# Updated Stress Testing Features in RiskMetrics RiskManager

## Historical Scenarios for Fall 2008, Treatment of Yield Curve Shocks, and a Hectic Day Risk Setting

September 2011

# Introduction

MSCI has updated RiskMetrics RiskManager 4's stress testing library with 6 new predictive historical stress testing scenarios designed to help users replicate the effects of the 2008 financial crises. Three of the scenarios (*WaMu collapse 1D (2008), Black Week 5D (2008) and Fall 2008 (2008)*) provide a standard framework for stress testing portfolios against the shocks of Fall 2008. The three other new stress scenarios are slightly modified versions of the standard scenarios. Each modified version includes factor changes designed to prevent negative rates (which could result from shifting the current low yield curve to reflect the Fall 2008 steep decrease in short term yields).

Like other predictive stress tests, the 6 new stress tests use RiskManager's predictive stress test functionality to spread the selected shocks to other factors based on the factor covariances. In order to calculate the covariance based on turbulent days, MSCI has added a new 'Hectic days risk setting for stress testing' risk setting.

The time frame and factor selection for the stress tests are described in the first part of this paper. The construction of the modified scenarios and how to choose between the standard and modified scenarios are covered in the second part of the paper. The new 'Hectic days' risk setting is introduced in the third part of the paper.

# Scenarios for Fall 2008

## Time frame selection

Two market events offer natural end points for the historical scenarios:

1. On September 9, 2008 Korea Development Bank announced that it would not buy Lehman Brothers. As a result, Lehman fell by 44.95%, and the value of the S&P 500 index decreased by 3.4%. A few days later Lehman filed for Chapter 11 bankruptcy.
2. Asset prices suffered significant decreases during Fall 2008. The S&P 500 reached its lowest level by the end of November.

Therefore, the period under investigation covers the time range between September 9, 2008 and December 1, 2008.

We defined scenario time frames in order to select important events within this period. We selected the scenario time frames as the periods with the greatest 1-day and 5-day losses.

Greatest losses were identified with respect to the level of MSCI World Index in USD. This index reflects the global price changes in those developed markets identified by MSCI, covering a wide range of stocks. We also used several local indices (S&P 500, FTSE 100, DAX, Nikkei 225) in local currency to confirm our date range choice.

The period selection is illustrated in Exhibit 1, and the resulting time frames are detailed in Exhibit 2. In the 5-day scenario, the Black Week (October 6-10, 2008) was the common worst 5-day period for global and local indices.

The 1-day performances of the indices were less consistent, so we selected September 29, 2008 which provided high losses for each index and refers to a specific event, the Washington Mutual collapse. On this day, asset prices fell more than on the day of the Lehman collapse.

The worst 1-day and 5-day scenarios are complemented with a third scenario which is defined to incorporate factor changes for the entire 3-month period.

*Exhibit 1: Selected scenario time frames for Fall 2008 based on the performance of the MSCI World Index (level of September 8, 2008 = 100)*

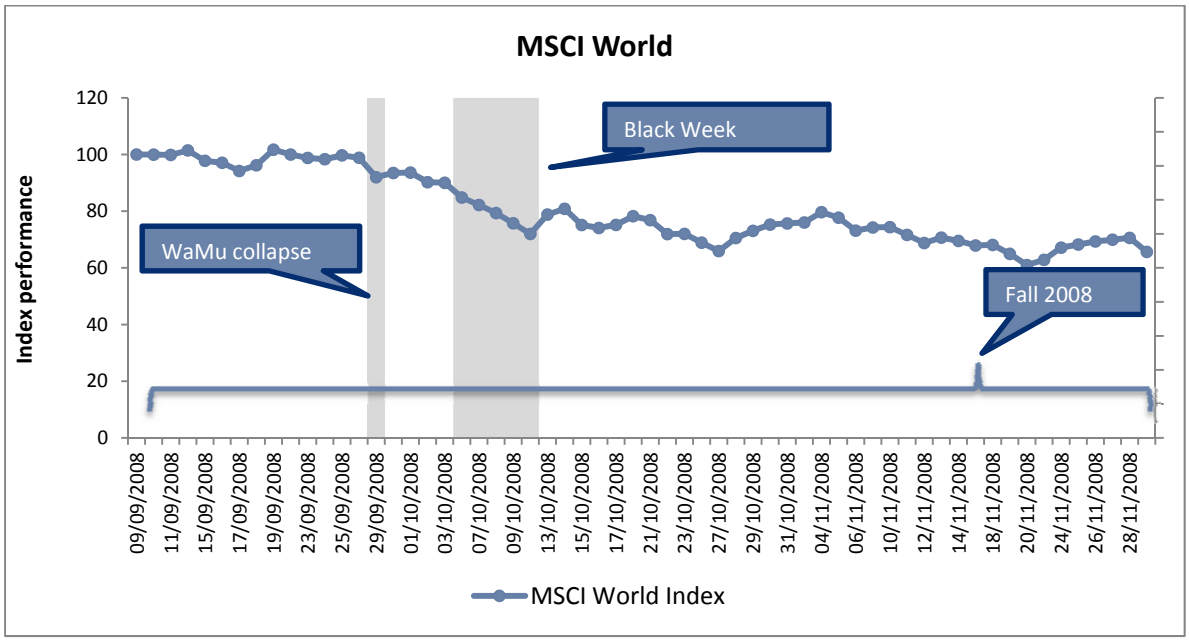


*Exhibit 2: Scenario time frames for Fall 2008*

| | Time frame | Dates |
|---|---|---|
| WaMu collapse | 1 D | September 29, 2008 |
| Black Week | 5 D | October 6-10, 2008 |
| Fall 2008 | 3 M | September 9 - December 1, 2008 |

## Scenario Definitions

Historical stress tests can be defined based on the factor changes within specific time frames. In RiskManager 4, users can define a 'By Date' scenario by specifying the start and end dates. Another option for users is to design a 'By Risk Factor' scenario with selected core risk factors for each scenario. In RiskManager 4, we defined predictive 'By Risk Factor' scenarios in order to capture the effect of the main factor changes.

For each of the three time periods, we began with a large set of candidate core risk factors. The aim was to reduce the number of shock factors as much as possible without losing key variables, while making the scenario easy to interpret. We selected a minimal set of factors that – when applied in a predictive stress test – recovered the actual move in the MSCI World Index. In other words, the core factors we chose represent the unique aspects of the historical scenarios, with other factors following the core factors consistently with the observed covariances[1].

In addition to the factors which were selected based on the MSCI World Index, we added the 5-year Markit CDX North American Investment Grade Index spread to indicate corporate credit shocks. From the family of Markit CDX North American Investment Grade indices, series 9 index was used because that was the most liquidly traded at that time. As the 5-year Markit CDX North American Investment Grade series 9 index will expire in December 2012, this factor will have a predictive effect in the scenarios only if the covariances are calculated before the expiry of the CDX. Otherwise, for the purpose of stress testing, the index may be replaced by another series of CDX – with the same maturity, with the same shock size – to incorporate a similar corporate credit shock effect into the scenario.

The scenarios contain FX factors (Swiss Franc, Euro, British Pound, and Japanese Yen). Some of these factors were identified as core predictive factors. The other FX factors are added to the scenarios in a non-predictive manner.

Exhibit 3 contains the factors for each scenario. The set of factors differ across the scenarios. Although present in the Black Week scenario, the CBOE Volatility Index (VIX) does not appear in the WaMu collapse scenario, although the VIX level increased by almost 12% during that day. The VIX change does not appear in the WaMu scenario because in predictive stress testing, scenario definitions should contain only the 'surprises', namely the shocks that moved inconsistently with previously known correlations. The VIX index is not included in the WaMu collapse scenario because its change is not exceptional in the market moves specified in Exhibit 3.

For the same reason, only some relevant terms are chosen for yield curves. For each yield curve, the important terms are selected based on the behavior of the curve during Fall 2008. For example, yields for the 3-month and 24-month terms moved highly correlated on the USD Government curve, but were less coupled on the USD Swap curve during that period. Therefore, both terms are added to specify the swap curve changes.

The factors in Exhibit 3 provide a description of the events for the different scenarios.

In the WaMu collapse scenario, the S&P 500 decreases by 8.79%. In the predictive stress test, this shock will be propagated to the other factors through the covariance matrix of factors thereby describing a general market decline. The actual price drop in the financial sector during September 29 was higher than implied by this market movement and correlations; therefore MSCI World Financials Index is inserted into the scenario to model a relatively higher shock within the financial sector. For the same

[1] The covariances were calculated with the 'Hectic days risk setting for stress testing' which will be discussed later in this paper.

reason, the MSCI World Value Index which has a high exposure to the financial sector is also included in the scenario. The Swiss Franc slightly weakened in relation to the US Dollar during the day of the WaMu collapse. USD and EUR yield curves suffered a sharp downward shift on September 29, 2008.

The Black Week scenario includes a set of variables similar to the WaMu collapse scenario and models a general market decline (measured by the S&P 500 and FTSE 100 indices) with a relatively bad performance of the financial sector (described with MSCI World Financials Index). The scenario models increasing fear of economic slowdown (signaled by gold price); moving FX rates; corporate credit shock; and liquidity shock incorporated by declining short-term government rates together with increasing short-term swap spreads. The increased market volatility level is also integrated in the scenario.

The 3-month Fall 2008 scenario is designed to describe the worst factor changes during Fall 2008. Each factor change refers to the largest change relative to September 8, 2008, except for the yield curves where the shock refers to the change during the period between September 9 and December 1, 2008.

The Fall 2008 scenario factors of Exhibit 3 indicate decreased stock prices, increased volatility, relatively bad performance of the financial sectors, bad economic outlook, significant changes in FX rates, corporate credit shock, downward shifting and a steepening yield curve, as well as, increasing short-term and decreasing long-term swap spreads.

*Exhibit 3: Scenario definitions (standard scenarios). Changes in italics identify non-predictive shocks*

**Scenario name: WaMu collapse 1D (2008)**
***Description:* This scenario models the factor changes of September 29, 2008.**
**Models 1-day market decline with relatively bad performance of the financial sector, bad economic outlook, corporate credit shock, and downward shift in the yield curves.**

| Name | | Change amount |
|---|---|---|
| S&P 500 | | -8.79% |
| MSCI World Financials Index | | -9.66% |
| MSCI World Value Index (in USD) | | -7.30% |
| Swiss Franc (CHF in USD) | | -0.47% |
| *Euro (EUR in USD)* | | *-1.18%* |
| *British Pound (GBP in USD)* | | *-1.83%* |
| *Japanese Yen (JPY in USD)* | | *1.12%* |
| USD zero coupon yield curve | | |
| | 14D | 0.00% |
| | 1M | -0.21% |
| | 3M | -0.61% |
| | 60M | -0.34% |
| | 120M | -0.27% |
| EUR zero coupon yield curve | | |
| | 3M | -0.13% |
| | 12M | -0.27% |
| | 60M | -0.20% |
| | 120M | -0.16% |
| Markit CDX North American Investment Grade Index (series 9, 60M) | | 4.29 bps |

*Exhibit 3 cont'd: Scenario definitions (standard scenarios). Changes in italics identify non-predictive shocks*

**Scenario name: Black Week 2008 (2008)**
***Description:*** **This scenario models the factor changes of October 6-10, 2008. Because of a recovery, the end date for gold prices is October 9.**
**Models 5-day market decline with increased market volatility, relatively bad performance of the financial sector, bad expectations on economic growth, corporate credit shock, declining short-term rates, and increasing short-term swap spreads.**

| Name | | Change amount |
|---|---|---|
| S&P 500 | | -18.20% |
| FTSE 100 | | -21.05% |
| CBOE Volatility Index | | 24.81% |
| MSCI World Financials Index | | -23.85% |
| LME Gold (12M) | | 9.14% |
| Swiss Franc (CHF in USD) | | 0.88% |
| Euro (EUR in USD) | | -2.18% |
| British Pound (GBP in USD) | | -4.10% |
| *Japanese Yen (JPY in USD)* | | *6.09%* |
| USD zero coupon yield curve | | |
| | 14D | -0.26% |
| | 1M | -0.10% |
| | 3M | -0.23% |
| | 60M | 0.15% |
| | 120M | 0.29% |
| USD zero coupon swap curve | | |
| | 3M | 0.33% |
| | 24M | -0.06% |
| | 240M | -0.14% |
| EUR zero coupon yield curve | | |
| | 3M | -1.44% |
| | 12M | -0.45% |
| | 60M | -0.04% |
| | 120M | 0.09% |
| Markit CDX North American Investment Grade Index (series 9, 60M) | | 47.03 bps |

**Scenario name: Fall 2008 (2008)**
***Description:*** **This scenario models the factor changes of Fall 2008.**
**Describes the worst factor changes during the events of Fall 2008. Each factor change refers to the largest change relative to September 8, 2008 except for the yield curves where the shock refers to the change during the period September 9 - December 1, 2008.**
**Models general market decline with increased market volatility, relatively bad performance of the financial sector, bad expectations on economic growth, corporate credit shock, downward shifting and steepening yield curve, and increasing short-term and decreasing long-term swap spreads.**

| Name | | Change amount |
|---|---|---|
| S&P 500 | | -40.65% |
| CBOE Volatility Index | | 58.22% |
| MSCI World Value Index (in USD) | | -40.32% |
| NYMEX Light Sweet Crude Oil - 1st Nearby | | -53.66% |
| *Swiss Franc (CHF in USD)* | | *-8.11%* |
| Euro (EUR in USD) | | -12.36% |
| *British Pound (GBP in USD)* | | *-16.26%* |
| Japanese Yen (JPY in USD) | | 15.91% |
| USD zero coupon yield curve | | |
| | 14D | -1.48% |
| | 1M | -1.60% |
| | 3M | -1.67% |
| | 60M | -1.28% |
| | 120M | -0.93% |
| USD zero coupon swap curve | | |
| | 3M | -0.52% |
| | 24M | -1.19% |
| | 240M | -1.82% |
| Markit CDX North American Investment Grade Index (series 9, 60M) | | 179.88 bps |

# Shocking Yield Curves in a Low-yield Environment

The USD and EUR government yield curves suffered a significant downward change during Fall 2008. As shown in Exhibit 3, yield curve movements are present in the three standard historical scenarios.

Although the yield curves appear in the scenario definitions, their effect cannot be felt if the current yield level is already low. If the yield level is initially lower than the magnitude of the shock size, the resulting factor value would be negative.

For example, the 3-month USD government zero coupon yield was 0.04% on June 8, 2011. The change during the Black Week in 2008 was -0.23% (see Exhibit 3). If we apply this shock to the yield level of 0.04%, the resulting yield would be -0.19%.

RiskManager does not allow for negative rates, and would set the level to 0 in this case.

With the floor on rates, based on current yield curve levels, our stress test would not reflect both the direct impact of the yield curve shock as well as the shock-spreading effect on other factors. Our solution to this problem is to include a factor capable of absorbing the yield shocks of Fall 2008.

To incorporate this factor, we created a modified scenario for each of the 3 standard scenarios. In the modified scenarios, the government curves are explicitly specified as unchanged, and the swap rates are moved by the historical swap spread changes.

Thus, the swap spread moves implied by the scenarios replicate the historical spread changes, allowing the modified scenarios to describe the same credit shock event. When these stress scenarios are run in RiskManager, this credit effect will be spread to the other market factors based on the covariances.

The modified scenarios are shown in Exhibit 4. The scenarios in Exhibit 4 are the same as in Exhibit 3 except for the yield curves.

## Choosing Standard or Modified Scenarios

When deciding whether to use the standard or the modified scenario for a stress test, RiskManager users will need to consider both the portfolio constituents and the current yield level. For example, the yield curve shocks of the standard scenarios may be applicable for the long-term end of the yield curve even if the current short rates are at a very low level. In this case, for a fixed income portfolio with high exposure to the long-term end of the yield curve, the standard scenarios with the original historical yield curve shocks should be used.

*Exhibit 4: Modified scenario definitions. Changes in italics identify non-predictive shocks*

**Scenario name: WaMu collapse 1D (2008) with swap spread shocks**

***Description:*** **This scenario models the factor changes of September 29, 2008.**
**Models 1-day market decline with relatively bad performance of the financial sector, bad economic outlook, corporate credit shock, and downward shift in the yield curves.**
**This modified scenario can be used even in a low-yield environment. The yield curve changes are set to reproduce the historical swap spread changes.**

| Name | | Change amount |
|---|---|---|
| S&P 500 | | -8.79% |
| MSCI World Financials Index | | -9.66% |
| MSCI World Value Index (in USD) | | -7.30% |
| Swiss Franc (CHF in USD) | | -0.47% |
| *Euro (EUR in USD)* | | *-1.18%* |
| *British Pound (GBP in USD)* | | *-1.83%* |
| *Japanese Yen (JPY in USD)* | | *1.12%* |
| USD zero coupon swap curve | | |
| | 3M | 0.93% |
| | 24M | 0.15% |
| | 240M | 0.00% |
| USD zero coupon yield curve | | |
| | all maturities | 0% |
| EUR zero coupon swap curve | | |
| | 3M | 0.34% |
| | 24M | 0.03% |
| | 240M | -0.09% |
| EUR zero coupon yield curve | | |
| | all maturities | 0% |
| Markit CDX North American Investment Grade Index (series 9, 60M) | | 4.29 bps |

**Scenario name: Black Week 5D (2008) with swap spread shocks**

***Description:*** **This scenario models the factor changes of October 6-10, 2008. Because of a recovery, the end date for gold prices is October 9.**
**Models 5-day market decline with increased market volatility, relatively bad performance of the financial sector, bad expectations on economic growth, corporate credit shock, declining short-term rates, and increasing short-term swap spreads.**
**This modified scenario can be used even in a low-yield environment. The yield curve changes are set to reproduce the historical swap spread changes.**

| Name | | Change amount |
|---|---|---|
| S&P 500 | | -18.20% |
| FTSE 100 | | -21.05% |
| CBOE Volatility Index | | 24.81% |
| MSCI World Financials Index | | -23.85% |
| LME Gold (12M) | | 9.14% |
| Swiss Franc (CHF in USD) | | 0.88% |
| Euro (EUR in USD) | | -2.18% |
| British Pound (GBP in USD) | | -4.10% |
| *Japanese Yen (JPY in USD)* | | *6.09%* |
| USD zero coupon swap curve | | |
| | 3M | 0.55% |
| | 24M | -0.08% |
| | 240M | -0.20% |
| USD zero coupon yield curve | | |
| | all maturities | 0% |
| EUR zero coupon swap curve | | |
| | 3M | 1.49% |
| | 24M | -0.03% |
| | 240M | 0.17% |
| EUR zero coupon yield curve | | |
| | all maturities | 0% |
| Markit CDX North American Investment Grade Index (series 9, 60M) | | 47.03 bps |

*Exhibit 4 cont'd: Modified scenario definitions*

**Scenario name: Fall 2008 (2008) with swap spread shocks**

***Description:*** **This scenario models the factor changes of Fall 2008.**
**Describes the worst factor changes during the events of Fall 2008. Each factor change refers to the largest change relative to September 8, 2008. except for the yield curves where the shock refers to the change during the period September 9 - December 1, 2008.**
**Models general market decline with increased market volatility, relatively bad performance of the financial sector, bad expectations on economic growth, corporate credit shock, downward shifting and steepening yield curve, and increasing short-term and decreasing long-term swap spreads.**
**This modified scenario can be used even in a low-yield environment. The yield curve changes are set to reproduce the historical swap spread changes.**

| Name | | Change amount |
|---|---|---|
| S&P 500 | | -40.65% |
| CBOE Volatility Index | | 58.22% |
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| NYMEX Light Sweet Crude Oil - 1st Nearby | | -53.66% |
| *Swiss Franc (CHF in USD)* | | *-8.11%* |
| Euro (EUR in USD) | | -12.36% |
| *British Pound (GBP in USD)* | | *-16.26%* |
| Japanese Yen (JPY in USD) | | 15.91% |
| USD zero coupon swap curve | | |
| | 3M | 1.15% |
| | 24M | 0.22% |
| | 240M | -0.76% |
| USD zero coupon yield curve | | |
| | all maturities | 0% |
| Markit CDX North American Investment Grade Index (series 9, 60M) | | 179.88 bps |

# Hectic Days Risk Setting for Stress Testing

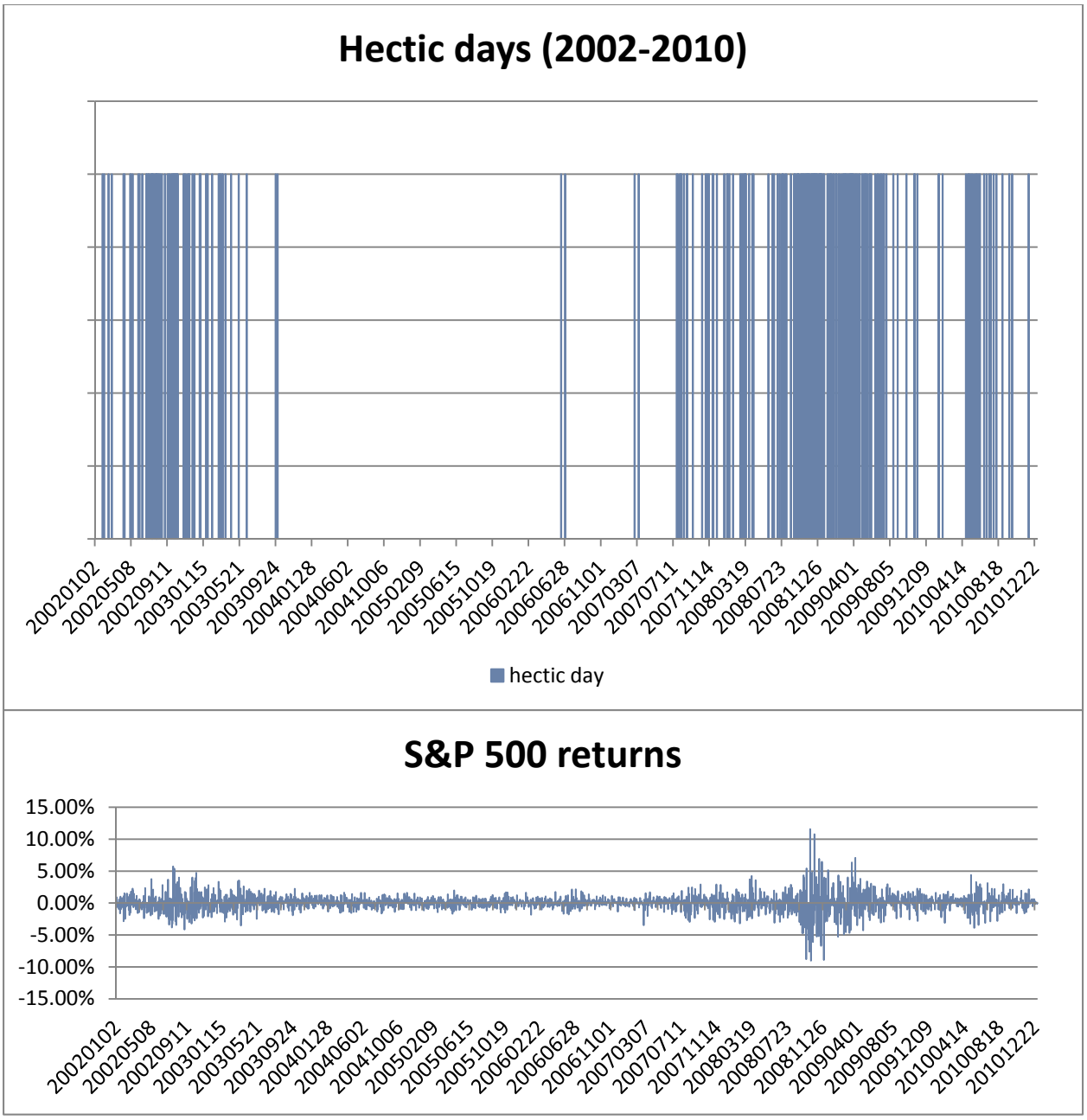
Empirically, volatilities increase and correlations tend towards one during extreme market conditions. This empirical fact was our motivation to define a new risk setting in RiskManager for stress testing purposes. This risk setting considers the 'hectic' days from the time frame 2002-2010 and calculates the covariance matrix of factors based on the hectic days only.

If we apply this risk setting during the stress testing procedure, the calculated covariances of factors will reflect the co-movement of assets during turbulent market periods. This is especially important in the case of stress testing when analyzing the stressed portfolio values during some extreme market

situations. When the new risk setting is used, the shocks defined in a predictive stress scenario will be spread to the other factors based on their behavior during the hectic days.

To identify the hectic days of the period 2002-2010, we fitted a Gaussian mixture model based on Kim and Finger (2000)[2]. We used the S&P 500 historical data to estimate the model parameters.

*Exhibit 5: Hectic days of 2002-2010 and the S&P 500 returns*




[2] J. Kim, C. Finger: A Stress Test to Incorporate Correlation Breakdown. Journal of Risk, Vol 2 , Num 3, Spring 2000

Based on the model results, we selected the 252 most hectic dates from the time range. This means that we calculate the covariance matrix based on approximately 1 year of – not necessarily consecutive – daily factor changes.

Exhibit 5 shows the hectic days for the modeled period along with the S&P 500 relative price changes. The hectic days match high S&P 500 returns in absolute values. The barcode-like graph for the hectic days meets our expectations about the recent history of asset prices: we have many hectic days during the dotcom bubble burst and the financial crisis.

This risk setting can be applied with any predictive 'By Risk Factor' scenario within RiskManager.

# Summary

We designed 3 standard and 3 modified scenarios to simulate the events of Fall 2008.

The three standard scenarios cover the price changes of three periods: 1. September 29, 2008; 2. October 6-10, 2008; and 3. September 9 – December 1, 2008. The time frames were chosen to describe the highest price changes during Fall 2008.

The modified scenarios are modifications of the standard scenarios, and should be used (depending upon portfolio constituents) in a low-yield environment, similar to the current one.

A new risk setting is implemented in RiskManager 4 which calculates the covariance matrix of the factors based on the hectic days between 2002 and 2010. The hectic days were identified by fitting a statistical model on historical prices. When this risk setting is applied during the stress testing process, the resulting calculated covariance matrix will incorporate the co-movement of assets in extreme market conditions.

# Availability of the New Features in RiskManager 4

The new RiskManager 4 by Risk Factor predictive historical scenarios are:

- WaMu collapse 1D (2008)
- WaMu collapse 1D (2008) with swap spread shocks
- Black Week 5D (2008)
- Black Week 5D (2008) with swap spread shocks
- Fall 2008 (2008)
- Fall 2008 (2008) with swap spread shocks

The display name of the new RiskManager 4 Risk Setting is:

- Hectic days risk setting for stress testing

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