An MSCI Brand

RiskMetrics Stress Testing

A guide to Stress Testing in RiskManager

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Stress Testing

The value of a portfolio can move up or down depending on whether market events happen in your favor or not. Market events can be historical such as Black Monday 1987 or the collapse of Lehman Brothers 2008 whereas other possible events are generic moves like Equities down 10% or Steepening of the EUR Swap curve.

Applying such stressed scenarios to a portfolio is known as Stress Testing and is used to see how a portfolio reacts to selected stresses. There are many reasons for stress testing:

- Will there be any significant change in portfolio or position value
- What hedges can one put on to reduce any big losses (What-If analysis)
- Standard sensitivity calculations (IR DV01, Equity Delta, Vega, …)
- Regulatory requirements (e.g. Solvency II, Banking Stress Tests,…)

There are various ways to setup and run stress tests with RiskMetrics.

The purpose of this guide is to introduce the different stress test types, show how they are setup/configured and to explain the methodology to understand the results.

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RiskManager 4 options:

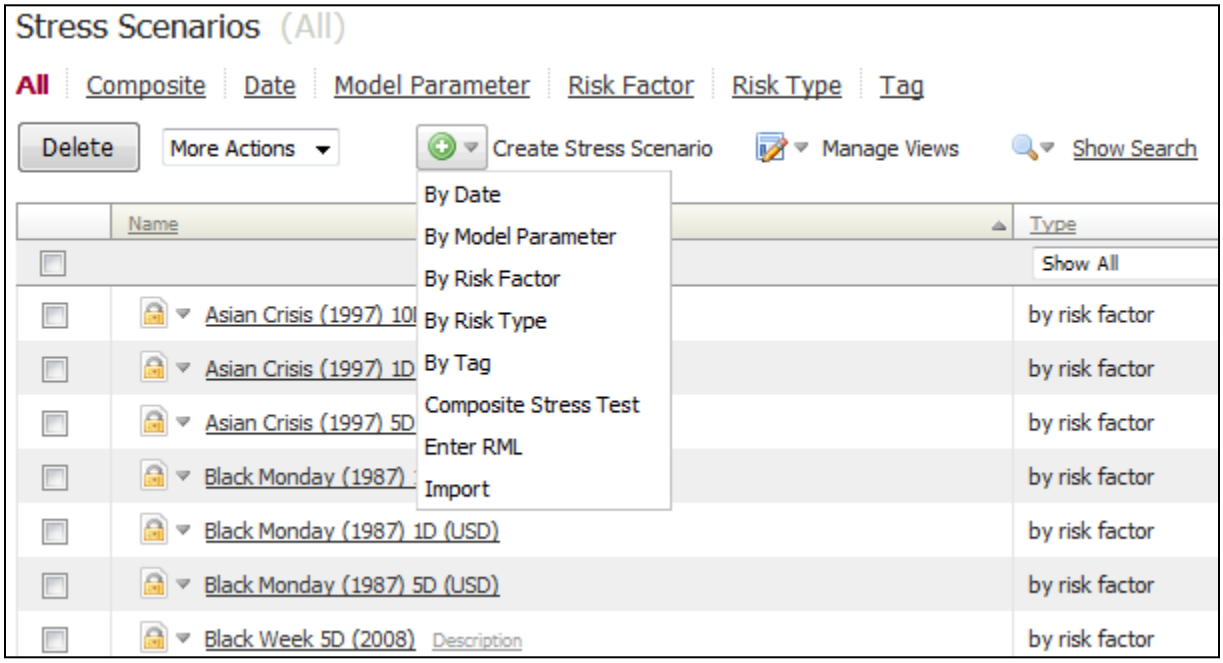


Fig. 1

1.1. By Date Stress

The user only needs to specify a date range from t_1 to t_2.

When running this stress test RiskServer first identifies all Risk Factors (RF) that are used in the selected portfolio positions. Any historical changes for each of these risk factors between time t_1 and t_2 are recorded and applied to the current value.

For instance, if the portfolio consists of shares in Vodafone (LSE) and Microsoft (NASDAQ); and the reporting currency is USD, then the Risk Factors are VOD in GBP, USD/GBP and MSFT in USD.

From the RiskMetrics historical time series database RiskServer knows how much these three individual risk factors have changed from time t_1 to t_2 and will apply the changes to the respective current (typically analysis date) factor levels.

The By Date Stress test is very easy to setup as only two dates are required.

Multiple date ranges are also possible where End date need not be larger than Start date, i.e. reverse periods are possible.

Historic correlations over the specified time periods are taken into account as history is repeated.

If history for time series is not available for selected periods, then flat filling will be used, and zero return is applied. In the case of equities, it is good practice to include a proxy name equity time series to fill out newer listings.

As an example Nasdaq Index plus a suitable Beta can be used as proxy for Google prior to 2004 historic periods.

Fig. 2

Pros & Con:

This stress test is very easy to setup as only start and end dates are required. Multiple Periods are allowed and one can also input reverse periods i.e. Start date does not have to occur prior to End date. One reason this was implemented is because it was hard to find a historic period in which house prices declined from 1997 to 2007; allowing reverse periods would take care of this.

The only parameter in the risk setting (valuation spec) that has an influence on the By Date Stress is the Pricing Date as the initial value is based on this. Analysis Date also has an effect for time based securities. Neither Time Series History nor Decay Factor has any influence. Although not a predictive stress test, the historic correlations between all risk factors are taken into account as we repeat exactly what happened to them during the selected period.

This stress cannot be used for older stress tests such as Black Monday or Gulf War as the time series data in RiskMetrics starts from May 1997. Recently listed equity instruments should be linked with a proxy time series to allow for less recent historic events.

1.2. By Risk Factor Stress

This stress test allows you to select one or a group of risk factors and specifies a stress amount. This can be by percent, an absolute amount, percent of standard deviation, or users can set to a level of their choice.

There are two types of settings under the Risk Factor Stress that can result in very different outcomes: Predictive and Simple

1. **Simple:**

No correlations are taken into account. Only the risk factors selected in the stress test will be stressed by the given amount, and any other risk factor will not be affected at all. As an example, assume you hold a FSTE 100 future in your portfolio and stress a major constituent like British Petroleum. This will have no effect on the FTSE future at all unless the future is modeled at constituent level; regardless, only the BP constituent will be stressed.

Another example is to stress the Dow Jones Industrial index down by 50% in a simple manner. This will have no effect on any positions except those directly referencing the DJI time series such as DJI Futures or Options. In a simple stress test, correlations are not taken into account; only those risk factors chosen in the stress test will be stressed.

2. **Predictive:**

Correlations among all risk factors in the stress test and portfolio are calculated according to a risk setting of your choice (time series period, return horizon, decay factor), and these are taken into account in the calculations. For instance just stressing the USD Govt 10Y node up 100bp will affect all risk factors in the portfolio (interest rates, equities, foreign exchange etc) according to historic correlations.

It is possible to choose which risk factors in the stress test you want to stress in a predictive or simple manner. For instance, you could increase Dow Jones up by 1% in a predictive way so that it affects all risk factors, but set EUR Swap 1Y node to exactly 1.5 percent.

Only significant non-highly correlated risk factors should be used in a predictive stress test and the RiskMetrics' research team has considered this when putting together the library of historic stress tests in RiskManager. If risk factors selected are too highly correlated (larger than 99%) then RiskServer automatically drops some; otherwise regression calculations cannot be performed.

RiskServer distinguishes between Risk Factors used in the portfolio positions and those specified in a risk factor stress test. The former are called endogenous (peripheral) and the latter exogenous (core) risk factors. Overlapping is possible and this is typically the case so that core factors are often among the peripheral factors.

In the stress test shown below we want to stress UK supermarkets up by 10% and see what effect it will have on the entire portfolio. You should first select the equity time series by searching for the name and adding to the list. It shall be a predictive stress test with a relative shift of +10%. The already selected time series shall both have a predictive effect on other risk factors. Add a third by clicking Use Selected.

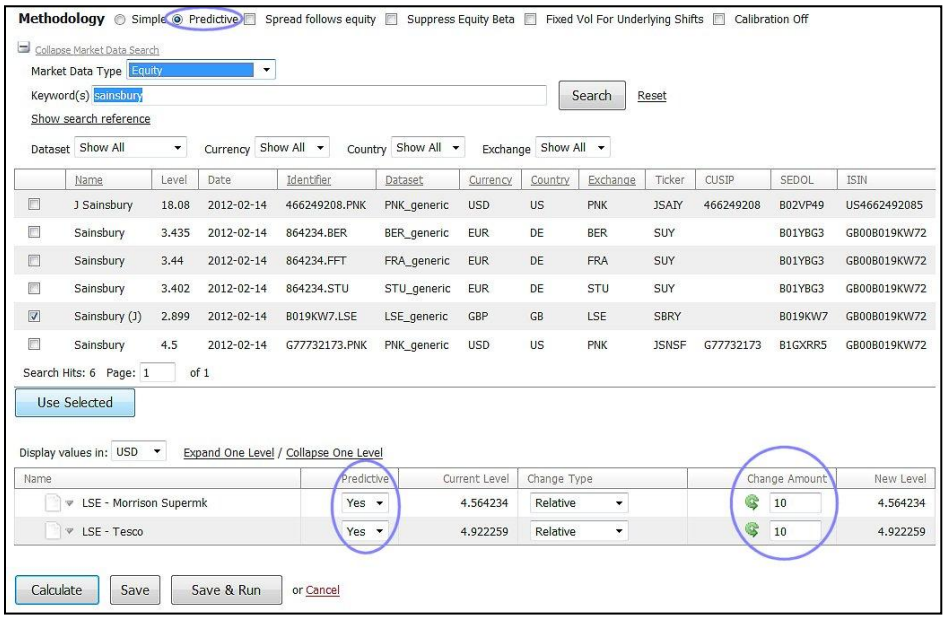


Fig. 3

Any risk factor in RiskMetrics can be used in a Risk Factor stress test.

Now we want to steepen the USD Swap curve. First add USD Swap, which can be found under Interest Rate Curves.

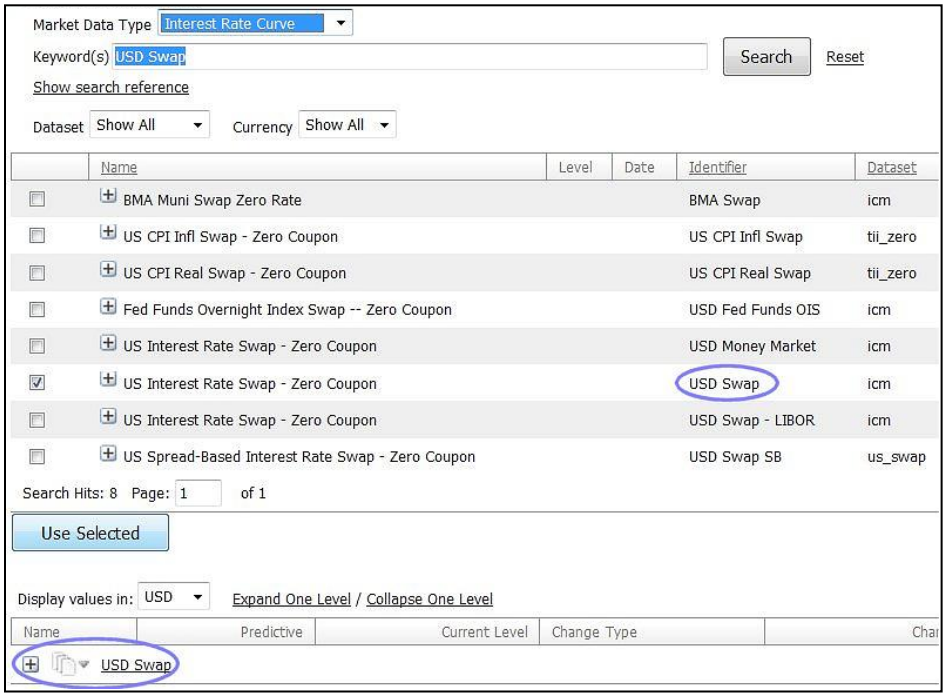


Fig. 4

Initially this will select the whole term structure of USD Swap, which contains more than 20 nodes. These are listed after clicking the plus sign to the left of the curve.
To see a graphical representation of the term structure, click on USD Swap at the top.

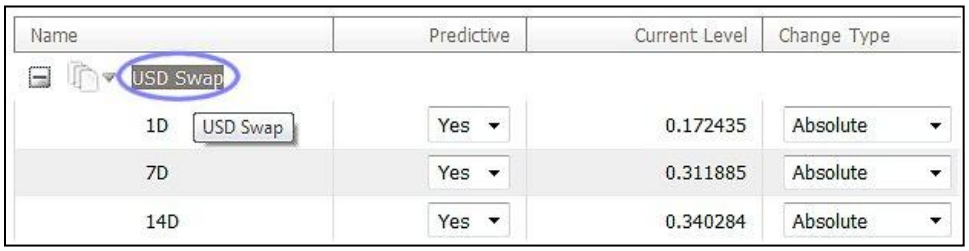


Fig. 5

Absolute, relative or % of Standard Deviation shifts can be applied, and you can also set the level to a specified value. In the example below the short end of the Swap curve is being increased to create a U-shape term structure.

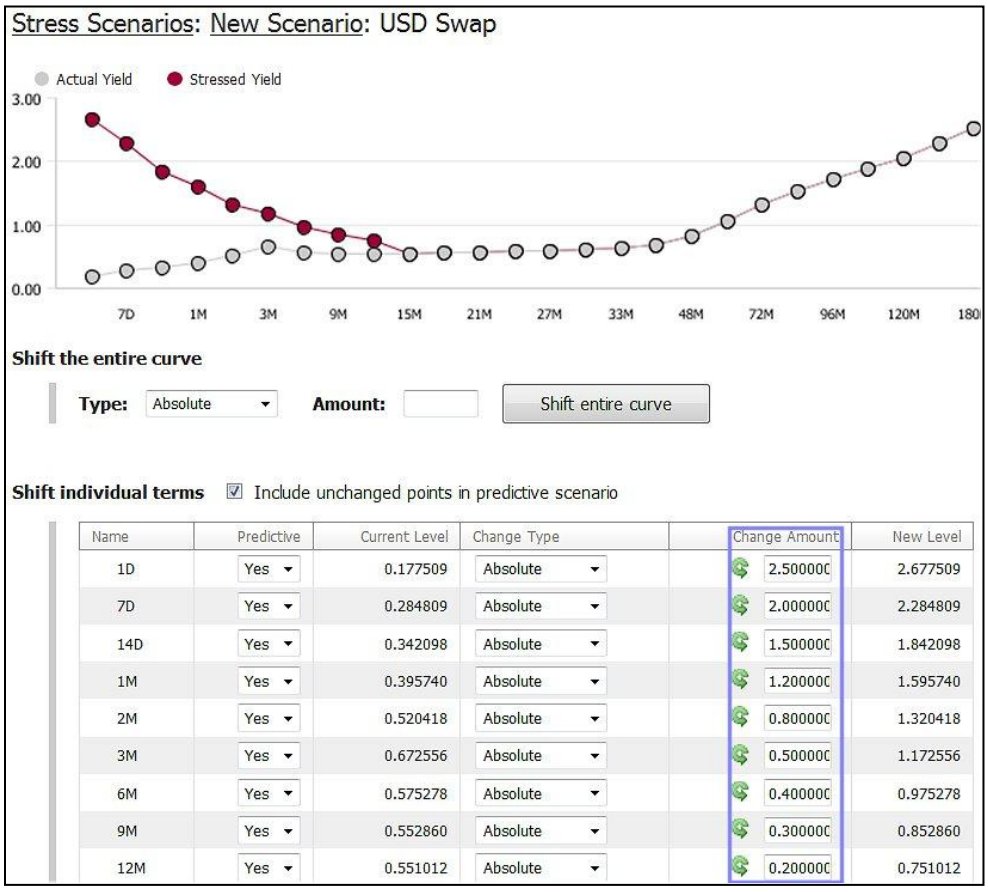
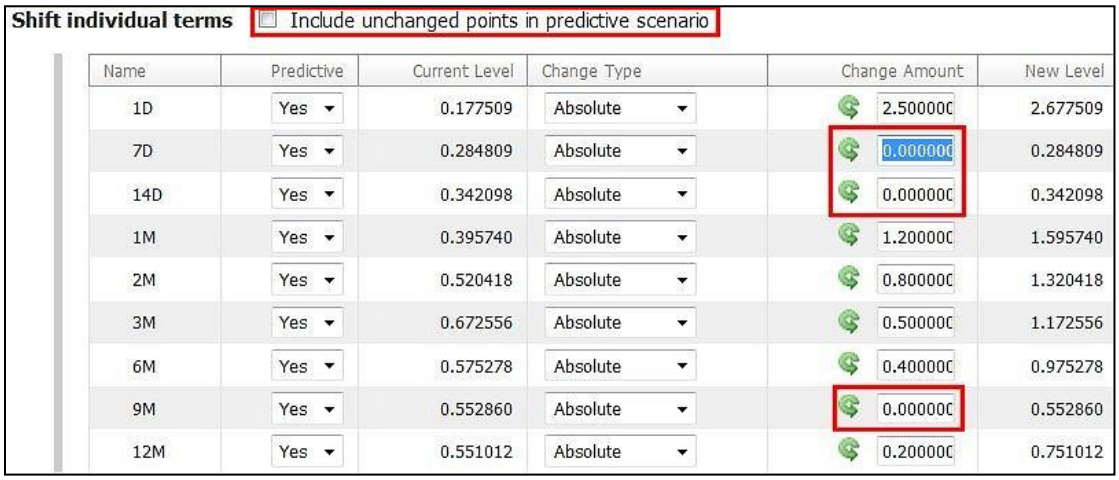


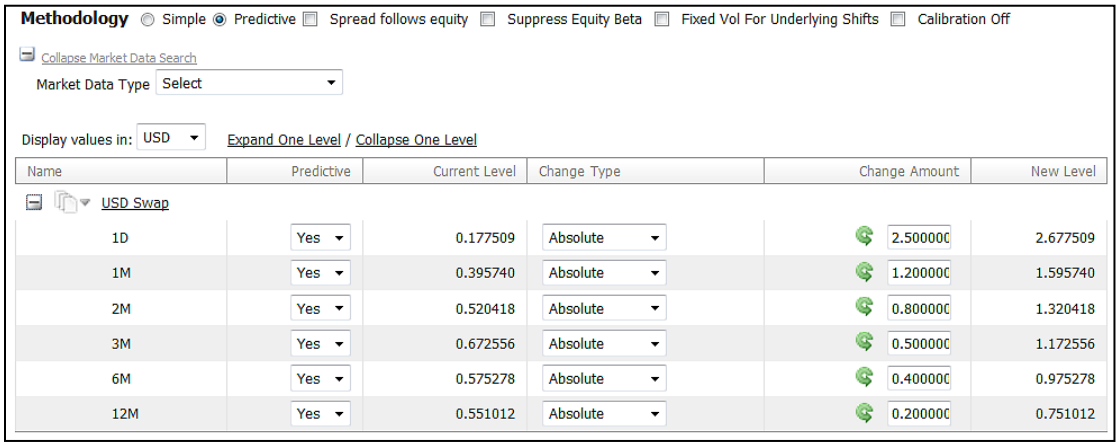
Fig. 6

In a predictive stress test you may not want to include every single node; so individual nodes can be dropped. First, the stress test must be a predictive one, and then you can change the nodes to non-predictive status before unchecking the box "Include unchanged points in predictive scenario". After saving this screen all non-predictive nodes will not appear nor be used in the stress test anymore.



Name	Predictive	Current Level	Change Type	Change Amount	New Level
1D	Yes	0.177509	Absolute	2.500000	2.677509
7D	Yes	0.284809	Absolute	0.000000	0.284809
14D	Yes	0.342098	Absolute	0.000000	0.342098
1M	Yes	0.395740	Absolute	1.200000	1.595740
2M	Yes	0.520418	Absolute	0.800000	1.320418
3M	Yes	0.672556	Absolute	0.500000	1.172556
6M	Yes	0.575278	Absolute	0.400000	0.975278
9M	Yes	0.552860	Absolute	0.000000	0.552860
12M	Yes	0.551012	Absolute	0.200000	0.751012

Fig. 7



Name	Predictive	Current Level	Change Type	Change Amount	New Level
USD Swap					
1D	Yes	0.177509	Absolute	2.500000	2.677509
1M	Yes	0.395740	Absolute	1.200000	1.595740
2M	Yes	0.520418	Absolute	0.800000	1.320418
3M	Yes	0.672556	Absolute	0.500000	1.172556
6M	Yes	0.575278	Absolute	0.400000	0.975278
12M	Yes	0.551012	Absolute	0.200000	0.751012

Fig. 8

Note that RiskServer will automatically drop time series that are very highly correlated, so including the whole term structure in a predictive stress test does not mean that all the nodes will be used. A warning message will be given if time series are dropped.

Combinations of time series from all different data types are possible. Most historical stress tests in RiskManager are setup using the By Risk Factor stress test for very good reasons. The earliest observation date in the database is May 1997 so applying a By Date stress test for Black Monday will not work.

Many equity time series may only have recently been listed so By Date stress tests will have no effect on the prior to IPO dates.

Pros and Cons:

Even old (prior to 1997 and much earlier) historic stress tests can be replicated using the By Risk Factor stress test. Predictive method allows correlations to be taken into account, and the correlations are based on the risk setting parameters, i.e. correlations are not fixed in RiskServer and are calculated on the fly. RiskServer automatically drops highly correlated core risk factors to allow for the regression analysis and calculation of beta sensitivities.

Users should choose a suitable historic period for correlation calculations, RiskManager provides the Hectic Days[1] risk setting. Mathematically, the results are correct; but some may not make economic sense. Limits may need to be set for risk factor changes (see 5.1).

….

[1] High correlated periods are selected, see Updated Stress Testing features in RiskMetrics RiskManager

1.3. By Risk Type Stress

This stress test allows users to apply a stress to a data type such as Commodities, Break Even Inflation, Foreign Exchange, Equity, Interest Rates, Implied Volatilities etc.

Data types are a collection of individual risk factors of the same category grouped together that make up the Risk Type drill down.

Two different stresses can be applied independently to data types of your choice: Global Shift or Predictive.

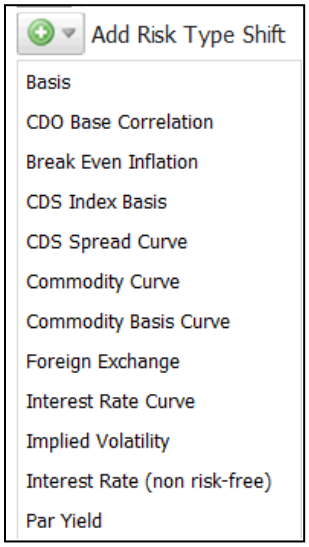


Fig. 9

1. **Global Shift**

Based on the same concept as the simple stress test where you can move all equity time series by X percent or all Interest Rates by Y basis points etc. RiskManager also provides Units of Standard Deviation based on percentage or log returns as another shift choice. Basis point shift in the Interest Rate is a parallel shift in the yield curve where a one basis point shift is equivalent to Interest Rate DV01.

This stress test partly replaces the Generalized Stress Test in RiskManager 3.

2. **Predictive stress test**

Similar to the predictive stress test in the By Risk Factor Stress, correlations are taken into account and portfolio risk factors are moved according to their sensitivity to the core risk factors specified in the stress. Only Risk Factor stress tests of the predictive type can be selected in the drop-down list. Instead of moving all peripheral risk factors (in the portfolio), only those of the chosen data type are stressed. All other non-selected risk factors remain unchanged. As an example, applying the Blank Monday stress test only on Interest Rates will only affect fixed income instruments and the IR part of derivatives and futures, but not FX rates or equities and equities as underlying.

When using this stress test, first select the data types that you wish to shock. Only those listed will be stressed and no others.

In the example below, we are shifting all equity time series down by 20% and all interest rate curves up by 100 basis points. The foreign exchange risk factors shall be stressed in a predictive way. Assuming the base currency is USD and the portfolio consists of positions in USD, EUR and JPY, RiskServer first calculates the correlations between S&P 500 Index and these three currencies. USD cash positions will remain unchanged as base currency is USD, but the EUR and JPY exchange rates will be affected. If there is a long convertible bond position denominated in CHF in the portfolio, then it will be repriced with a 20% lower equity price, interest rates 100bp higher and a different CHF exchange rate. Implied volatility time series will not be affected as they were not specified in this stress test.

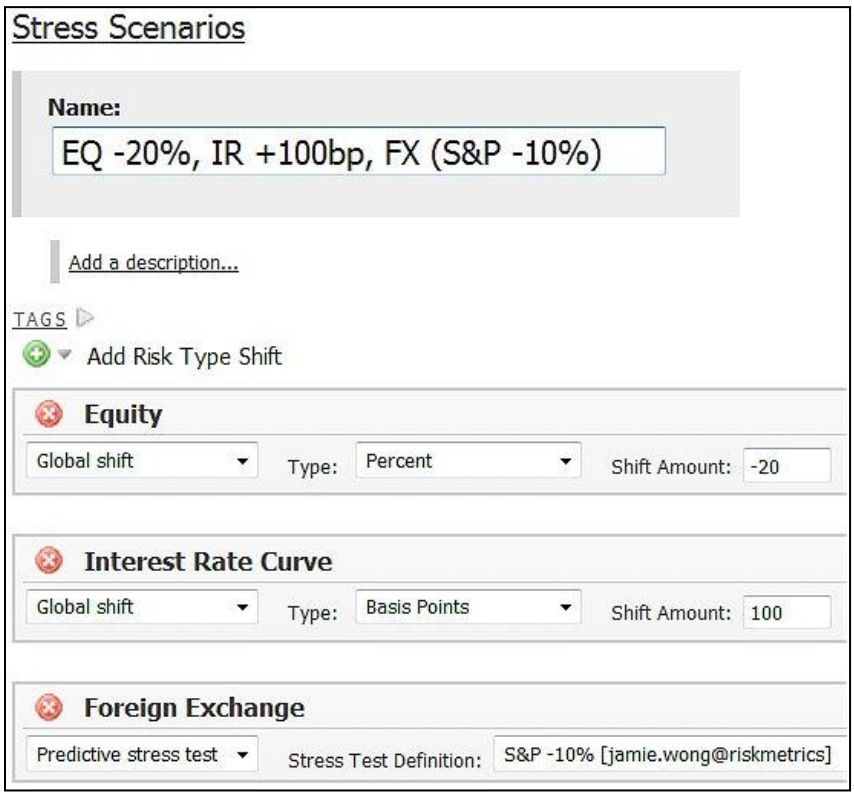


Fig. 10

Pros and Cons:

By Risk Type is another stress test that is fairly easy to setup. You can stress all risk factors in a certain group by the same amount (similar to a parallel shift with correlations among risk factors equal to one) or in a predictive way taking historic correlations into account. Individual nodes of a par yield curve term structure can be shocked. This stress test is typically used to replicate sensitivity statistics like generalized Greeks or dollar delta.

1.4. By Model Parameter Stress

RiskMetrics uses full valuation models to price securities and calculate P&L scenarios. The pricing formulas require data input for example a European equity call option uses the Black Scholes option pricing model where inputs are underlying equity price, risk free rate, time to maturity, fx rate and implied volatility.

If an option price is provided then RiskServer tries to calibrate to the price by finding a suitable implied volatility. This is the unknown factor, which is also a model parameter in RiskServer. Parameters are security/model specific such as credit spread or recovery rate for a bond, recovery rate for a credit default swap etc.

Below is a list of parameters that can be stressed.

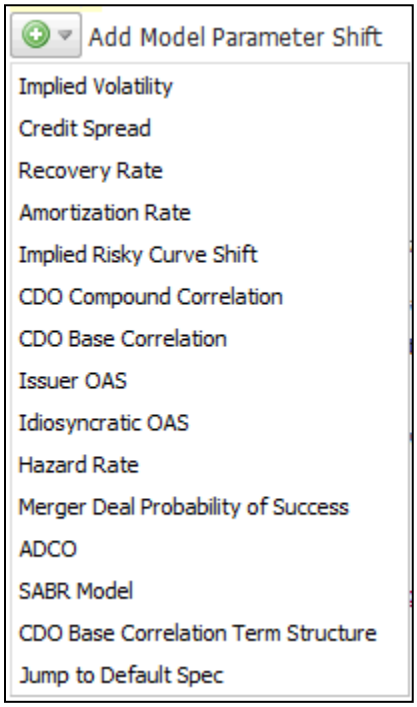


Fig. 11

1. **Credit Spread, Issuer OAS and Idiosyncratic OAS**

In RiskServer the Issuer OAS is defined as the Spread resulting from the selected credit model. Credit models require probabilities of default and these can be derived from Issuer Yield Curves, CDS Spreads or the Issuer Equity Levels. These three models are Bond Spread, CDS Spread and CreditGrade models respectively. The Issuer OAS is a direct function of the credit model.

Credit Spread is the total spread required on top of the risk free rate to match a provided market price. Idiosyncratic Spread is related to the other two spreads as follows:

Credit Spread = Issuer OAS + Idiosyncratic OAS

The more accurate the Credit Model used, the smaller the Idiosyncratic OAS.

Any of these three spreads can be directly shocked in the parameter stress test.

2. **Hazard Rate**

For a credit position, this is the probability that the Issuer will default given that it has not defaulted yet. Stressing Hazard Rates up by say 10000 basis points will force all securities that are using a credit model to default. Once a bond defaults, the recovery rate amount will remain, and one minus recovery rate in the case of a credit default swap protection buyer.

3. **Implied Risky Curve Shift**

This applies to credit models that use the Hull White bridge such as Credit Grades, CDS Spread and Hull White bond spread model. Credit models use Hazard Rates to calculate the expected loss of a risky bond, and this gives us the risky bond price, which involves a credit spread on top of the risk free curve. If the risky curve is shocked, this is converted into implied hazard rates, and these are used to work out the stressed expected loss again. Term structure shifts of the credit spread can be performed under this stress test.

4. **Jump To Default Stress**

Many portfolios will have holdings in corporate or sovereign debt, and the investment or risk manager may be interested to know what losses will occur if one or multiple bond issuers default. Most credit positions (Generic Bond, Credit Default Swap, Convertible Bond etc) in RiskServer have a field called IssuerName. This field is automatically populated for exchange traded positions processed through our Terms and Conditions server.

The JTD stress will automatically group the issuers together and default them one by one or all together.

In order to setup a JTD Stress, first create a By Model Parameter stress test. Select Jump To Default Spec in the Add Model Parameter list, where you can either choose to default all issuers at the same time or pick specific issuers only.

For the latter case, the exact Issuer Names need to be entered into the stress for all those issuers that shall be exposed to the stress.

Include this stress test in a report (see 2.2) where it is necessary to use the column engine drill down Issuer Name to get the desired results.

Fig.13 shows the output of a Jump To Default stress, where the portfolio contains Sovereign and Corporate bonds as well as some Credit Default Swaps. As expected the long bond positions lose about 60% of their value (default recovery rate is 40%) and CDS protection positions gain in value after the credit event.

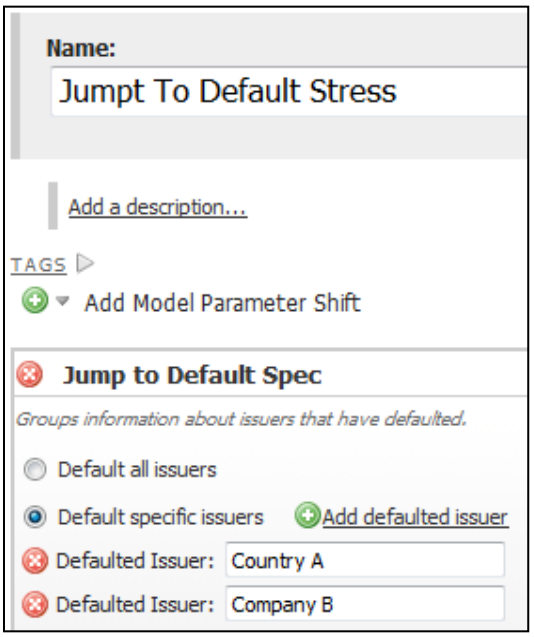


Fig. 12

		JTD - All Issuers				
	PV	Delta Jump To Default				
Name	Total	Total	Italy, Republic of	Pfizer Inc.	Rolls-Royce PLC	Spain, Kingdom of
Total	**64,300,042.95**	**-19,608,919.19**	**-12,998,880.38**	**-1,575,940.86**	**-4,450,623.95**	**-583,474.01**
Italy	18,503,951.96	-12,998,880.38	-12,998,880.38			
ITALY, REPUBLIC OF (GOVERNMENT) 9 11/01/2023	18,503,951.96	-12,998,880.38	-12,998,880.38			
Pfizer	11,528,885.37	-1,575,940.86		-1,575,940.86		
CDS on Pfizer	-30,736.38	5,969,730.89		5,969,730.89		
PFIZER INC 4.65 03/01/2018	11,559,621.75	-7,545,671.75		-7,545,671.75		
Rolls Royce	20,526,278.94	-4,450,623.95			-4,450,623.95	
CDS on Rolls Royce	-38,330.66	9,404,909.30			9,404,909.30	
ROLLS-ROYCE PLC 7.375 06/14/2016	20,564,609.60	-13,855,533.24			-13,855,533.24	
Spain	13,740,926.68	-583,474.01				-583,474.01
CDS on Rep. of Spain	-103,840.24	7,894,982.71				7,894,982.71
SPAIN, KINGDOM OF (GOVERNMENT) 6.15 01/31/2013	13,844,766.92	-8,478,456.72				-8,478,456.72

Fig. 13

1.5. Composite Stress Test

The composite stress test allows combinations of any of the previously mentioned stress tests. The order of how the stress tests are entered is pre-defined and only one type of stress test per category is allowed.

Overall Market: Predictive by Risk Factor or Date stress test. A non-predictive risk factor stress test will automatically become predictive even if not previously specified.

Risk Type: Any Risk Type stress test

Risk Factor: Stresses applied to risk factors specified in this stress test will take precedence even if they were covered in any of the two above drop-downs.

Model Parameter: Any model parameter stress test.

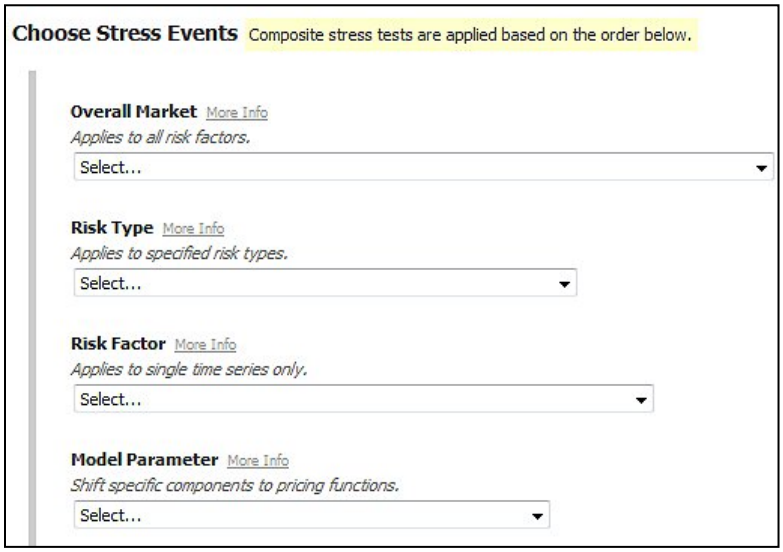


Fig. 14

This stress test can be used to override existing ones for fine tuning. For instance, you could create a stress test of All Equities down 5%, except Intel and Sony Corp. You could also create a By Risk Type stress with -5% global shift to all equities and an additional simple risk factor stress setting Intel and Sony to absolute change of zero, and use them together in a composite stress test. A more complicated way to do this would be to select and shift all individual equities by -5% except these two companies.

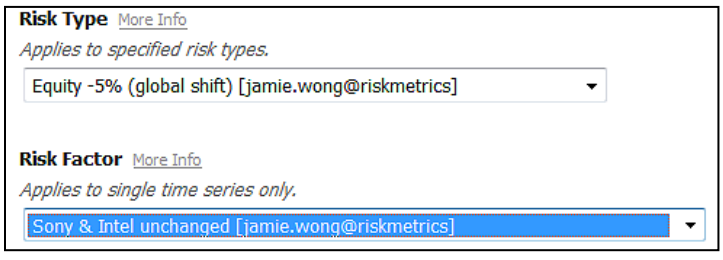


Fig. 15

Pros and Cons:

Allows for combination of multiple stress tests, where the order matters. Typically, the stress tests higher up the list have a broader scope.

Not all types of stress tests can be selected here, for instance By Tag Stress Tests cannot be chosen.

1.6. By Tag Stress

RiskManager allows positions/holdings to be categorized by "tags". Additional custom information such as Strategy, AssetClass, GICSSector etc can be added to each position, which allows for slicing and dicing of portfolios down to Fund, Country, position level etc. For instance "Country" is a tag name, whereas Germany, Brazil, Australia are corresponding tag values. Each individual holding can have multiple tag pairs such as Fund = Global Equities, Region = BeNeLux, Industry = Pharmaceuticals etc. Below is a screenshot of some tag pairs for a Nestle S.A. equity position.

customBucketList

customBucket (29)

	{} customDimensionName	{} customBucketValue
1	SecurityName	Nestle S.A Ord Shs
2	assetType	CMN
3	Currency	CHF
4	icbIndustry	Consumer Goods
5	icbSuperSector	Food & Beverage
6	icbSector	Food Producers
7	icbSubSector	Food Products
8	gicsIndustryGroup	Food Beverage & Tobacco
9	gicsIndustry	Food Products
10	gicsSubIndustry	Packaged Foods & Meats
11	gicsSector	Consumer Staples
12	Country	CH
13	Region	Europe / Middle East / Africa
14	SubRegion	Europe
15	IssuerCountryOfDomicile	CH
16	marketCapCategory	Large Cap

Fig. 16

CustomDimensionName is the technical name for tag name in RiskServer and customBucketValue stands for tag value. In RiskServer there are two types of tags: Engine and Custom.

An engine tag is automatically added to the position even if it is not specified by the user. For instance if you load a Microsoft Equity position with 1000 shares, then engine tags attached to this positions are postionType = Equity, currency = USD (assuming Nasdaq listing), Long/Short = Long since 1000 shares were entered.

Custom tags are user specific that RiskServer would not know by default. Examples include Fund = US Equities, Fund Manager = Investor 1 etc.

In the previous section, stress test shocks were applied to the specified risk factors in ALL positions of the portfolio. Stress by Tag allows users to narrow down which positions are or are not exposed to a stress test. The stress test below is setup so that the Tech Wreck stress test is only applied to positions that are in the Insurance industry under Financials, and Food Products under the Consumer Staple sector. The order of the tag names matters; and in general, the ones above have a wider scope than those further down the list. The below example may not be the best as an Insurance company will always be among the financials so that the gicsSector tag may not be required. A more powerful use would be all Insurance companies in Countries UK or DE where we replace gicsSector with Country and use two rows again for Country DE & UK and both with gicsIndustry Insurance. Note that the tag names and values are all case sensitive, so positions will need to be tagged consistently. The RiskMetrics Terms & Conditions database provides a wide range of consistent tags. Clicking on the link "Show Available Tag Values" allows you to choose among a list of valid tag values.

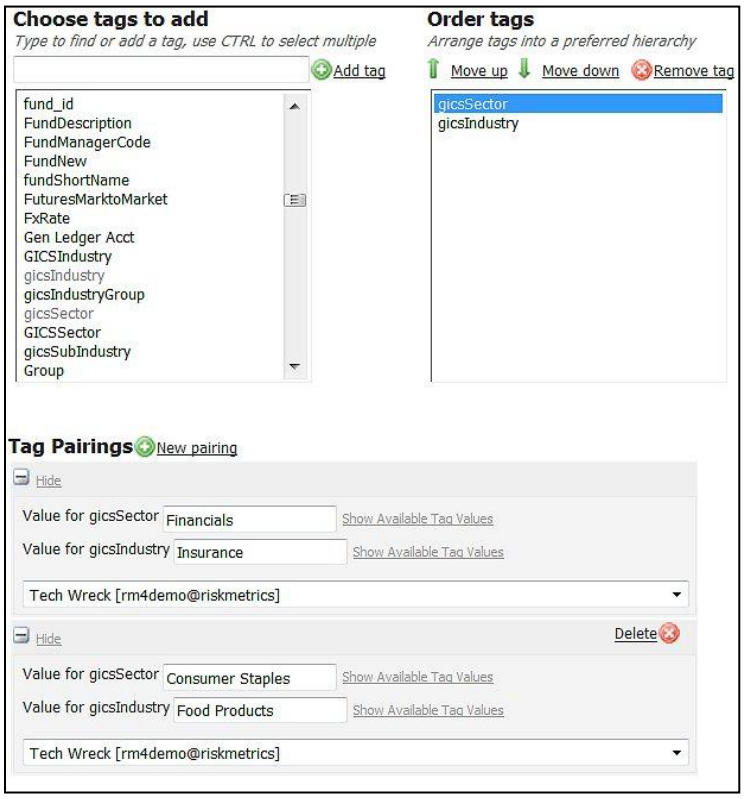


Fig. 17

Pros and Cos:

Powerful stress test feature based on the custom tags that are provided by the user or by the T&C database during enrichment. It is possible to stress selected positions only, and within multiple levels of hierarchy. Predictive or simple stress tests can be run.

Currently, Engine Tags cannot be stressed here, but there is a workaround using the User Defined Statistic (see 1.7).

1.7. User Defined Statistic (Stress by Tag alternative)

In 2011 the User Defined statistic was released to RiskServer 5.2. One of the purposes of this feature is to allow a user to select what statistic to apply to certain positions. A common uses is to allow users to define their own exposure statistic like use Present Value for Equities and Bond, but use Underlying PV for Bond Futures and Contract for Differences.

There is also a good use case for this statistic under stress testing. The example below illustrates how you can use the User Defined Statistic to apply a stress test to specific position types.

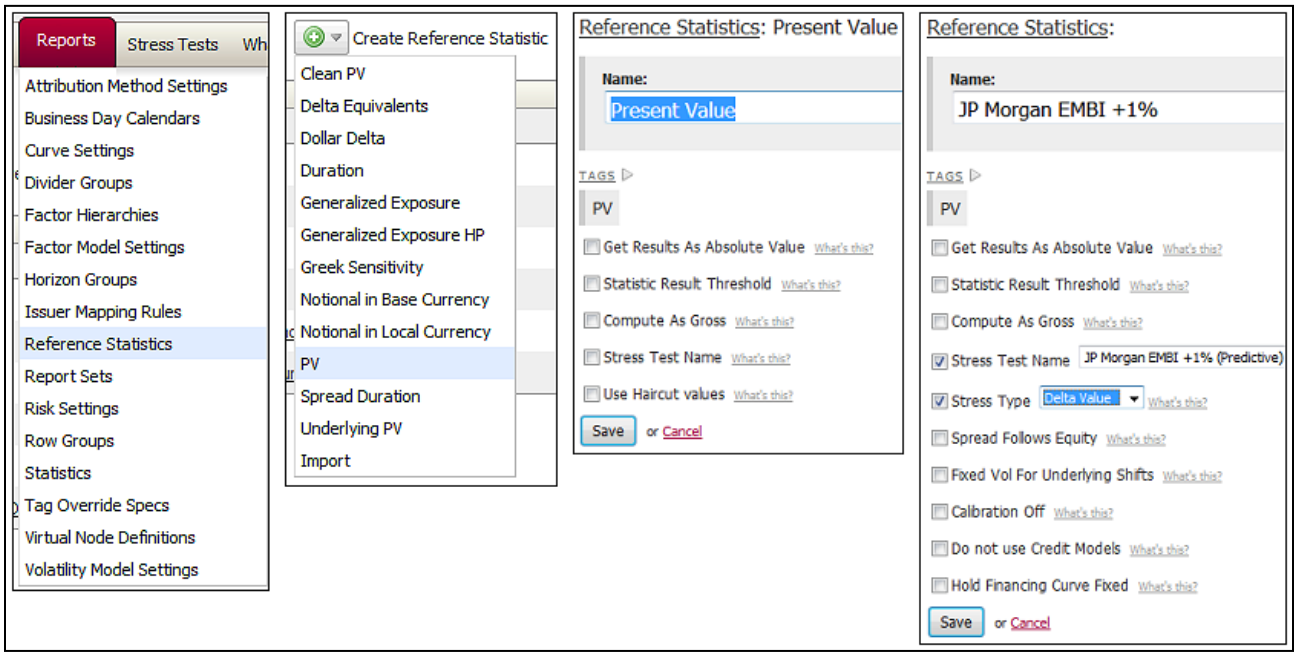


Fig. 18

You first need to create a Reference statistic, which can be found in the Reports drop-down menu.

Choose the Present Value (PV) statistic.

Start by creating a normal Present Value statistic by just naming this Present Value with no other configurations and save this as Present Value.

Then build a new PV reference statistic for the stress test by selecting the stress test you wish to apply to a set of positions and whether you want to display the Stress Test PV Delta or the full Stressed Value. The above will show the Stress Test PV Delta value and you'll save it with the stress test name (JPM EMBI +1%).

Multiple such reference statistics may have to be set up for each other stress test you want to run.

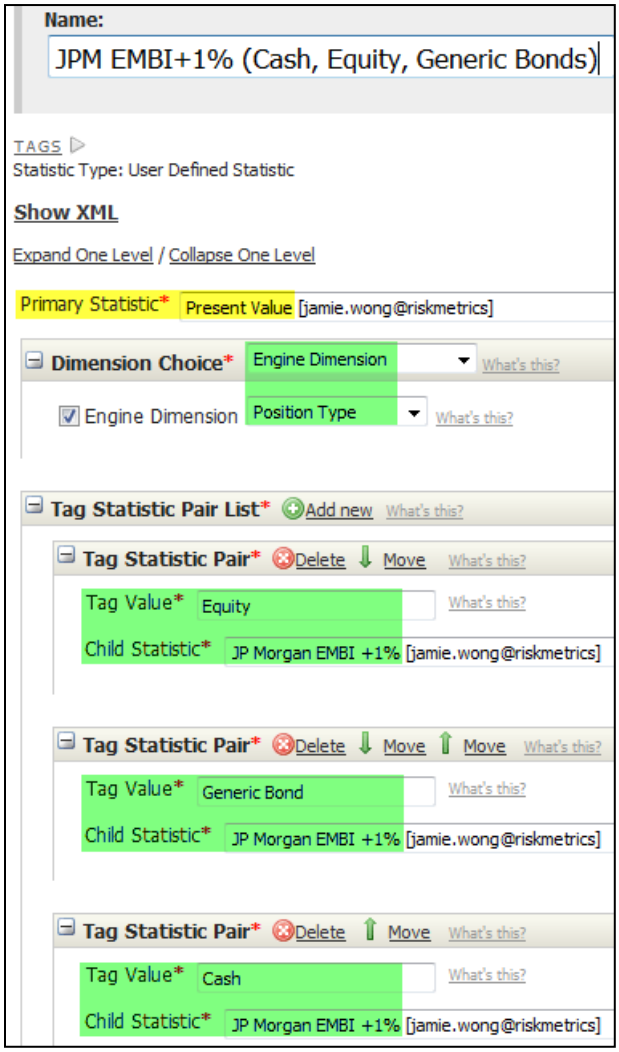


Fig. 19

Now you need to create the user-defined statistic by clicking on Statistics under the Reports menu. It is also possible to arrive at this stage by clicking on Manage Statistics while creating or editing a report.

Primary Statistic (Present Value) is what we want to be displayed for all positions that are not stressed, i.e. the complement of all tag values that we select.

In this example we want to stress all securities with the Engine Tag: Position Type equal to Equity, Generic Bond and Cash. The stress test (child statistic) that shall be applied is the JP Morgan EMBI+1% stress test.

Note that both Primary and Child Statistics first need to be created under Reference Statistic but only once and can be reused in future user defined statistics again.

Once the User Defined stat is configured, you can select how the individual values are aggregated.

Options are Addition Aggregation (simply add all numbers), Default Aggregation (will apply the default aggregation method that is used in the Primary statistic) and No Aggregation.

For a stress test and present value report, select the Addition Aggregation method. Since this is also how Present Value (primary stat) is aggregated by default, selecting Default Aggregation method will return exactly the same results.

2. Setting up and running a stress test in RiskManager 4

RiskManager already has a library of stress tests available for the user once you log in. In the Stress Test tab you will see an extensive list of stress tests such as Asian Crisis, Black Monday & Week, Gulf War, 2008 Financial Meltdown, WaMu collapse etc.

There are two ways to see the results of a Stress Test on your portfolio: Running them directly on a portfolio from the Stress Test tab or including them in columns in a Report.

2.1. Running a stress test directly

Click on the Stress Tests tab to view list of available stress tests.

Choose "Run" in the drop-down menu next to the stress test you want to run.

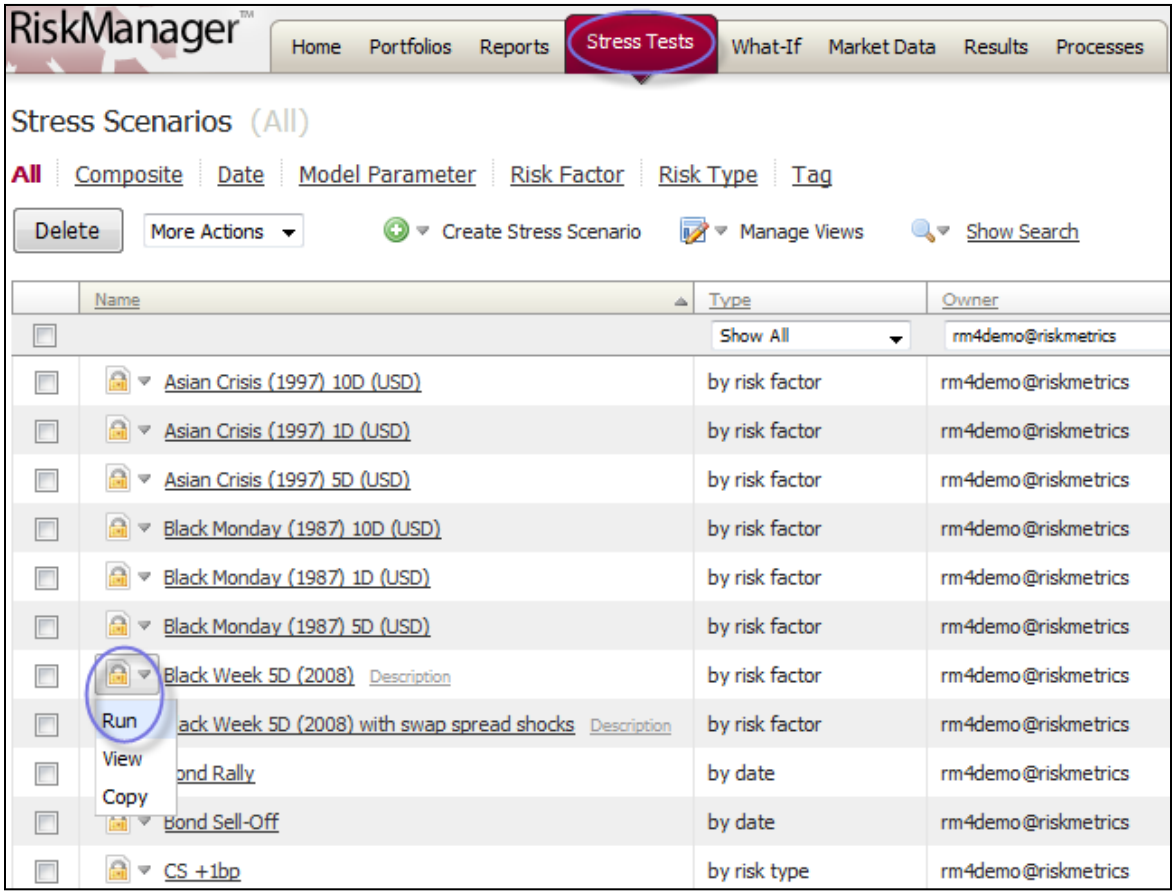


Fig. 20

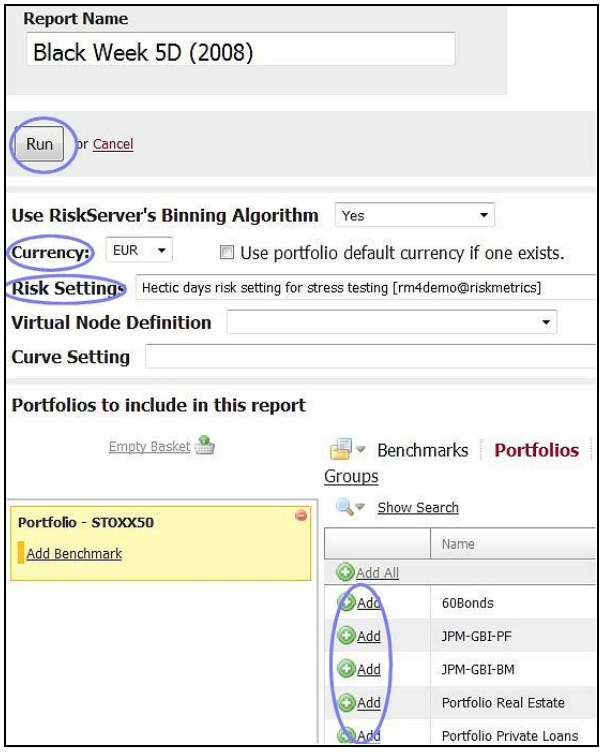


Fig. 21

In the next screen, you user can select the portfolio(s) to run the stress test against.

Also a Base Currency and a Risk Setting (correlations are based on this).

Do not run yet!

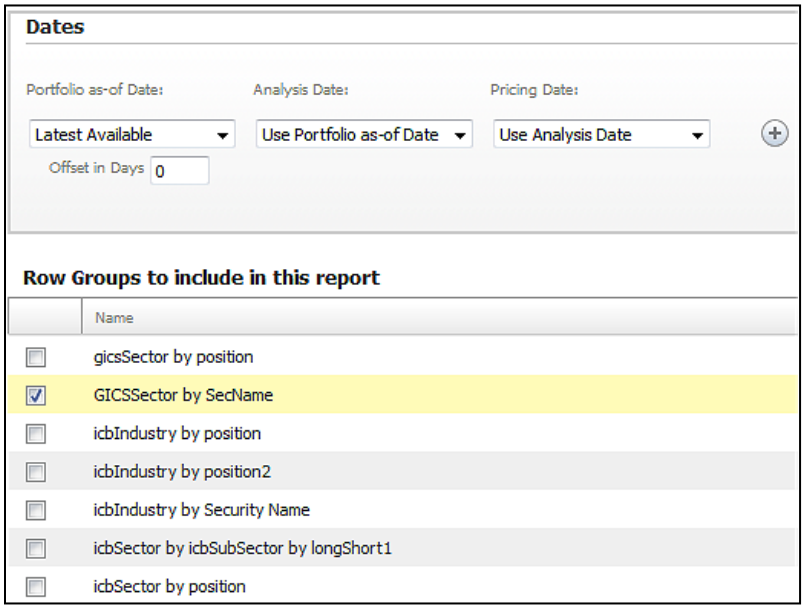


Fig. 22

At the bottom of this next page you can also select the Portfolio As of Date (AoD) and a Row Group for row drill-downs.

Now the report can be run!

Results of the ad hoc Stress Test with drill-down by GICSSector and SecurityName.

A simple report is generated with three statistics: current Present Value, Stressed PV and Stressed PV Delta.

		Black Week 5D (2008)	
Name	presentValue	Stress presentValue	Delta presentValue
Total	**23,372,125**	**17,627,583**	**-5,744,541**
Consumer Discretionary	731,331	536,098	-195,233
Consumer Staples	1,742,122	1,430,196	-311,926
Energy	3,096,798	2,268,731	-828,067
Financials	6,829,980	4,779,567	-2,050,413
Health Care	2,791,391	2,324,814	-466,577
Industrials	835,679	633,874	-201,805
Information Technology	951,295	760,212	-191,083
Materials	1,929,329	1,267,927	-661,401
Telecommunication Services	2,751,374	2,330,020	-421,354
Utilities	1,712,826	1,296,145	-416,681

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Fig. 23

Results can also be seen in percent of total Portfolio Value or percent of Row PV (Cell PV) and in this example drilled down to SecurityName level.

Here the numbers are expressed in percent of row Present Value.

The Materials sector drops the most (-34.3%) and Telecoms the least (-15.3%). British American Tobacco declines the most (-21%) among Consumer Staples.

		Black Week 5D (2008)	
Name	presentValue	Stress presentValue	Delta presentValue
Total	**100.00**	**75.42**	**-24.58**
Consumer Discretionary	100.00	73.30	-26.70
Daimler Ord Shs	100.00	73.30	-26.70
Consumer Staples	100.00	82.10	-17.90
British American Tobacco Ord Shs	100.00	78.98	-21.02
Diageo Ord Shs	100.00	81.61	-18.39
Nestle S.A Ord Shs	100.00	87.72	-12.28
Tesco Ord Shs	100.00	81.08	-18.92
Energy	100.00	73.26	-26.74
BG Group Ord Shs	100.00	71.81	-28.19
BP Ord Shs	100.00	71.15	-28.85
ENI Ord Shs	100.00	78.08	-21.92

Fig. 24

2.2. Stress tests in a RiskManager report

A stress test can also be run inside a report. It can be added to an existing report or setup in a new report. To create a new report, click the Reports tab and select Custom under Create Report.

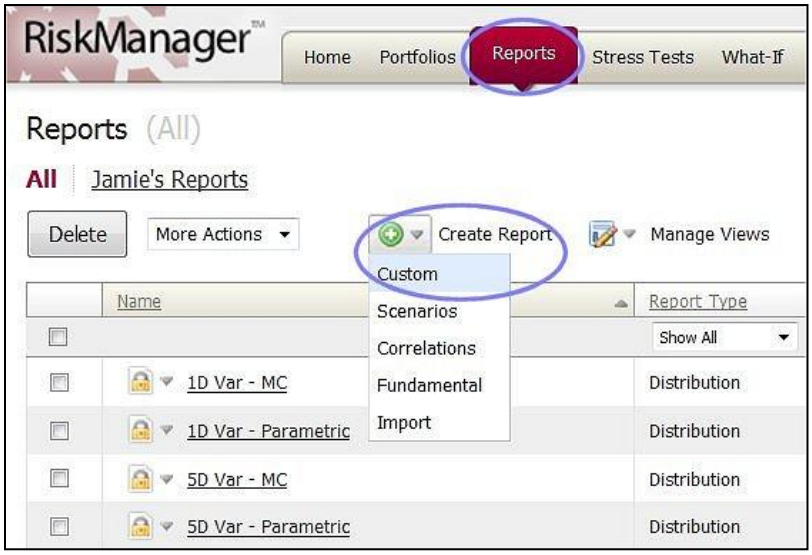

Fig. 25

The stress test will appear as a statistic so it needs to be added by first clicking on Add/Edit Columns. Stress tests can be used to display the new stressed Present Value or the change in PV. In any case, first add a Present Value (PV) statistic, which is listed under Valuation statistics.

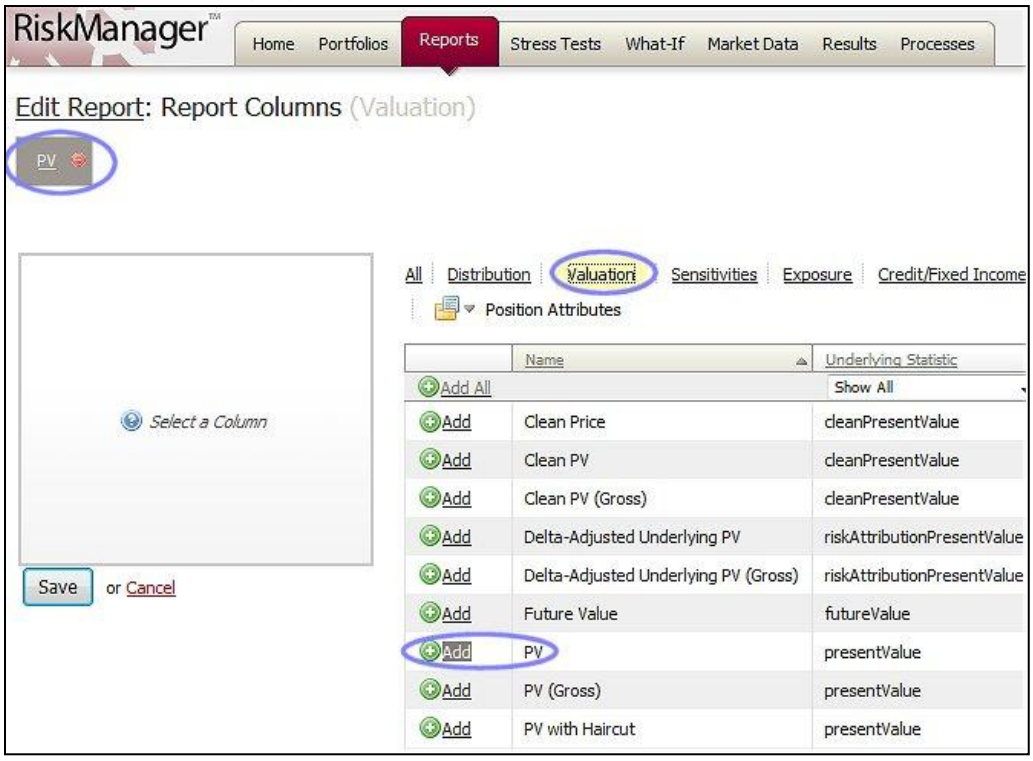

Fig. 26

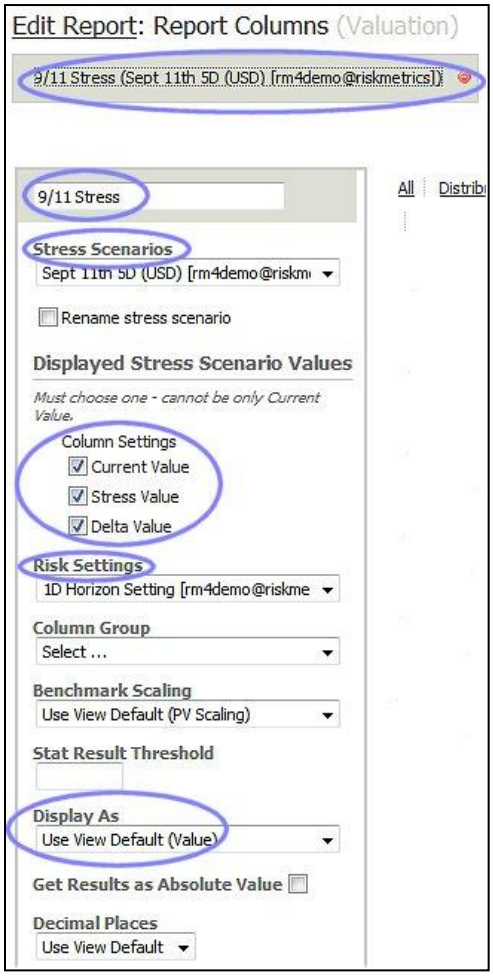

Fig. 27

After adding the PV statistic, click on it to modify. Select the Stress Scenario you want to run and a relevant risk setting. Again the risk setting will be used to calculate all correlations in a predictive stress tests.

The statistic options allow you to display the current (unstressed) value, a Stressed PV Value and the Change in PV (Delta) as a result of the stress.

Here all three are selected.

This report will display the results in dollar values, but it can also be displayed in percent or basis points of original Total Portfolio PV or row PV.

Click Update after configuring the statistic and continue to add more statistics, or click save.

After returning to the custom report page you need to select a Row Group and then Save & Run the report. This only needs to be done when creating a new report; not necessarily when editing an existing one. Portfolios can be selected as usual when running a report.

Fig. 28

Only a single Present Value statistic was added, but there are three results because of the chosen column selections. Original total Present Value of the Portfolio is €83.2mln. As a result of the stress test total portfolio value goes to €84.6 an increase of €1.4mln.

currencies by position Run What-If

Expand One Level / Collapse One Level

Results 1 to 5 of 5

	Sept 11th 5D (USD)		
Name	9/11 Stress	Stress 9/11 Stress	Delta 9/11 Stress
Total	**83,235,074**	**84,621,619**	**1,386,545**
DKK	1,408,522	1,431,412	22,890
EUR	65,402,361	66,481,848	1,079,488
GBP	15,267,620	15,545,727	278,107
SEK	1,156,572	1,162,632	6,060

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Fig. 29

3. More Stress Test results

In the 5 day Gulf War stress Swedish equities are the biggest loser down 12.25% exceeding the Germany and Finland. Great Britain is the smallest loser declining by only 3.16%

	Gulf War (5D)			Gulf War (%)
Name	Gulf War (5D)	Stress Gulf War (5D)	Delta Gulf War (5D)	Delta Gulf War (%)
Total	**30,817,315**	**29,072,807**	**-1,744,508**	**-5.66**
CH	4,242,844	3,954,727	-288,117	-6.79
DE	5,795,630	5,266,612	-529,018	-9.13
ES	2,588,248	2,423,453	-164,795	-6.37
FI	565,359	524,311	-41,048	-7.26
FR	3,080,142	2,893,771	-186,371	-6.05
GB	12,368,968	11,978,005	-390,963	-3.16
IT	1,578,317	1,507,325	-70,992	-4.50
SE	597,807	524,602	-73,205	-12.25

Fig. 30

German Equities lose the most in value (-$529K), so we drill down further into this group to explore more. In order to enable this level of drill-down. a row group with dimensions Country by SecurityName was used. Among the German equities Daimler loses the most in dollar terms, but Allianz declines the most in percentage terms.

	Gulf War (5D)			Gulf War (%)
Name	Gulf War (5D)	Stress Gulf War (5D)	Delta Gulf War (5D)	Delta Gulf War (%)
DE	**5,795,630**	**5,266,612**	**-529,018**	**-9.13**
Allianz Ord Shs	609,244	530,992	-78,252	-12.84
BASF SE Ord Shs	565,679	521,956	-43,723	-7.73
Bayer N Ord Shs	597,908	536,804	-61,104	-10.22
Daimler Ord Shs	964,296	860,136	-104,161	-10.80
Deutsche Bank Ord Shs	747,789	664,890	-82,899	-11.09
Deutsche Telekom Registered Ord Shs	570,706	524,317	-46,389	-8.13
E ON N Ord Shs	490,993	476,124	-14,869	-3.03
RWE A Ord Shs	544,799	516,424	-28,375	-5.21
SAP Ord Shs	91,164	81,260	-9,905	-10.86
Siemens N Ord Shs	613,052	553,710	-59,342	-9.68

Fig. 31

The following reports will all use the same set of sample positions, which include an equity index future, JPY & USD cash, convertible bond by RWE, Tesco and Walt Disney cash equity, and a risk free (no credit model) zero coupon bond.

Analysis date is 1st February 2012 with base currency USD and holding amounts are all fictional.

		Equities -10%	Jul+Aug 2011
	Present Value	Delta Equities -10%	Delta Jul+Aug 2011
Name	Total	Total	Total
Total	**5,921,946**	**-300,340**	**-99,912**
Hang Seng Dec12 Future	0	-131,400	-109,207
JPY 100mln (Cash)	1,313,543	0	75,923
RWE Convertible Bond 4% 2020	1,848,769	-78,633	-70,033
Tesco (Equity)	509,771	-50,977	-21,565
USD 1mln (Cash)	1,000,000	0	0
Walt Disney Co. (Equity)	393,300	-39,330	-56,299
Zero Coupon (USD 1mln, Dec 2020)	856,563	0	81,268

Fig. 32

The value of this portfolio is just under $6mln, Present Value of the Future is zero as they are marked to market and P&L can be set aside in cash. This view has two stress tests:

Risk type stress global shift all equities down by 10% and a by date stress looking at the period from 01/07/2011 to 31/08/2011.

Note that the Risk Type drill down has been chosen in the stress tests so that you can drill down into the stressed numbers to see which risk types are affecting the valuation. As expected, only equity risk factors are being stressed here and only so positions using equity risk factors are affected.

		Equities -10%						
	Present Value	Delta Equities -10%						
Name	Total	Total	Equity Risk	FX Risk	IR Total Risk	IR Market Risk	Issuer Specific Risk	Vega Risk
Total	**5,921,946**	**-300,340**	**-300,340**	**0**	**0**	**0**	**0**	**0**
Hang Seng Dec12 Future	0	-131,400	-131,400	0	0	0		
JPY 100mln (Cash)	1,313,543	0		0				
RWE Convertible Bond 4% 2020	1,848,769	-78,633	-78,633	0	0	0	0	0
Tesco (Equity)	509,771	-50,977	-50,977	0				
USD 1mln (Cash)	1,000,000	0						
Walt Disney Co. (Equity)	393,300	-39,330	-39,330					
Zero Coupon (USD 1mln, Dec 2020)	856,563	0			0	0		

Fig. 33

The long HSI future loses a value of $131,400. Values (even zero) are displayed in those fields in which positions reference a risk factor of that type. For instance, the Tesco Equity has risk factors TSCO cash equity and GBP/USD as the reporting currency is USD. The stress test will only affect the equity risk factor and FX risk factor remains unchanged.

The global shifts in Risk Type stress tests are simple stress tests, so only those risk factors specified will be stressed.

The By Date stress will affect all risk factors in a simple manner. RiskServer looks at how all risk factors behaved over the stress period and applies the changes to the current levels. According to the stress results; during the Summer 2011 period, USD declined against JPY and US yields have fallen. In the case of Tesco, the equity levels dropped by $29K, but GBP appreciated (+$7K) resulting in a net loss of around $22K

	Jul+Aug 2011						
	Delta Jul+Aug 2011						
	Total	Equity Risk	FX Risk	IR Total Risk	IR Market Risk	Issuer Specific Risk	Vega Risk
	-99,912	**-423,890**	**72,650**	**71,144**	**139,322**	**-63,336**	**211,517**
Hang Seng Dec12 Future	-109,207	-109,309	0	-12	-12		
JPY 100mln (Cash)	75,923		75,923				
RWE Convertible Bond 4% 2020	-70,033	-229,627	-10,787	-10,112	58,066	-63,336	211,517
Tesco (Equity)	-21,565	-28,656	7,513				
USD 1mln (Cash)	0						
Walt Disney Co. (Equity)	-56,299	-56,299					
Zero Coupon (USD 1mln, Dec 2020)	81,268			81,268	81,268		

Fig. 34

The convertible equity declines alone would have caused a loss of $230K, but risk free rates and an increase in implied volatility adds value back into the convert.

Note that the CB was modeled with a credit model; and in this case, using the CDS spread curve model. Issuer Specific risk or spread risk comes from those risk factors that are used to derive the default probabilities. Both Issuer Specific and IR Market Risk contribute to the IR Total Risk. They will not add up exactly to the total as there are correlations between risk free and spread risk factors and often the pricing model in which these risk factors are used are non-linear.

The USD cash position remains unchanged as it is denominated in the reporting currency and there are no other risk factors.

FX Risk of the HSI future is zero as the present value of the future is zero.

Future PV = #contracts *multiplier*(Market Price – Entry Price). If no exercise price is provided, it will be set equal to market price resulting in zero PV. Changing FX will change the market price, and at the same time entry price; and they will cancel each other out again.

In the following report, there is a simple stress test only shocking Hang Seng Index down by 20% in a simple manner, and in a predictive setting.

		HangSeng -20% (Simple)	Hang Seng -20% (Pred.)						
	Present Value	Delta HSI -20%	Delta HSI -20%						
Name	Total	⊞ Total	⊟ Total	Equity Risk	FX Risk	IR Total Risk	IR Market Risk	Issuer Specific Risk	Vega Risk
Total	**5,921,946**	**-262,799**	**-453,885**	**-401,998**	**-111,739**	**-9,928**	**24,281**	**-33,660**	**66,653**
Hang Seng Dec12 Future	0	-262,799	-262,845	-262,799	0	-272	-272		
JPY 100mln (Cash)	1,313,543	0	16,566		16,566				
RWE Convertible Bond 4% 2020	1,848,769	0	-115,246	-60,798	-102,122	-20,264	13,945	-33,660	66,653
Tesco (Equity)	509,771	0	-56,016	-31,448	-26,183				
USD 1mln (Cash)	1,000,000	0	0						
Walt Disney Co. (Equity)	393,300	0	-46,952	-46,952					
Zero Coupon (USD 1mln, Dec 2020)	856,563	0	10,608			10,608	10,608		

Fig. 35

As expected, the simple stress test only shifts the HSI risk factor and nothing else. Only one position uses this time series so only this one is stressed. Even though there is correlation between HSI and other risk factors, these are not applied in a simple stress test.

The predictive HSI -20% stress is applied to all risk factors where there is correlation.

In the following report, the same predictive stress HSI -20% is used, but this is inserted in to a Risk Type stress where we want to stress only equity risk factors in a predictive way using this stress. As expected, the equity risk factors are all stressed the same way as in the original stress; but no other risk types are stressed.

Tesco only declines by $31K as the GBP/USD rates is left unchanged. The FX rate stress resulted in an additional loss of $26K in the general predictive stress test.

		HangSeng -20% (Pred.)	HangSeng -20% (Predictive, Equity only)						
	PV	Delta HSI -20%	Delta HSI -20% (EQ)						
Name	Total	Total	Total	Equity Risk	FX Risk	IR Total Risk	IR Market Risk	Issuer Specific Risk	Vega Risk
Total	**5,921,946**	**-453,885**	**-401,998**	**-401,998**	**0**	**0**	**0**	**0**	**0**
Hang Seng Dec12 Future	0	-262,845	-262,799	-262,799	0	0	0		
JPY 100mln (Cash)	1,313,543	16,566	0		0				
RWE Convertible Bond 4% 2020	1,848,769	-115,246	-60,798	-60,798	0	0	0	0	0
Tesco (Equity)	509,771	-56,016	-31,448	-31,448	0				
USD 1mln (Cash)	1,000,000	0	0						
Walt Disney Co. (Equity)	393,300	-46,952	-46,952	-46,952					
Zero Coupon (USD 1mln, Dec 2020)	856,563	10,608	0			0	0		

Fig. 36

4. Stress Test Diagnostics

RiskServer has a very useful statistic called Stress Test Diagnostics.

To understand how this statistic works it is instrumental to understand the RiskMetrics full valuation models.

Value = $f(rf_1, rf_2, .., rf_n)$ with risk factor levels rf_i and pricing function f(…).

After the stress test is applied the risk factor levels may change to rf_1', rf_2', .., rf_n' and the security is re-priced again as Value' = $f(rf_1', rf_2', .., rf_n')$.

Using Stress Test diagnostics the stressed levels rf_i' can be displayed. If a dummy stress test is applied (e.g. stressing MSFT up by 0% in a simple way) then one can also display the initial levels rf_i.

In RiskManager 4 Stress Test Diagnostics is not available in the statistic library by default and will need to be created first.

In RM4 go to Reports → Statistics → Create Statistic and select Stress Test Diagnostics

	Dummy Stress	Hang Seng -20%	Hang Seng -20%
Name	Stress Stress Diagnostics - Levels	Stress Stress Diagnostics - Levels	Stress Stress Diagnostics - R-Square
Total			
Hang Seng Dec12 Future			
HKD Govt 12M	0.002498	0.002209	0.000716
HKD Govt 6M	0.002299	0.002325	0.000001
Hong Kong - Hang Seng	20,333.37	16,266.70	1.000000
Hong Kong Dollar	0.128958	0.128874	0.020770
JPY 100mln (Cash)			
Japanese Yen	0.013135	0.013301	0.023993
RWE Convertible Bond 4% 2020			
Tesco (Equity)			
British Pound	1.585850	1.504396	0.361174
LSE - Tesco	3.214500	3.016197	0.109767
USD 1mln (Cash)			
U.S. Dollar	1.000000	1.000000	-
Walt Disney Co. (Equity)			
NYSE - Walt Disney Co	39.330000	34.634790	0.320997
Zero Coupon (USD 1mln, Dec 2020)			
USD Govt 108M	0.017542	0.016164	1.959570
USD Govt 84M	0.012855	0.011444	1.217579
	Initial Levels	Stressed Levels	R-Square

Fig. 37

When setting up a Stress Test Diagnostic report the last row drill down level must be by risk factor and two levels are required. In this example the levels are Positions by Risk Factors. Note that there can be many risk factors in each position, and so this statistic should not be used on a large portfolio. Also many statistics such as Present Value will not allow for the Risk Factor drill down. In that case that statistic will be dropped from the report. Since the RWE convertible bond has many risk factors, these have all been collapsed in the report view above.

In this report a dummy stress test was created (risk factor stress, shift FTSE 100 up by 0, simple). Displaying the levels with this dummy stress returns the unstressed, i.e. current levels as of pricing date.

When the predictive Hang Seng stress is applied, the stressed levels are shown in column 2.

HSI risk factor in the future is stressed by exactly -20% as expected.

Walt Disney falls by 12% and Tesco by 6%.

Japanese Yen appreciates slightly from 0.01330 to 0.02399, but the British Pound drops by 5.14%.

Almost all interest rate curves fall ranging from +1.16% to -10.98%

R-Squared ranges from almost zero for HKD Govt 6M curve to 1.96 for USD Govt 108M.

All the above stressed risk factor levels are plugged back into the pricing formula to calculate the stressed position values.

5. Additional Configurations

- Return Limits
- Spread follows equity
- Suppress Equity beta
- Fixed Vol for underlying Shifts
- Calibration off

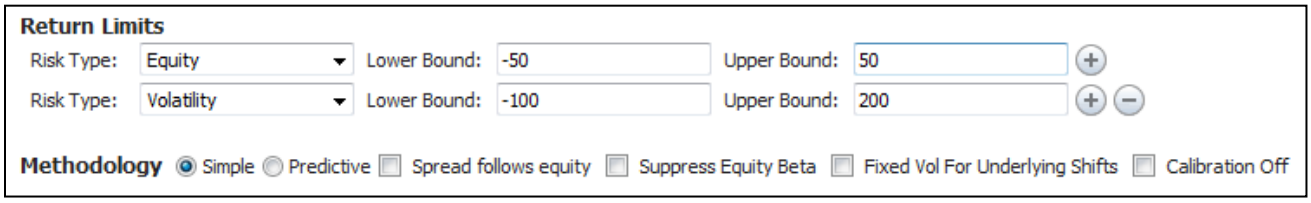


Fig. 38

5.1. Return Limits

In a predictive stress test the exposure (betas) of the peripheral factors to the core factors is calculated. Let's assume our peripheral factor is riskFactor1 and the single core factor in the stress test is riskFactor2. First RiskServer calculates the beta of riskFactor1 to riskFactor2, call it B12. If riskFactor2 is stressed up by 20% then riskFactor1 will be stressed up by 0.2*B12. Note that B12 can be positive or negative depending on the historic correlations.

Return Limits allow the user to set a range, which the peripheral risk type cannot be stressed beyond. The amount is entered in percent so the above screenshot tells RiskServer to stress all Equity risk factors by no more than +/-50% and the lowest volatility number is 0 (minus 100%) with a largest increase of no more than 200%.

One of the main reasons Return Limits was introduced to stress tests is because Beta between core and peripheral risk factors can be high (especially if volatility of a core risk factor is low) and therefore stress amounts are very large. Even though mathematically the calculations are correct, economically it makes sense to restrict the amount risk factors can be stressed by.

5.2. Spread follows equity

CreditGrades is a Merton based model that links the default probability of an issuer with the issuer equity level, equity volatility and long term debt ratio. In short the lower the equity price the more likely the issuer is to default as it gets closer to a default barrier. If the field 'Spread Follows Equity' is enabled then moves in equity price will affect default probabilities. If a stress test causes equity levels to drop, then default probabilities increase and the value of corporate debt decreases (or the value of a credit default swap increases). In case of a convertible bond, the drop in equity value will cause the CB to drop in value; but an increase in default probability causes the value to drop even further due to rises in credit spread. Disabling 'spread follows equity' will only result in a price drop due to the equity option part decreasing in value, and not due to credit spread change.

5.3. Suppress equity beta

Many equity position types (equity, equity option, convertible bond, etc.) allow for any equity time series, where the user can also specify a beta. For instance one can represent the returns of $equity_1$ as $equity_1 * beta_{12}$.

Running a simple stress test that shocks all equities up by 10% will result in a $10\% * beta_{12}$ move in $equity_1$. If 'Suppress equity beta,' is enabled then the beta will be ignored and in this case $equity_1$ will also increase by exactly 10%. In essence this option sets all equity betas to one. The purpose of this is that all equity time series shall behave the same way in the case of stress tests, but for distributional statistics such as VaR or Expected Shortfall, we want the equity to be more or less volatile than the reference time series using the beta.

5.4. Fixed Vol for underlying Shifts

The price of an equity option is a function of time to expiry (t), underlying equity level (S), risk free rate (r), volatility (σ) and strike (k). Market Price = f(t, S, r, σ, k), where f() is the well known Black Scholes option pricing model in case of European style call options.

Delta of the option changes with respect to equity levels. The call option becomes more In The Money, the higher the equity price and delta moves towards one. Because of the volatility smile (non constant volatility), implied volatility σ is a function of equity level as well. If you do not "fix" volatility, a change in equity level will change both S and σ, which are used for re-pricing. Typically one only wants to looks at equity delta, i.e. the change in option price only due to equity changes while keeping all other factors constant. Enabling 'Fixed Vol for underlying Shifts' does exactly this and the option will be priced with the initial volatility number even if equity risk factors are shifted. To replicate the equity delta (equity +/-0.1%) or gamma (+/-0.2%) statistics under Generalized Greeks, this field should be enabled.

5.5. Calibration off

RiskMetrics allows users to enter a Market Price into most position types. First RiskServer calculates the model price using fair market values and then can calibrate towards the market price. This results in some parameters being used for the calibration such as Implied Volatility, Credit Spread, Correlations etc.

For instance the model price of a zero coupon bond is $P_1 = N*e^{-T*R}$ with notional amount N, time to maturity T and risk free rate R. If a market price P_2 is entered then RiskServer calibrates to this price using the credit spread CS.

CS is the solution to the equation $P_2 = N*e^{-T*(R+CS)}$

Let's assume that after a stress test is performed the initial risk free rate R changes to R'.

After enabling 'Calibration Off' the new stressed value will be $N*e^{-T*R'}$ ignoring any market price calibrations.

Without enabling this option the stressed value will be $N*e^{-T*(R'+CS)}$ inheriting the parameter from the calibration process.

6. Appendix

We will now take a closer look at how the stress test numbers are computed by RiskServer. A small sample set of fictitious positions were used in the report with Analysis Date : 1st Feb 2012

- Two cash positions worth 1m USD and 100m JPY
- Cash equity positions: 100,000 in Tesco (LSE) and 10,000 Walt Disney (NYSE)
- 50 Hang Seng Index future contracts (contracts size 10) expiring in December 2012
- Zero Coupon bond with USD1m notional amount due 31st December 2020
- Convertible Bond with maturity end of 2020 and converting into 150 RWE shares per 5000 EUR

6.1. Analytics & methodology

This first report consists of three statistics namely Present Value and two stress tests. The first stress is a simple Risk Type stress where all equities are stressed down by 10%. The second is a By Date stress that is replaying the period from 1st July to 31st August 2011. Both stress tests are broken down into Risk Type.

We will now replicate all these numbers (except the convertible bond) and you can follow these in the accompanying spreadsheet for exact calculations and formulae as well. The main purpose of this exercise is to see how risk factors are stressed and how these stressed levels are used in the revaluation again to find stressed PV. The same concept applies to all position types.

	Equities -10%								Jul+Aug 2011
	Present Value	Delta Equities -10%							Delta Jul+Aug 2011
ame	Total	Total	Equity Risk	FX Risk	IR Total Risk	IR Market Risk	Issuer Specific Risk	Vega Risk	Total
otal	**7,235,943**	**-300,340**	**-300,340**	**0**	**0**	**0**	**0**	**0**	**-101,270**
Hang Seng Dec12 Future	1,313,997	-131,400	-131,400	0	0	0			-110,565
JPY 100mln (Cash)	1,313,543	0		0					75,923
RWE Convertible Bond 4% 2020	1,848,769	-78,633	-78,633	0	0	0	0	0	-70,033
Tesco (Equity)	509,771	-50,977	-50,977	0					-21,565
USD 1mln (Cash)	1,000,000	0							0
Walt Disney Co. (Equity)	393,300	-39,330	-39,330						-56,299
Zero Coupon (USD 1mln, Dec 2020)	856,563	0			0	0			81,268

Fig. 39

	Equities -10%		Jul+Aug 2011						
	Present Value	Delta Equities -10%	Delta Jul+Aug 2011						
Name	Total	Total	Total	Equity Risk	FX Risk	IR Total Risk	IR Market Risk	Issuer Specific Risk	Vega Risk
Total	**7,235,943**	**-300,340**	**-101,270**	**-423,890**	**71,292**	**71,144**	**139,322**	**-63,336**	**211,517**
Hang Seng Dec12 Future	1,313,997	-131,400	-110,565	-109,309	-1,358	-12	-12		
JPY 100mln (Cash)	1,313,543	0	75,923		75,923				
RWE Convertible Bond 4% 2020	1,848,769	-78,633	-70,033	-229,627	-10,787	-10,112	58,066	-63,336	211,517
Tesco (Equity)	509,771	-50,977	-21,565	-28,656	7,513				
USD 1mln (Cash)	1,000,000	0	0						
Walt Disney Co. (Equity)	393,300	-39,330	-56,299	-56,299					
Zero Coupon (USD 1mln, Dec 2020)	856,563	0	81,268			81,268	81,268		

Fig. 40

1. **Pricing**

In order to price securities you need to know the analysis date (important for securities with a time component), pricing date, underlying risk factor levels and the pricing functions.

Date	Tesco	Walt Disney Co	Hang Seng	Hong Kong Dollar	British Pound	Hong Kong Dollar	JPY	U.S. Dollar	HKD Govt 6M	HKD Govt 12M	USD Govt 84M	USD Govt 108M
20120131	3.20	38.90	20,390	0.1290	1.58	0.1290	0.01311	1.00	0.2400	0.2600	1.2617	1.7304
20120201	3.21	39.33	20,333	0.1290	1.59	0.1290	0.01314	1.00	0.2300	0.2500	1.2897	1.7620
20120202	3.19	38.91	20,739	0.1289	1.58	0.1289	0.01313	1.00	0.2300	0.2500	1.2674	1.7524
	Equity			Foreign Exchange					Interest Rates			

Equity	#shares	price	FX	Value
Walt Disney	10,000	39.33	1.00	393,300.00
Tesco	100,000	3.21	1.59	509,771.48

Cash	Amount	FX	Value
JPY	100,000,000	0.0131	1,313,543
USD	1,000,000	1.0000	1,000,000

Zero Coupon			
Analysis Date	01/02/2012		
Maturity Date	31/12/2020		
Notional	1,000,000		
Time To Maturity	8.920548		
	discrete rate	continuous	term
USD Govt 84M	1.2897	1.2855%	7
USD Govt 108M	1.7620	1.7542%	9
interpolated rate		*1.7356%*	
Present Value	856,563.40		

HangSeng Future			
Analysis Date	01/02/2012		
Expiry Date	27/12/2012		
#Contracts	10		
Multiplier	50		
Time To Maturity	0.904109589		
	discrete	continuous	term
HKD Govt 6M	0.2300	0.2299%	0.5
HKD Govt 12M	0.2500	0.2498%	1
interpolated rate		0.2460%	
Hang Seng Level	20,333		
HKD Rate	0.1290		
Market Value	1,313,996.89		

Fig. 41

In Fig.41 the eleven risk factors for all sample positions (excluding the convertible bond and USD is not a risk factor as base currency is USD) have been identified with analysis and pricing date being the 1st February 2012. The historic data can be retrieved from RiskManager or Web Services.

Given that the base currency is USD. the value of an equity holding is simply #shares*Price*FX with the FX rate being the exchange rate between USD and the corresponding local currency.

Similarly cash can be valued very easily as Amount*FX.

In the case of interest rate securities, the downloaded data from the time series database are all discrete rates. For simplicity we work with continuous rates and convert the discrete rates with their compound factor. Note that the compound factor may vary among different IR curves and is shown as the payment frequency in RiskManager. USD Govt and HKD Govt have a compound factor of two.

Continuous Rate = 2*Ln(1+Discrete/{2*100}) for compound factor 2.

For the zero coupon bond we need to determine the time to maturity T of the next cash flow, where the default day count convention is Actual over 365. Since the time nodes are not continuous the next step is to find the two surrounding nodes around T with $t_1 < T < t_2$. In our example T=8.92 year, t_1=7 years and t_2=9 years, because there is no 96M node for USD Govt curve available yet.

Given the continuously compounding rates for t_1 and t_2 we linearly interpolate between them to find the T year rate r_T and use this to discount the cash flow to get PV = Notional * $\exp(-T*r_T)$.

A fixed coupon bond can be calculated as the sum of a series of zero coupon bonds.

Forward rates need to be calculated with spot rates in the case of floating rate notes[2].

Equity or Index Futures are modeled using the equity future position type. The price of a future is the current spot price of the underlying plus the cost of carry, i.e. borrowing at the risk free rate. Given the future expiry date we determine the time to maturity τ and the corresponding spot rate r_τ through interpolation again. In this case time to maturity is in 0.9 years and the neighboring HKD Govt nodes used are 6M and 12M. The market price of the future is underlying price *$\exp(\tau*r_\tau)$ where r_τ is used to inflate the spot price, not discount.

The present value of a future is given by #contracts*multiplier*(market price-entry price) where entry price is assumed to be equal to market price if it is not provided, which results in zero pv.

[2] See Generic Bond technical document for further details on FRN and forward rates.

2. **Equity -10%**

Only equity risk factors are stressed and nothing else.

First find the levels of all N equity risk factors from the pricing date t $rf_{i,t}$ for i = 1, 2, … N

A 10% drop is equivalent to a log return of R=ln(0.9).

Apply this stress to all equity risk factors: $rf'_{i,t} = rf_{i,t} * e^{R}$

Use these stressed risk factors in the valuation models for full re-pricing again.

Stressed $equity_i$ present value = #shares* $rf'_{i,t}$ * fx_j

Note that we only use the stressed equity risk factor and leave the current fx rate (fx_j) as is, because this is a simple equity only stress. For obvious reasons, we will not go through the equity tree for the convertible bond to derive the stressed price, but the principal is the same: all but equity risk factors remain constant throughout this stress.

					Equity -10%				
Equity	#shares	price	FX	Value	% Stress	Log Stress	Stressed Price	Stressed Value	Delta Value
Walt Disney	10,000	39.33	1.00	393,300.00	-10%	-10.54%	35.40	353,970.00	- 39,330.00
Tesco	100,000	3.21	1.59	509,771.48	-10%	-10.54%	2.89	458,794.33	- 50,977.15
Hang Seng	500	20,333	0.1290	1,313,996.89	-10%	-10.54%	18300.03	1,182,597.20	- 131,399.69

Fig. 42

3. **July + August 2011**

In this stress we need to identify all risk factors in the portfolio positions and see how these behaved during the two months in 2011.

Date	Tesco	Walt Disney Co	British Pound	JPY	U.S. Dollar	HKD Govt 6M	HKD Govt 12M	USD Govt 84M	USD Govt 108M
20110629	3.98	38.35	1.60	0.01236	1.00	0.2400	0.2900	2.4889	3.0814
20110630	4.02	39.04	1.61	0.01238	1.00	0.2400	0.2860	2.5704	3.1397
20110701	4.01	39.75	1.60	0.01236	1.00	0.2400	0.2860	2.6031	3.1619
20110704	4.04	39.75	1.61	0.01237	1.00	0.2400	0.2900	2.6031	3.1619
20110705	4.06	39.97	1.61	0.01234	1.00	0.2500	0.3000	2.5239	3.1022
20110829	3.66	33.16	1.64	0.01299	1.00	0.2600	0.2800	1.6230	2.1632
20110830	3.65	33.58	1.63	0.01303	1.00	0.2600	0.2800	1.5447	2.0802
20110831	3.79	34.06	1.63	0.01308	1.00	0.2600	0.2800	1.5962	2.1316
20110901	3.81	33.38	1.62	0.01299	1.00	0.2600	0.2800	1.5076	2.0365
20110902	3.75	32.46	1.62	0.01303	1.00	0.2600	0.2800	1.4201	1.9034
20120131	3.20	38.90	1.58	0.01311	1.00	0.2400	0.2600	1.2617	1.7304
20120201	3.21	39.33	1.59	0.01314	1.00	0.2300	0.2500	1.2897	1.7620
20120202	3.19	38.91	1.58	0.01313	1.00	0.2300	0.2500	1.2674	1.7524
20120203	3.27	40.00	1.58	0.01306	1.00	0.2300	0.2500	1.3581	1.8559
	Equity		Foreign Exchange			Interest Rates			
Change over July & August									
Percentage	-5.62%	-14.31%	1.47%	5.78%	0.00%	8.33%	-2.10%	-38.68%	-32.59%
Log	-5.79%	-15.45%	1.46%	5.62%	0.00%	8.00%	-2.12%	-48.91%	-39.43%
Apply	3.033802	33.70012	1.60922	0.0138947	1				

Fig. 43

Fig. 43 shows the first five risk factors that have been identified for the cash equity and cash securities. Again the Log returns are calculated over the stress period (blue area) and these returns are applied to the current values (yellow) as usual: $rf'_{i,t} = rf_{i,t} * \exp(R_i)$ where R_i is the log return for risk factor i.

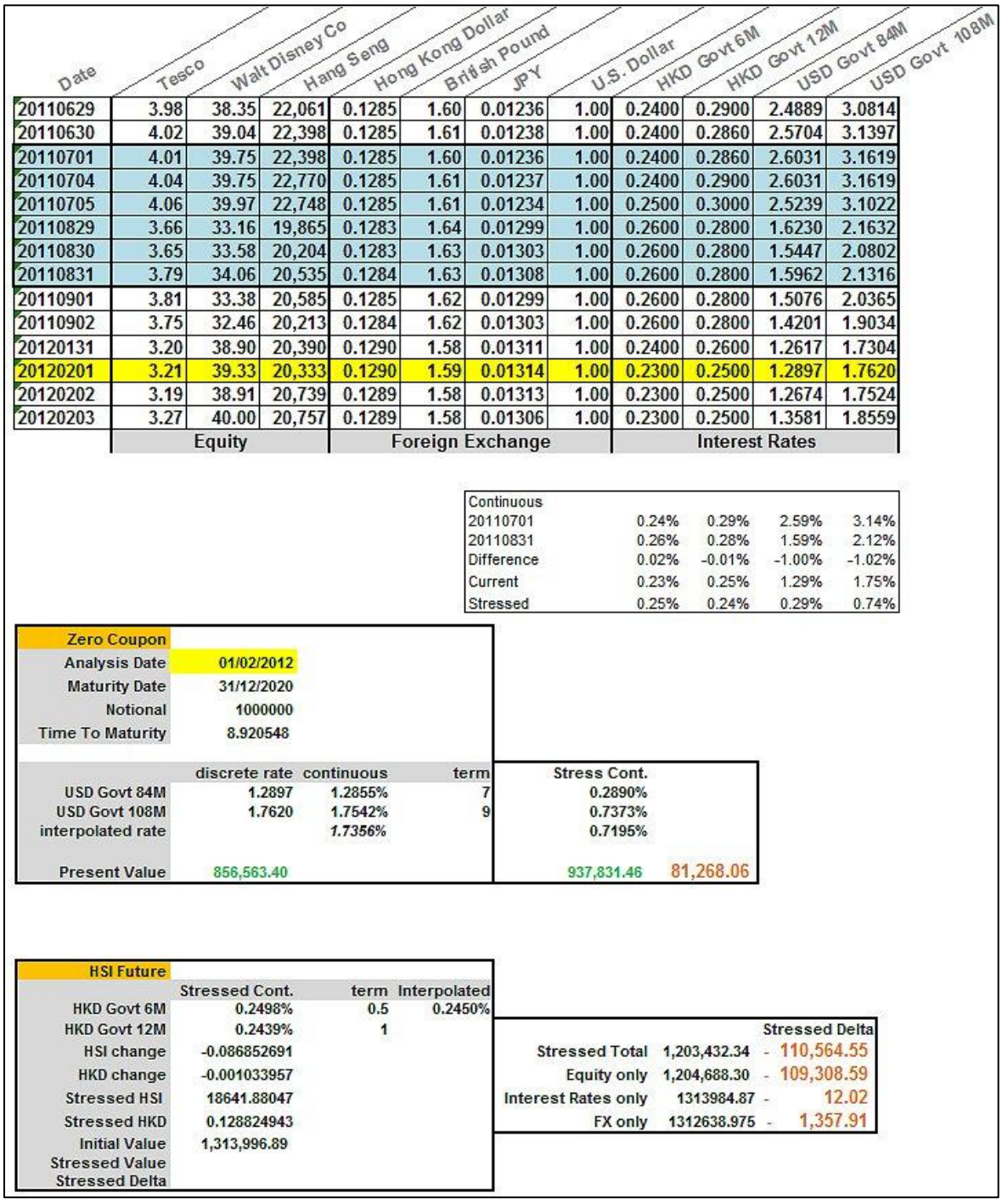
The five pink values are the stressed levels that are used to revalue the holdings again to obtain the Stressed PV and Stressed PV delta as shown in Fig. 44

Equity	#shares	price	FX	Stressed Value	Initial	Delta
Walt Disney	10,000	33.70	1.00	337,001.21	393,300.00	- 56,298.79
Tesco	100,000	3.03	1.61	488,206.60	509,771.48	- 21,564.88

Cash	Amount	FX	Stressed Value	Initial	Delta
JPY	100,000,000	0.0139	1,389,466	1,313,543	75,923.35
USD	1,000,000	1.0000	1,000,000	1,000,000	-

Fig. 44

RiskServer handles Interest Rate shifts differently. Instead of looking at Log returns, Difference returns are used[3]. First the discrete rates are converted into continuously compounding rates for the two stress dates and the difference is added to the current level as can be seen in Fig.45 in the continuous box. This gives us the stressed levels that are used for valuation again.



Date	Tesco	Walt Disney Co	Hang Seng	Hong Kong Dollar	British Pound	JPY	U.S. Dollar	HKD Govt 6M	HKD Govt 12M	USD Govt 84M	USD Govt 108M
20110629	3.98	38.35	22,061	0.1285	1.60	0.01236	1.00	0.2400	0.2900	2.4889	3.0814
20110630	4.02	39.04	22,398	0.1285	1.61	0.01238	1.00	0.2400	0.2860	2.5704	3.1397
20110701	4.01	39.75	22,398	0.1285	1.60	0.01236	1.00	0.2400	0.2860	2.6031	3.1619
20110704	4.04	39.75	22,770	0.1285	1.61	0.01237	1.00	0.2400	0.2900	2.6031	3.1619
20110705	4.06	39.97	22,748	0.1285	1.61	0.01234	1.00	0.2500	0.3000	2.5239	3.1022
20110829	3.66	33.16	19,865	0.1283	1.64	0.01299	1.00	0.2600	0.2800	1.6230	2.1632
20110830	3.65	33.58	20,204	0.1283	1.63	0.01303	1.00	0.2600	0.2800	1.5447	2.0802
20110831	3.79	34.06	20,535	0.1284	1.63	0.01308	1.00	0.2600	0.2800	1.5962	2.1316
20110901	3.81	33.38	20,585	0.1285	1.62	0.01299	1.00	0.2600	0.2800	1.5076	2.0365
20110902	3.75	32.46	20,213	0.1284	1.62	0.01303	1.00	0.2600	0.2800	1.4201	1.9034
20120131	3.20	38.90	20,390	0.1290	1.58	0.01311	1.00	0.2400	0.2600	1.2617	1.7304
20120201	3.21	39.33	20,333	0.1290	1.59	0.01314	1.00	0.2300	0.2500	1.2897	1.7620
20120202	3.19	38.91	20,739	0.1289	1.58	0.01313	1.00	0.2300	0.2500	1.2674	1.7524
20120203	3.27	40.00	20,757	0.1289	1.58	0.01306	1.00	0.2300	0.2500	1.3581	1.8559
	Equity			Foreign Exchange				Interest Rates			

Continuous				
20110701	0.24%	0.29%	2.59%	3.14%
20110831	0.26%	0.28%	1.59%	2.12%
Difference	0.02%	-0.01%	-1.00%	-1.02%
Current	0.23%	0.25%	1.29%	1.75%
Stressed	0.25%	0.24%	0.29%	0.74%

Zero Coupon				
Analysis Date	01/02/2012			
Maturity Date	31/12/2020			
Notional	1000000			
Time To Maturity	8.920548			
	discrete rate	continuous	term	Stress Cont.
USD Govt 84M	1.2897	1.2855%	7	0.2890%
USD Govt 108M	1.7620	1.7542%	9	0.7373%
interpolated rate		1.7356%		0.7195%
Present Value	856,563.40			937,831.46 81,268.06

HSI Future			
	Stressed Cont.	term	Interpolated
HKD Govt 6M	0.2498%	0.5	0.2450%
HKD Govt 12M	0.2439%	1	
HSI change	-0.086852691		
HKD change	-0.001033957		
Stressed HSI	18641.88047		
Stressed HKD	0.128824943		
Initial Value	1,313,996.89		
Stressed Value			
Stressed Delta			

		Stressed Delta
Stressed Total	1,203,432.34	- 110,564.55
Equity only	1,204,688.30	- 109,308.59
Interest Rates only	1313984.87	- 12.02
FX only	1312638.975	- 1,357.91

Fig. 45

[3] Choice of returns (difference or log) for date types can be selected in the risk setting/valuation spec.

The Hang Seng index index future has risk factors HSI equity time series, HKD/USD currency and an interest rate component for the cost of carry. All four of these (two IR nodes) are stressed according to historic changes where log returns are applied to the non interest rate factors, and difference returns are used for HKD Govt components.

Stress Test results can be decomposed into risk type. To determine the stress effect on FX risk factors, RiskServer only stresses the FX levels and keeps everything else constant. This results in the loss of $1,357.91 due to the historic period July+August 2011 currency moves, which is also reported in Fig.40. Interest rate changes have a negligible effect of only minus $12.

4. Predictive Stress Tests

A Predictive stress test takes into account all correlations among risk factors. The report Fig.46 consists of three stress test: DAX increases by 1%, S&P decreases by 8% and finally S&P down 5%, Nikkei down 10% and CAC 40 up 4% all at the same time.

Stress 1 and 2 only have a single core risk factor whereas Stress 3 has three, so intercorrelations among these three risk factors also need to be accounted for.

	DAX+1%			S&P -8%	S&P-5%, N225-10%, CAC+4%
Name	DAX+1%	Stress DAX+1%	Delta DAX+1%	Delta S&P -8%	Delta PV
Total	**4,387,174.39**	**4,394,951.89**	**7,777.49**	**-57,117.10**	**-57,339.34**
Hang Seng Dec12 Future	1,313,996.89	1,317,544.82	3,547.93	-24,918.05	-74,153.68
JPY 100mln (Cash)	1,313,542.62	1,314,619.65	1,077.02	4,707.51	34,088.80
Tesco (Equity)	509,771.48	512,027.83	2,256.35	-19,328.05	-7,210.74
Walt Disney Co. (Equity)	393,300.00	395,077.30	1,777.30	-37,456.42	-21,774.01
Zero Coupon (USD 1mln, Dec 2020)	856,563.40	855,682.29	-881.11	19,877.92	11,710.29

Fig. 46

Since this is the same portfolio as the one in Fig.41, all peripheral risk factors are the same eleven previously shown. For Stress 1 and 2, we need to add the DAX or S&P as an additional risk factor to our market group to calculate a 12x12 covariance matrix. RiskManager 3 or 4 allows the user to create a market group with these twelve risk factors and generate a 12x12 correlation matrix as well as a volatility vector for each risk factor. In RM3 this can be done using the Market Data Correlations report, whereas the Running Simulations option in the Market Data Viewer screen is used in RM4 (Fig.47). Make sure that the same risk settings, currency, historic period and pricing dates are used as in the report, and that price volatility option is selected[4].

[4] Price volatility means looking at the volatility of the discount factor as opposed to yields for interest rates

Name	Vol (%	British Pound	Hong Kong Dollar	Japanese Yen	Tesco	Walt Disney Co	Hong Kong - Hang Seng Index	HKD Govt 6M	HKD Govt 12M	USD Govt 84M	USD Govt 108M	German Equity Index - DAX	France - Cac 40 Index	Japan - Nikkei 225 Index	S&P - S&P 500 Index
		0.47	0.03	0.47	3.02	1.21	1.24	0.01	0.02	0.31	0.42	1.36	1.41	0.85	0.82
British Pound	0.47	1.00	0.30	0.40	0.22	0.32	0.32	0.00	-0.07	0.20	0.24	0.59	0.60	0.20	0.37
Hong Kong Dollar	0.03	0.30	1.00	0.38	0.14	0.21	0.41	-0.03	-0.16	-0.10	-0.07	0.33	0.31	0.10	0.11
Japanese Yen	0.47	0.40	0.38	1.00	0.02	-0.08	0.08	-0.22	-0.30	-0.18	-0.20	0.24	0.15	-0.29	-0.07
LSE - Tesco	3.02	0.22	0.14	0.02	1.00	0.08	0.12	0.32	0.25	0.15	0.14	0.11	0.21	0.15	0.07
NYSE - Walt Disney Co	1.21	0.32	0.21	-0.08	0.08	1.00	0.06	0.03	-0.01	0.47	0.56	0.51	0.46	0.11	0.82
Hong Kong - Hang Seng	1.24	0.32	0.41	0.08	0.12	0.06	1.00	0.18	0.04	-0.01	0.03	0.29	0.32	0.56	0.15
HKD Govt 6M	0.01	0.00	-0.03	-0.22	0.32	0.03	0.18	1.00	0.78	0.06	0.07	0.12	0.20	-0.08	0.03
HKD Govt 12M	0.02	-0.07	-0.16	-0.30	0.25	-0.01	0.04	0.78	1.00	0.07	0.06	0.10	0.20	-0.14	0.10
USD Govt 84M	0.31	0.20	-0.10	-0.18	0.15	0.47	-0.01	0.06	0.07	1.00	0.98	0.29	0.31	0.05	0.46
USD Govt 108M	0.42	0.24	-0.07	-0.20	0.14	0.56	0.03	0.07	0.06	0.98	1.00	0.34	0.35	0.12	0.54
Germany - DAX	1.36	0.59	0.33	0.24	0.11	0.51	0.29	0.12	0.10	0.29	0.34	1.00	0.92	0.04	0.65
France - CAC 40	1.41	0.60	0.31	0.15	0.21	0.46	0.32	0.20	0.20	0.31	0.35	0.92	1.00	0.09	0.59
Japan - Nikkei 225	0.85	0.20	0.10	-0.29	0.15	0.11	0.56	-0.08	-0.14	0.05	0.12	0.04	0.09	1.00	0.19
U.S. - S&P 500	0.82	0.37	0.11	-0.07	0.07	0.82	0.15	0.03	0.10	0.46	0.54	0.65	0.59	0.19	1.00

Fig. 47

Once the correlations and volatility matrix is generated, a covariance matrix can simply be calculated using the relationship Covar(a,b) = Correl(a,b)*Stdev(a)*Stdev(b)

	British Pound	Hong Kong Dollar	Japanese Yen	Tesco	Walt Disney Co	Hong Kong - Hang Seng Index	HKD Govt 6M	HKD Govt 12M	USD Govt 84M	USD Govt 108M	German Equity Index - DAX	France - Cac 40 Index	Japan - Nikkei 225 Index	S&P - S&P 500 Index
British Pound	0.2245	0.0049	0.0883	0.3184	0.1849	0.1882	0.0000	-0.0005	0.0296	0.0472	0.3779	0.3971	0.0784	0.1429
Hong Kong Dollar	0.0049	0.0012	0.0061	0.0143	0.0089	0.0177	0.0000	-0.0001	-0.0011	-0.0010	0.0154	0.0150	0.0029	0.0031
Japanese Yen	0.0883	0.0061	0.2215	0.0272	-0.0479	0.0455	-0.0007	-0.0024	-0.0259	-0.0401	0.1526	0.0975	-0.1150	-0.0287
LSE - Tesco	0.3184	0.0143	0.0272	9.1444	0.3049	0.4619	0.0068	0.0127	0.1430	0.1748	0.4443	0.8753	0.3932	0.1677
NYSE - Walt Disney Co	0.1849	0.0089	-0.0479	0.3049	1.4525	0.0927	0.0003	-0.0003	0.1771	0.2863	0.8394	0.7831	0.1086	0.8042
Hong Kong - Hang Seng	0.1882	0.0177	0.0455	0.4619	0.0927	1.5406	0.0016	0.0007	-0.0057	0.0133	0.4846	0.5612	0.5841	0.1496
HKD Govt 6M	0.0000	0.0000	-0.0007	0.0068	0.0003	0.0016	0.0000	0.0001	0.0001	0.0002	0.0012	0.0020	-0.0005	0.0002
HKD Govt 12M	-0.0005	-0.0001	-0.0024	0.0127	-0.0003	0.0007	0.0001	0.0003	0.0004	0.0004	0.0022	0.0046	-0.0020	0.0014
USD Govt 84M	0.0296	-0.0011	-0.0259	0.1430	0.1771	-0.0057	0.0001	0.0004	0.0986	0.1305	0.1233	0.1385	0.0129	0.1184
USD Govt 108M	0.0472	-0.0010	-0.0401	0.1748	0.2863	0.0133	0.0002	0.0004	0.1305	0.1794	0.1947	0.2061	0.0420	0.1874
Germany - DAX	0.3779	0.0154	0.1526	0.4443	0.8394	0.4846	0.0012	0.0022	0.1233	0.1947	1.8524	1.7531	0.0445	0.7296
France - CAC 40	0.3971	0.0150	0.0975	0.8753	0.7831	0.5612	0.0020	0.0046	0.1385	0.2061	1.7531	1.9805	0.1103	0.6779
Japan - Nikkei 225	0.0784	0.0029	-0.1150	0.3932	0.1086	0.5841	-0.0005	-0.0020	0.0129	0.0420	0.0445	0.1103	0.7180	0.1316
U.S. - S&P 500	0.1429	0.0031	-0.0287	0.1677	0.8042	0.1496	0.0002	0.0014	0.1184	0.1874	0.7296	0.6779	0.1316	0.6700

Fig. 48

Section 4.3 of Return to RiskMetrics[5] explains how to decompose the Covariance matrix into Σ_{12} (Covariance matrix between core and peripheral risk factors) and Σ_{22} (Covariance matrix of core risk factors). In our example there are three stress tests and so there will be three sets of the covariance matrix pairs. For Stress 1 (DAX only) Σ_{12} and Σ_{22} are the green and purple highlighted cells respectively. The blue enclosed area is used for Stress 2 (S&P only) whereas for the larger Stress 3 with three core risk factors the yellow area represents Σ_{12} and the orange 3x3 matrix is Σ_{22}.

[5] See Reference 1)

Now that the two covariance matrices are known we can derive the beta vectors, which are the sensitivity of the peripheral risk factors to the core risk factors.

Beta is known as Covar(a,b)/Var(b) and this can be calculated very easily in the case of a single core factor; but for multiple core factors, matrix algebra needs to be applied.

$$B=\Sigma_{12}\Sigma_{22}^{-1}$$

For example, the beta sensitivity of Walt Disney Co to S&P 500 Index is 0.8042/0.67 = 1.2

Beta	
DAX only	S&P only
0.2040	0.2133
0.0083	0.0046
0.0824	-0.0429
0.2398	0.2502
0.4531	1.2003
0.2616	0.2233
0.0006	0.0003
0.0012	0.0021
0.0665	0.1767
0.1051	0.2797

Beta (inter-correlation)		
CAC	N225	S&P
0.1964	0.0792	-0.0009
0.0092	0.0036	-0.0054
0.0950	-0.1549	-0.1086
0.5545	0.5388	-0.4166
-0.0249	-0.0722	1.2396
0.3309	0.8124	-0.2710
0.0014	-0.0007	-0.0010
0.0024	-0.0033	0.0004
0.0142	-0.0145	0.1653
0.0129	0.0080	0.2650

Fig. 49

To obtain the Beta (inter-correlation) matrix from Fig.49 in Excel, the formula used is =mmult(Yellow,minverse(Orange)) where Yellow and Orange correspond to the colored areas in Fig.48.

In the case that only the DAX is stressed up by 1%, we want to see what effect it has on Tesco. The Present Value of Tesco is #shares*$Price_{TSCO}$*$FX_{USD/GBP}$.

To obtain the stressed value, we need to stress the risk factors Price and FX to get Price' and FX'.

First the DAX is stressed up by 1% so that the peripheral risk factors should move by 1%*Beta in log return terms so we get the following returns (ignoring rounding[6]):

R_{TSCO} = 1%*$Beta_{TSCO,DAX}$ = ln(1+1%)*0.2398 = 0.2386%

R_{FX} = 1%*$Beta_{FX}$ = ln(1+1%)*0.2040 = 0.203%

$Price'_{Tsco}$ = $Price_{Tsco}$ * Exp(R_{TSCO}) = 3.21 * Exp(0.002386) = 3.2222

$FX'_{USD/GBP}$ = $F_{USD/GBP}$ * Exp(R_{FX}) = 1.59 * Exp(0.00203) = 1.5891

Stressed PV = 100,000 * 3.2222 * 1.5891 = $512,027.8

Delta PV = Stressed PV – Initial PV = $2,256

[6] See spreadsheet (reference 4) for exact calculations, rounding ignored here in the results

In the case of multiple core risk factors we need to use the Beta inter-correlation matrix.

Again we demonstrate this on the Tesco equity with two peripheral risk factors. The stress is the last from Fig.46: S&P -5%, Nikkei -10%, CAC +4% so three Beta need to be taken into account:

R'_{Tesco} = ln(1-5%)*(-0.4166)+ln(1-10%)*0.5388+ln(1+4%)*0.5545 = -1.3652%

R'_{FX} = ln(1-5%)*(-0.0009)+ln(1-10%)*0.0792+ln(1+4%)*0.1964 = -0.0595%

$Price''_{TSCO}$ = 3.21 * Exp(-1.3652%) = 3.1665

$FX''_{USD/GBP}$ = 1.59 * Exp(-0.0595%) = 1.5891

Stressed PV = 100,000 * 3.1665 * 1.5891 = 502,560.7

Delta PV = -$7,210.74

The effect on interest rate peripheral factors is also illustrated in the Excel spreadsheet. The main difference here is that IR price volatility is used. Return = Stress*Beta needs to be adjusted by the term of the IR node, and this adjusted return is added on top of the continuous rate.

In predictive stress tests a large correlation matrix is calculated on the fly according to parameters specified in the risk setting: Historic data time series, length of returns, decay factor (half life).

The accompanying spreadsheet also demonstrates how the correlations were derived with a decay factor. In general, a mean of zero is assumed. That is why the Sumproduct function was used instead of the typical Stdev, which takes the sample mean into account.

If Return horizon (sample frequency) is larger than one day and decay factor equals one (no decay) then the sample mean will also be used in calculations.

References

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2. Vega Risk in RiskManager, RiskMetrics February 2012

3. Updated Stress Testing Features in RiskMetrics RiskManager, MSCI September 2011

4. Spreadsheet replication of Stress Test results (from Appendix)
(https://support.msci.com/docs/DOC-3724)

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