60	4.54
HIST5YO	0.62	1.21	1.11	0.73	0.70	0.94	4.80	4.09	4.14	4.01
HIST_FHIST5Y97	0.63	1.18	0.90	0.75	0.69	0.92	5.10	5.06	4.50	4.23
MC_FHIST5Y97	0.60	1.27	0.84	0.77	0.68	0.88	5.52	5.55	4.78	4.87
HIST_FHIST5Y995	0.62	1.20	0.94	0.72	0.63	0.90	4.84	4.59	4.49	4.44
WHIST995	0.63	1.28	0.92	0.75	0.65	0.95	5.17	4.94	4.49	4.34

EXHIBIT 12 MSCI Model Scorecard for 95% VaR

	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	2.19	4.39	3.16	2.79	1.93	2.88	14.11	14.80	12.09	12.63
MC97	2.19	4.54	3.19	2.76	1.87	2.81	14.22	14.69	12.21	13.06
HIST1Y	2.39	4.74	3.25	2.97	1.96	2.91	14.46	15.03	12.94	13.30
HIST5YO	2.19	4.67	3.49	2.73	1.87	2.75	14.08	14.19	12.63	14.03
HIST_FHIST5Y97	2.21	4.51	3.23	2.73	1.82	2.81	14.46	14.65	12.40	13.35
MC_FHIST5Y97	2.20	4.54	3.18	2.73	1.83	2.79	14.40	14.76	12.40	13.18
HIST_FHIST5Y995	2.19	4.64	3.34	2.73	1.82	2.80	14.26	14.62	12.75	13.55
WHIST995	2.28	4.66	3.26	2.83	1.86	2.82	14.87	15.00	13.08	13.46

EXHIBIT 13 MSCI Model Scorecard for 97.5% ES

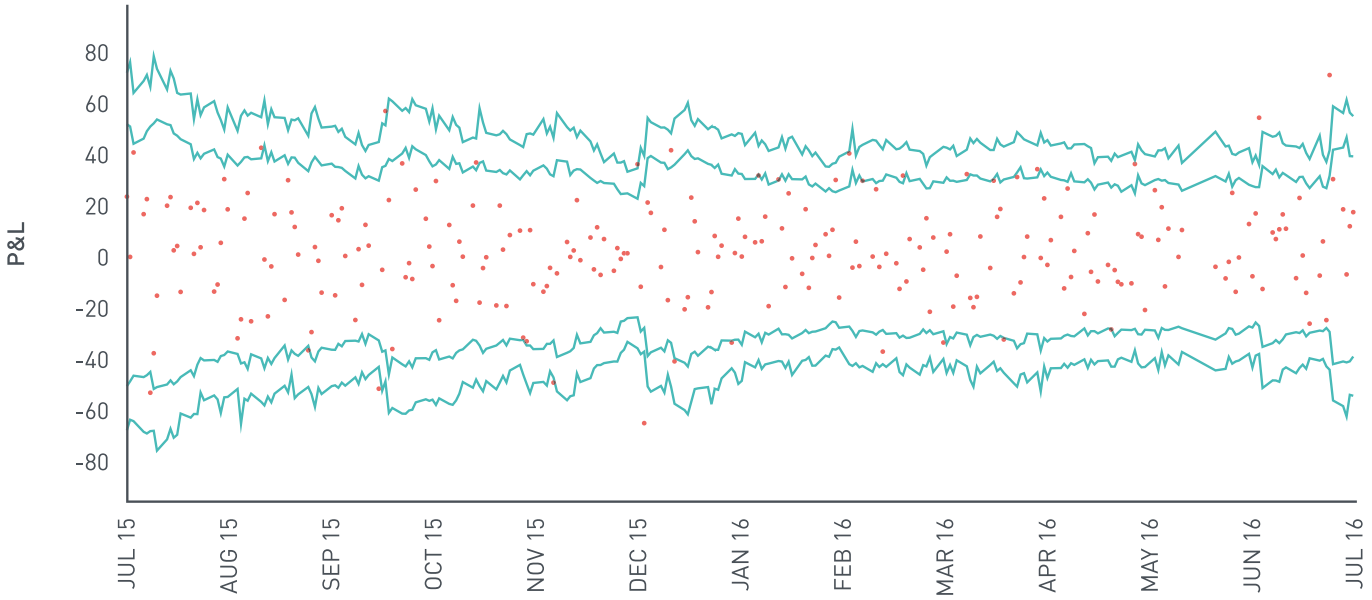
	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	99	377	197	151	114	210	6016	5173	3985	3975
MC97	93	379	200	141	109	199	6119	5232	4124	4162
HIST1Y	110	427	217	159	109	221	6140	5166	4228	4219
HIST5YO	98	410	257	140	111	200	5894	4607	4012	4213
HIST_FHIST5Y97	96	384	211	141	108	200	6196	4992	4215	4229
MC_FHIST5Y97	96	398	204	144	108	198	6486	5339	4350	4356
HIST_FHIST5Y995	100	415	230	142	105	199	6051	4779	4194	4183
WHIST995	105	413	227	152	106	208	6289	5144	4275	4189

EXHIBIT 14 MSCI Model Scorecard for 87.5% ES

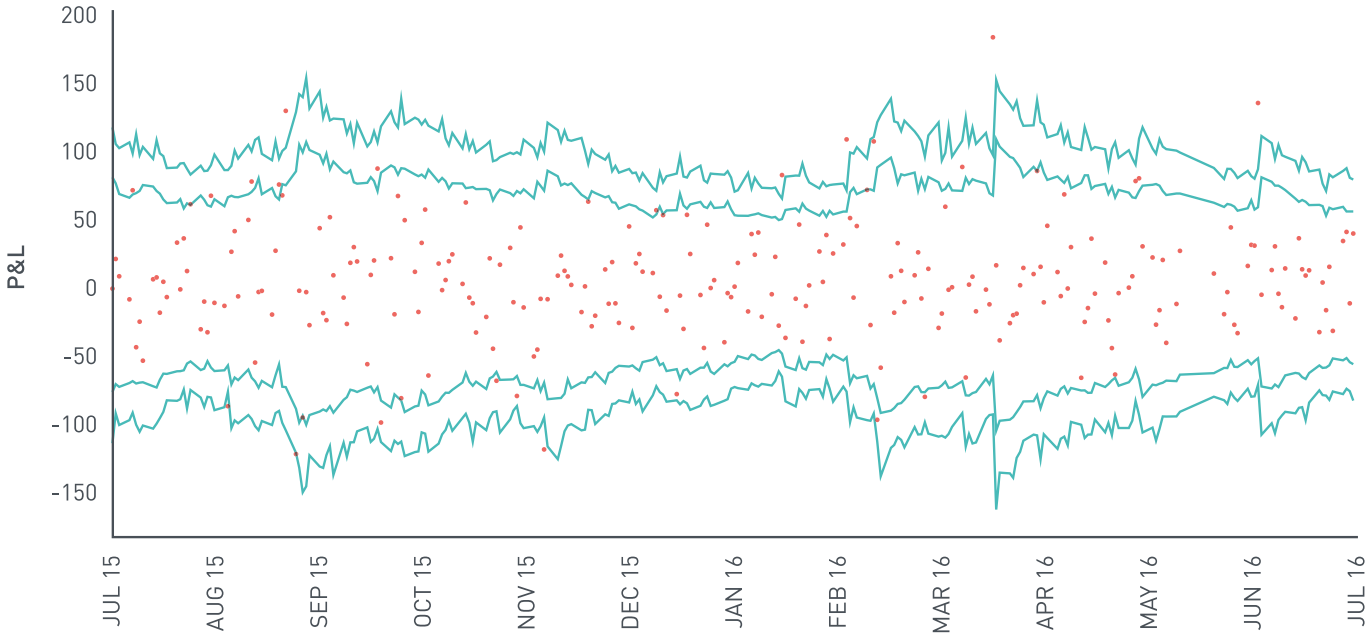
	CITIUSBIG	CITIWGBI	JPMEMBIG	JPMGBI	IBOXXCORP	IBOXXSOV	MSEAFE	MSEM	MSWORLD	MSUSA
MC94	225	912	427	346	195	400	10522	10143	7383	7879
MC97	223	928	431	342	191	391	10672	10034	7502	7939
HIST1Y	235	935	419	346	188	397	10873	10118	7537	8132
HIST5YO	222	915	468	336	187	378	10602	9830	7437	8253
HIST_FHIST5Y97	220	911	419	337	187	387	10804	10008	7577	8065
MC_FHIST5Y97	222	924	429	339	190	390	10829	9953	7547	7975
HIST_FHIST5Y995	218	922	437	336	185	377	10792	10005	7610	8233
WHIST995	226	918	420	339	185	384	10952	10142	7608	8141

EXHIBIT 15-20 Fixed Income VaR Band Plots. The 99% and 95% VaR Bands of the mc94 Model are Shown as Green Lines; P&Ls are Shown as Red Dots

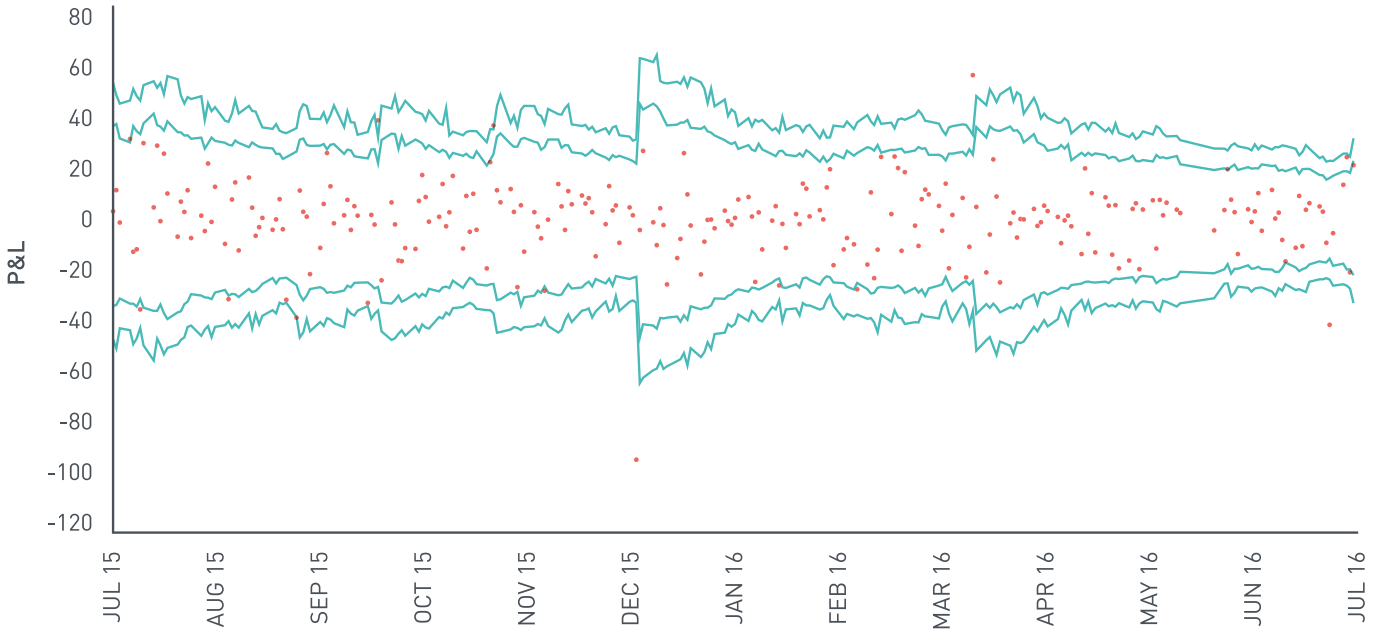
CITIUSBIG - MC94



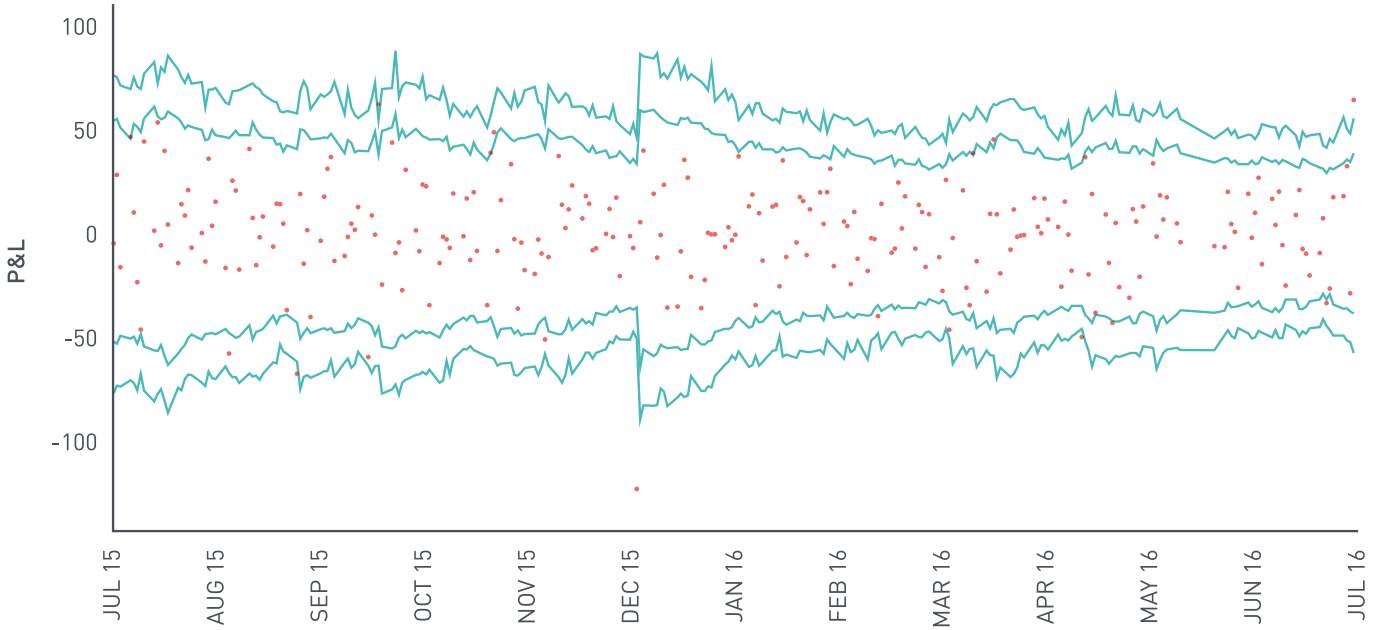
CITIWGBI - MC94



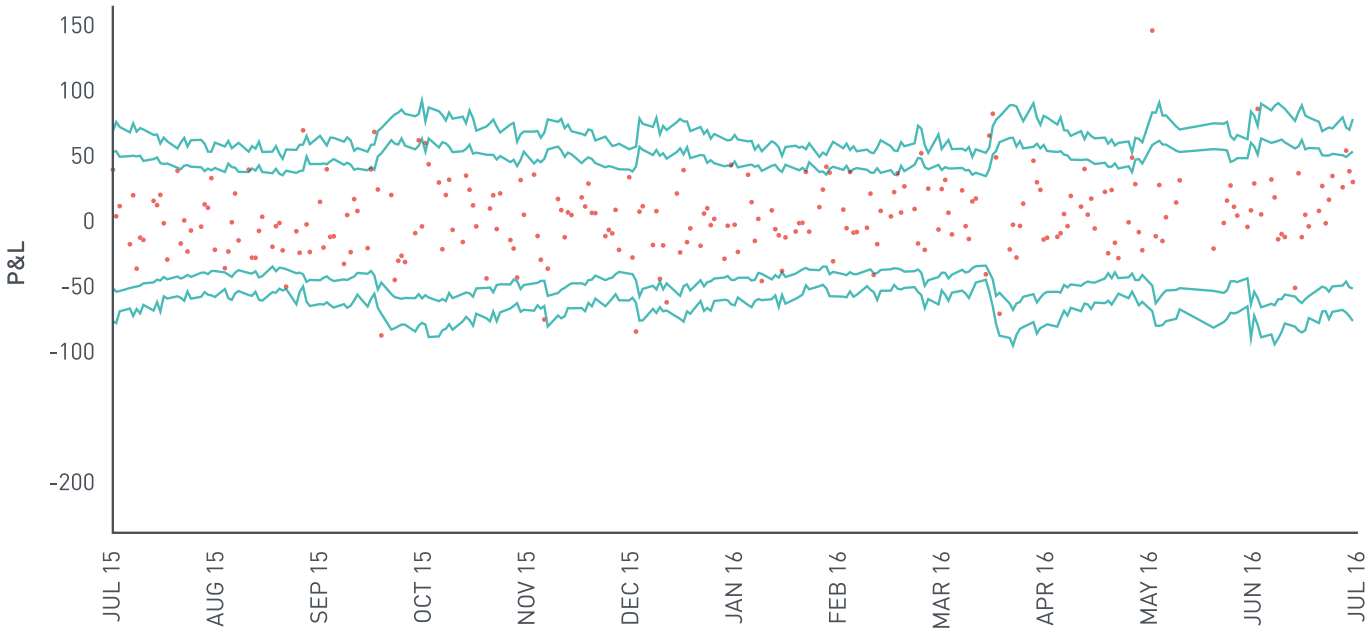
IBOXXCORP - MC94



IBOXXSOV - MC94



JPMEMBIG - MC94



JPMGBI - MC94

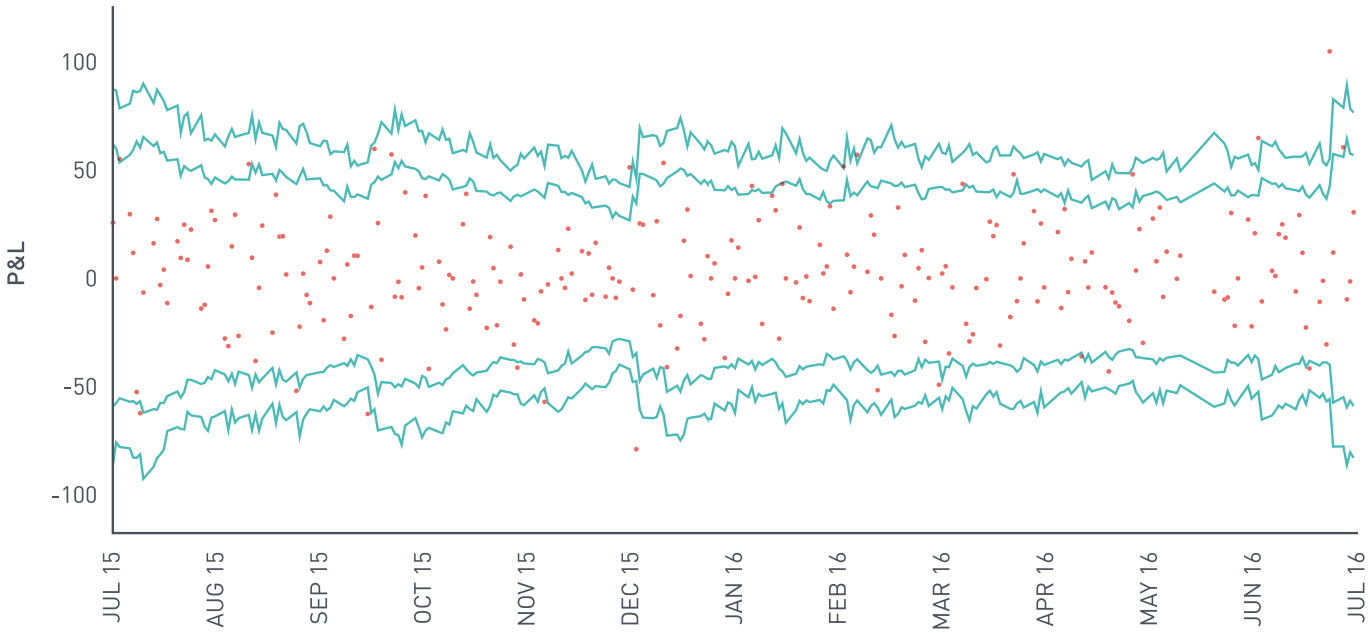
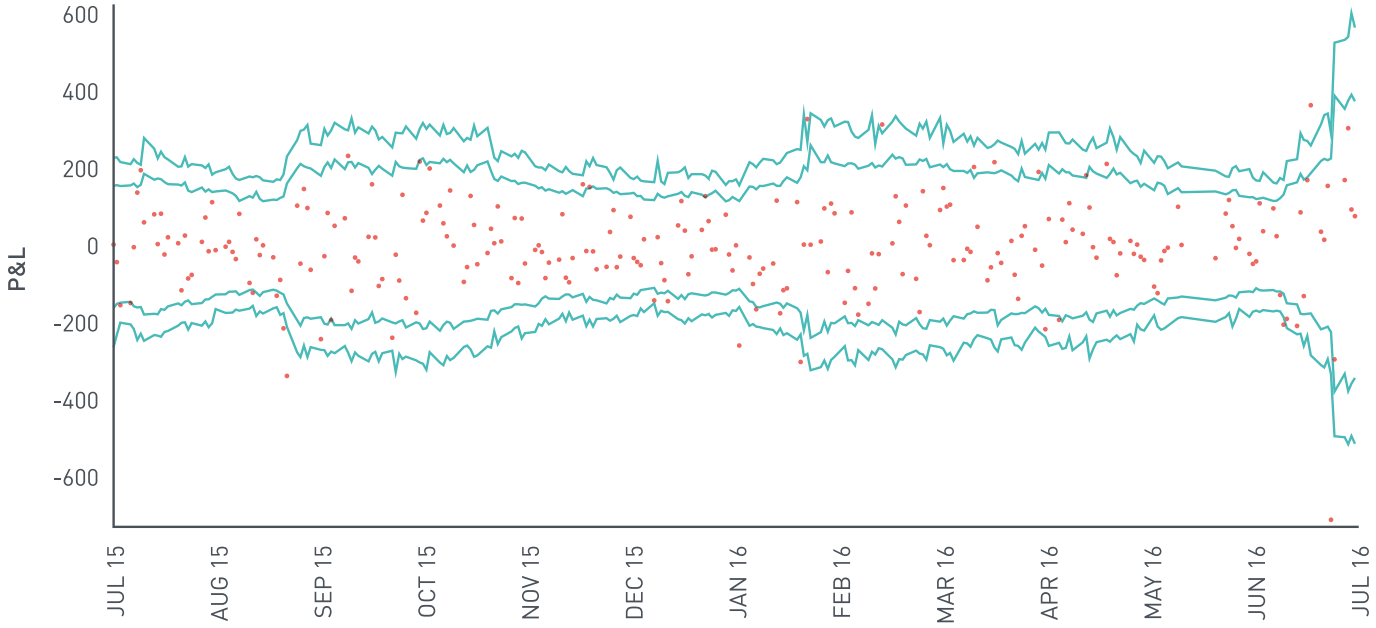
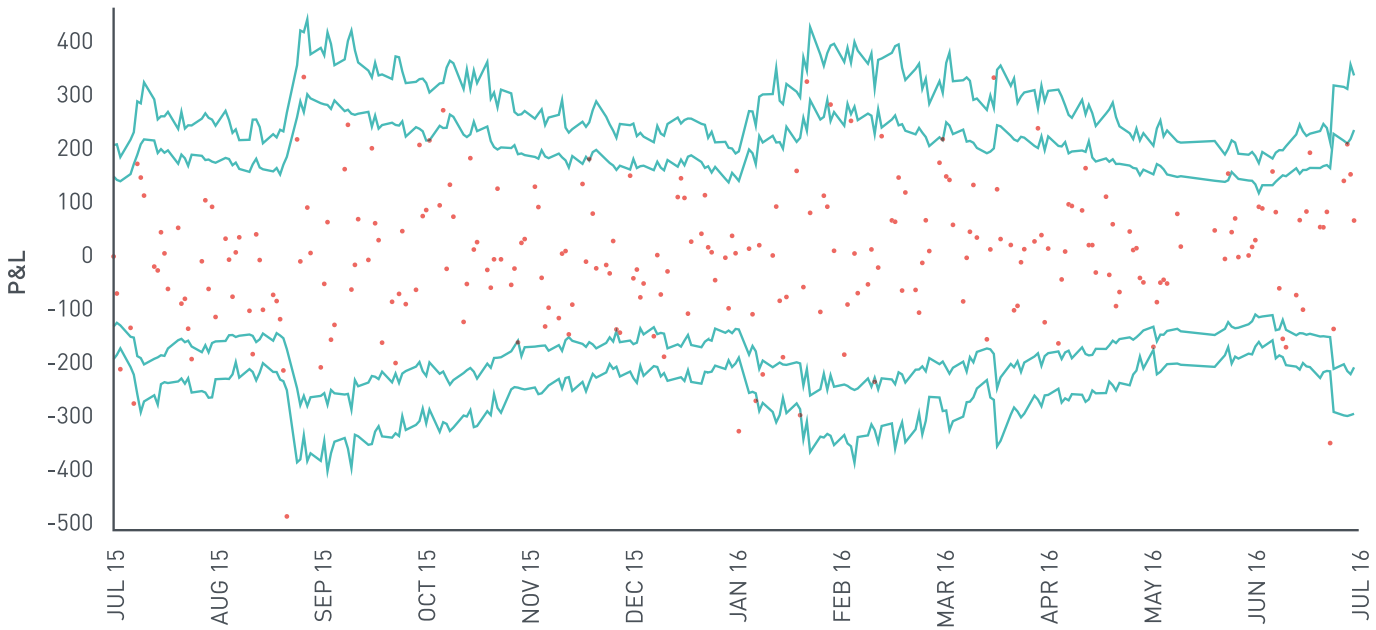


EXHIBIT 21-24 Equity VaR Band Plots. The 99% and 95% VaR Bands of the mc94 Model are Shown as Green Lines; P&Ls are Shown as Red Dots

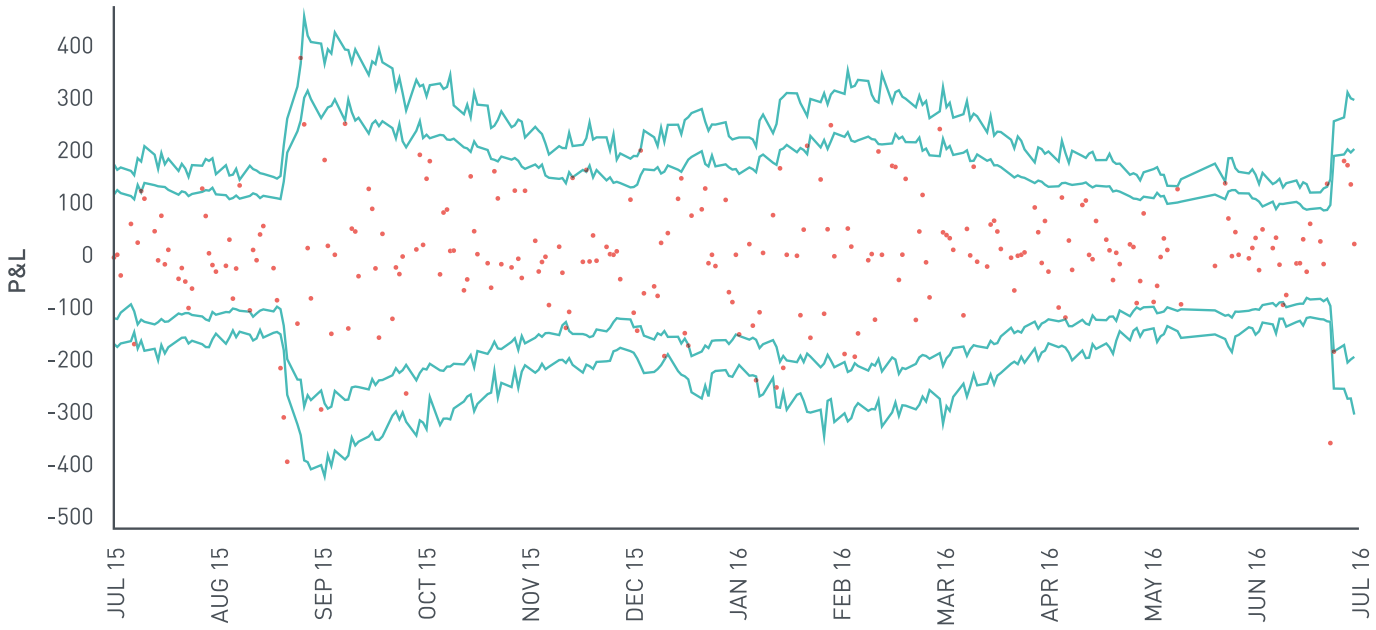
MSEAFE - MC94



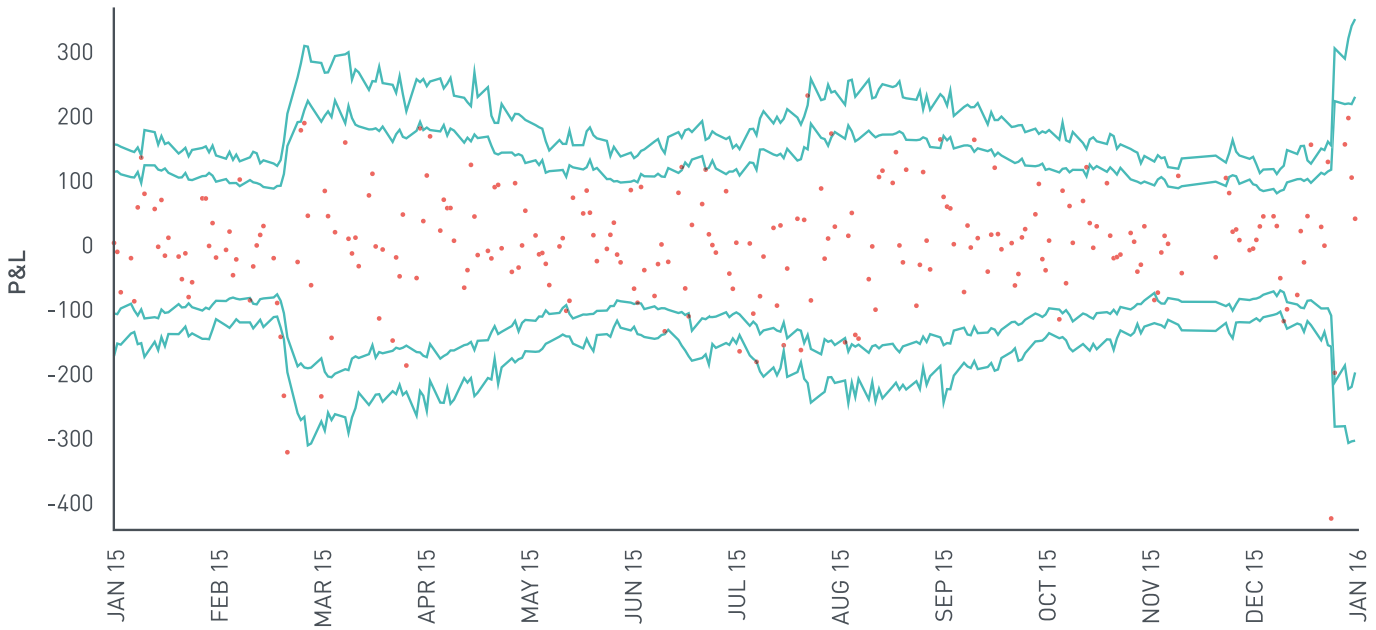
MSEM - MC94



MSUSA - MC94



MSWORLD - MC94



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