Stress-Testing in RiskManager: Contemplating a Eurozone Breakup

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Introduction

This paper illustrates how a stress test can be created where no historical references exist for the behavior of risk factors, horizon and risk climate that describe market risks resulting from a Greek default. Although the paper focuses on Greece, the methodology described to create RiskManager's Euro Stress Test Scenario could be applied to create scenarios for other hypothetical sovereign defaults.

This analysis is organized into four sections. The first section provides one storyline of cross-asset risks resulting from a hypothetical Greek default. The second section defines a stress test by choosing relevant market variables for predictive shocks. The appendix that follows is broken into two parts. Section three provides a step-by-step description of how the stress test was implemented in RiskManager. And, finally, section four presents the results of implementing our stressed scenario on three mock equity and fixed income portfolios.

The Storyline of Default

Creating a Hypothetical Greek Default

Hypothetical scenarios allow the simulation of shocks that are suspected to happen more frequently than suggested by historical observation, shocks that have not yet occurred, a breakdown of statistical patterns, and shocks reflecting structural breaks.

In the context of this analysis, we use the following storyline in *Figure 1* to think through one possible scenario resulting from a Greek default. Here, we consider the case where Greece leaves the European Union and the new drachma is heavily devalued compared to the Euro as the country defaults on its debt.

Figure 1: Events Following a Greek Default
1. Greece leaves the European Union and issues new drachma, which heavily devalues versus the Euro
2. Greece defaults on its government debt
3. All Greek domiciled assets are forced to re-denominate
4. Remaining countries stay in the Euro and the Eurozone stabilizes
5. Runs on Greek bonds pose risk to European banks as stocks are punished
6. Flight to quality inflows are seen in US Treasuries and other safe-haven assets

What Assets are Impacted by a Greek Default?

Once a default occurs, there are many possible routes that assets may follow given cross-asset correlations, volatility and market dynamics. In this section we attempt to translate a structural break in the Eurozone into market risk by creating a stress test.

In *Figure 2* below we can visualize some of the cross effects a Greek default may have on a variety of asset types. In order to choose our market variables, it is important to consider two possible contagion channels. The first is the wealth channel, which propagates an income shock of one country to lenders in other countries, generating losses, and results in a pullback in overall lending. The second channel deals with rebalancing where similar country fundamentals lead to perceptions of similar risks, which in turn may lead to a reduction in allocation (whether justified or not). Both effects tend to foster flight to quality reactions as investors move into safer assets.

Figure 2: Wealth and Rebalancing Shocks lead to Flight to Quality Behavior across Global Asset Classes	
Immediate devaluation of all Greek assets in Euro terms	*Flight to other European currencies such as CHF; Flight to USD and JPY*
Eurozone periphery sees short-term contagion to sovereign bonds	*Peripheral CDS spreads widen and bond yields push higher*
European financials see a spike in financing spreads	*Equities, particularly bank stocks, are punished*
Peripheral contagion fears lead to flight to quality trading	*US Treasuries and core European bonds see inflows; emergence of negative short rates*

Choosing the Desired Risk Climate and Horizon

Since correlations and volatilities may vary between normal times and stressed times, we utilize historical periods to represent the environment following a Greek default. The time path of a scenario is also an important consideration. For example, if volatility is mean-reverting, a longer half life may be used for a shock that is expected to occur through a longer horizon.

In *Figure 3* below, we utilize data from the Russia (1998), Argentina (2002), and Mexico (1994) default loss profiles. History tells us that across these crises 60-70% of the maximum loss is realized over the first 10 days of the initial shock and 90% of the total loss is realized within 60 days. Volatility in the respective currency market of each defaulting country remained elevated for roughly 90 days past the initial event.

Figure 3: Historical Precedents used to select historical loss patterns

Country	Crisis Date	10-day	60-day	90-day
Mexico	20-Dec-94	3-Jan-95	14-Mar-95	25-Apr-95
Russia	17-Aug-98	31-Aug-98	9-Nov-98	21-Dec-98
Argentina	3-Jan-02	17-Jan-02	28-Mar-02	9-May-02

We will use historical 10-day/60-day/90-day respective asset returns in *Figure 3* for each country as a proxy to predict what may happen in the case of Greek default. Results are shown by asset class in *Figure 4* below. The 10-day timeframe is the most relevant for this analysis given the severity of losses seen over that period, and this will be the horizon we focus on for our stress test implementation. Note that there is no change to portfolio composition during the shock.

Figure 4: Historical Asset Returns Post Sovereign Default

	Country	Crisis Date	10-day	60-day	90-day
Equity	Mexico	20-Dec-94	-33%	-60%	-60%
	US	20-Dec-94	2%	9%	11%
	Russia	17-Aug-98	-43%	-40%	-40%
	US	17-Aug-98	-14%	-1%	6%
	Argentina	3-Jan-02	-42%	-53%	-62%
	US	3-Jan-02	-2%	-1%	-8%
Currency	USD/MXN	20-Dec-94	-30.0%	-46.0%	-42.0%
	USD/JPY	20-Dec-94	0.4%	-9.1%	-18.6%
	USD/CHF	20-Dec-94	-1.3%	-11.5%	-15.2%
	USD/RUB	17-Aug-98	-34.0%	-59.0%	-69.0%
	USD/JPY	17-Aug-98	-3.2%	-16.8%	-20.4%
	USD/CHF	17-Aug-98	-3.8%	-7.6%	-9.5%
	USD/ARS	3-Jan-02	-49.0%	-67.0%	-69.0%
	USD/JPY	3-Jan-02	0.3%	0.6%	-2.4%
	USD/CHF	3-Jan-02	1.2%	2.1%	-2.8%
Interest Rates	MXN 1Y	20-Dec-94	2.4%	-9.5%	-12.3%
	MXN 5Y	20-Dec-94	1.5%	-10.6%	-12.5%
	MXN 10Y	20-Dec-94	0.9%	-9.2%	-10.2%
	MXN 30Y	20-Dec-94	1.0%	-6.4%	-6.6%
	RUB 1Y	17-Aug-98	-5.5%	-13.4%	-13.5%
	RUB 5Y	17-Aug-98	-7.8%	-14.6%	-16.5%
	RUB 10Y	17-Aug-98	-6.5%	-9.6%	-14.1%
	RUB 30Y	17-Aug-98	-4.7%	-5.0%	-8.8%
	ARS 1Y	3-Jan-02	-6.6%	20.5%	4.1%
	ARS 5Y	3-Jan-02	-4.5%	9.6%	1.1%
	ARS 10Y	3-Jan-02	-3.5%	5.0%	0.7%
	ARS 30Y	3-Jan-02	-2.3%	5.0%	0.7%

Stress Test Definition

Choosing Market Variables

Through the discussion in the preceding pages, we have arrived at a candidate stress test to capture the Eurozone Crisis. For Greek bonds, we will utilize RiskManager's jump-to-default (JTD) functionality. Jump-to-default risk is the risk that a credit defaults suddenly before the market is able to factor in its increased default risk into current spreads. It is important to note that this allows us to assume a possible impaired recovery rate for debt.

In *Figure* 5 below, we assume a 30% recovery rate that is less severe than the Russian recovery rate of 18% and more in line with the Argentine recovery rate of 33%. At the time of this writing, haircuts of 70% have been discussed by European leaders as a possibility, making our 30% assumption appear less stressed and a more consensus view. Investors may reference the implementation notes that follow to learn how to further stress Greek bonds, creating a more impaired recovery.

Figure 5: Predictive Stress Test Shocks

Greek Bonds	**Jump-to-Default stress and recovery rate = 30%**
German Government Yield 2Y node	**+50bps**
Italian Government Yield 2Y node	**+1,000bps**
Euro	**-20% depreciation versus USD**
Euro STOXX Bank Index	**-20%**
Euro STOXX 50 Index	**-15%**
Greek Athens General Index	**-20%**

One important observation made while choosing market variables was the impact that a stress of Italian and German short yields had on other Eurozone nations. For example, stressing Italian 2-year yields by 1,000bps had a far greater impact on other peripheral countries than core European economies. This higher beta or greater sensitivity across peripheral states is intuitive given wealth and rebalancing effects described in the first section. Alternatively, stressing German 2-year yields by 50bps had more of an impact on Belgium, Finland and the Netherlands compared to other European nations.

Since risky assets will be most affected by a Greek default, we make assumptions about the behavior of equities where we see banking shares as most sensitive to the crisis with possible disruptions in lending. The decline in the Euro reflects initial disruption from the default and continued stress as lending fears work through the market. It is notable to mention that these shocks, ranging between 15-20%, are less severe than their historical emerging market references due to liquidity effects.

Summary

Designing and implementing stress tests is as much an art as it is a science. During this process one makes a set of choices (i.e., which factors to stress, the magnitude of shocks, the correlation structure and so on) that have an impact on the results of the stress tests. RiskManager allows users to investigate the impact of these choices and to change the definitions where necessary.

Please feel free to contact your Client Consultant to gain a deeper understanding of our stress testing capabilities.

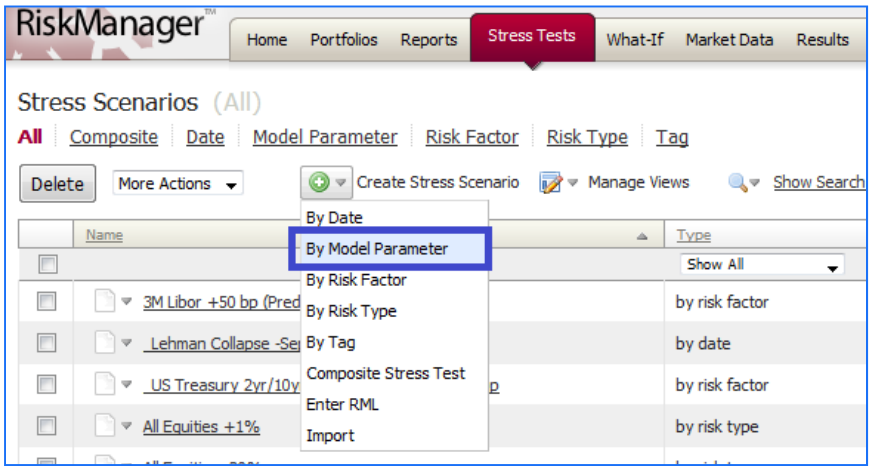
Appendix: Implementation in RiskManager

In the following paragraphs, we walk through key aspects of implementing the Euro Stress Test Scenario in RiskManager. Please note that while the examples and screen shots are from the RiskManager 4 application, they can just as easily be replicated in RiskManager 3.

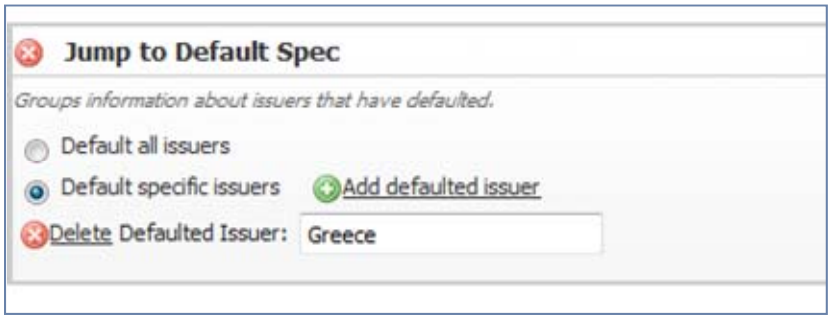
Jump to Default (JTD) Stress Test

The screenshots below show how one can implement a JTD stress test in RiskManager 4.

Step 1: Jump to Default Stress resides under the category of "By Model Parameter" stresses.



Step 2: Choose the "Jump to Default Spec" as shown in the screenshots below. The definition ensures that all Greece issued bonds are defaulted. Separately, we have changed the recovery rate of all the Greek issued bonds in the portfolio to 30% (down from the default 40%) **. Further information on this functionality is available in our technical documentation.

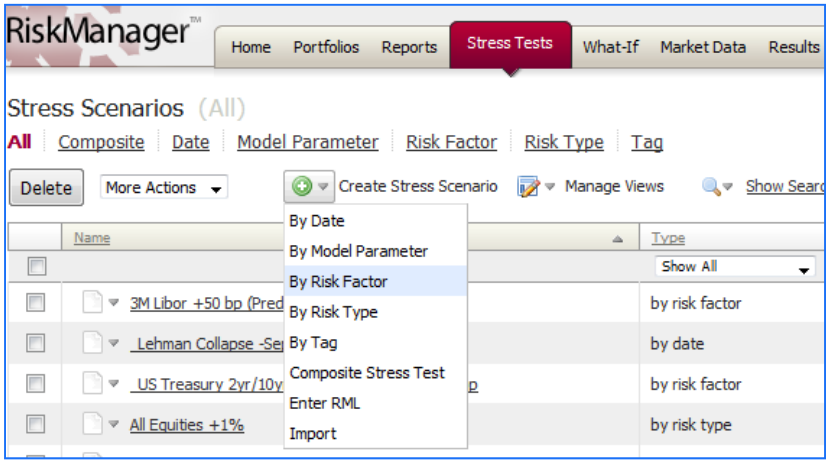


** Please note that users have the flexibility of modeling individual bond positions using their own recovery rate values. For the purpose of this exposition it is assumed that users are using our default recovery rate of 40%

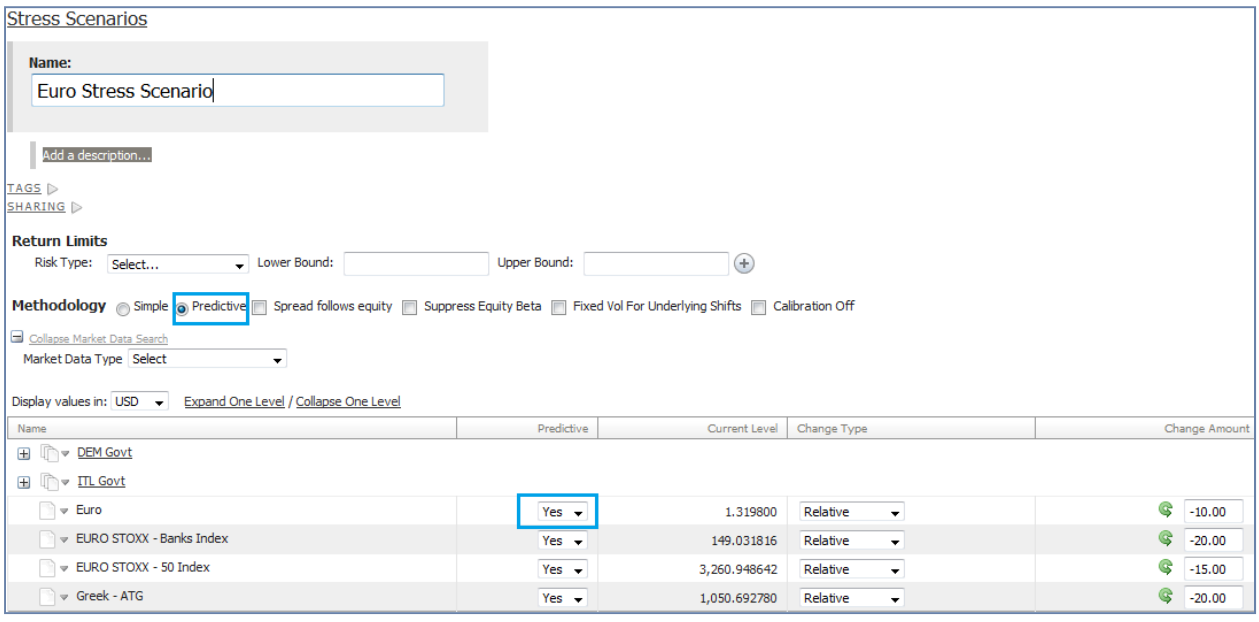
Predictive Stress Test

We now move on to creating the main part of the stress test as defined above. This is done using RiskManager's predictive stress test framework which is widely used by our client base.

Step 1: Choose the "By Risk Factor" category of stress test.



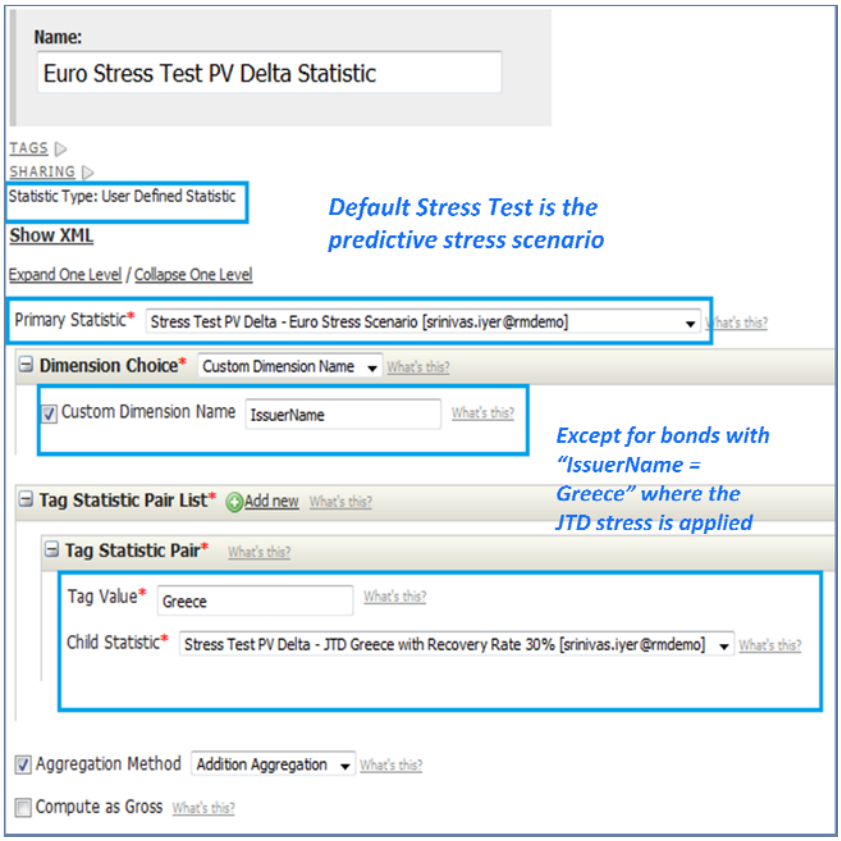
Step 2: Fill in the risk factors that have been identified in *Figure 5: Predictive Stress Test Shocks* as shown in the screenshot below. One point to highlight is that this definition can be expanded to include security specific stresses without impacting the regression-based predictive stress test framework. For example, if users hold specific Greek bank stocks, but do not want them to play a role in the regression, users can select the risk factor, and change the drop down menu under "Predictive" to be "No". This will ensure that the selected risk factor does not participate in the regression.



User Defined Statistic: Bringing it All Together

Recall that the stress scenario has two components above that need to be applied separately to different subsets of a portfolio. The Euro Stress Scenario (Predictive) is applied to all positions in the portfolio except to those bonds that have Greece as the Issuer name (JTD stress scenario).

To facilitate such types of use cases, RiskMetrics introduced the "User Defined Statistic" in 2011. The screenshot below displays how this can be implemented (using Stress Test PV Delta as the primary statistic). Please note that the tag "IssuerName" is automatically enriched for clients that use our Terms and Conditions enrichment. Clients that fully model their securities, can add their own custom tag/value for Greek Bonds and use them in the definition below. For more details please refer to the RiskManager Help Site or contact your assigned client consultant.



Stress Test Results

Three mock portfolios were created consisting of equity and fixed income index constituents. The results from the stress tests are shown below. They were run with an analysis date of 12/30/2011 using a 1-year look back with no decay with a reporting currency of US Dollars.

Portfolio 1 (P1): A set of sovereign bonds from the Eurozone countries

Portfolio 2 (P2): MSCI Europe Index

Portfolio 3 (P3): MSCI USA Index

Portfolio 1: Sovereign Bonds from Eurozone

This stress test results in a 17% loss of market value for the entire portfolio. Overall the Greek bonds lose about 20% of their market value. Looking closer at the Greek bonds one sees that the longer maturity Greek bonds end up *making* money.

Name	Market Value Weight (%)	Notional (Reporting Currency)	Euro Stress Test PV Delta (% of Market Value)
Total	**100.00**	**519,345,949**	**-17.05**
Austria, Republic of	12.14	51,926,000	-19.66
Belgium, Kingdom of	8.24	38,944,500	-23.63
Denmark, Kingdom of	13.65	52,011,949	-8.46
France	8.10	38,944,500	-14.50
Germany	12.90	51,926,000	-8.09
Greece	4.06	51,926,000	-20.19
Ireland, Republic of	9.86	51,926,000	-17.28
Italy, Republic of	9.27	51,926,000	-20.39
Portugal, Republic of	9.13	64,907,500	-20.80
Spain, Kingdom of	12.66	64,907,500	-23.95

Name	Market Value Weight (%)	Notional (Reporting Currency)	Euro Stress Test PV Delta (% of Market Value)
Greece	**4.06**	**51,926,000**	**-20.19**
GREECE (HELLENIC REPUBLIC) (GOVERNMENT) 4.3 03/20/2012	1.28	12,981,500	-35.99
GREECE (HELLENIC REPUBLIC) (GOVERNMENT) 4.5 09/20/2037	0.80	12,981,500	0.26
GREECE (HELLENIC REPUBLIC) (GOVERNMENT) 4.6 09/20/2040	0.80	12,981,500	0.19
GREECE (HELLENIC REPUBLIC) (GOVERNMENT) 5.25 05/18/2012	1.18	12,981,500	-30.76

It turns out that the two longer maturity bonds above were priced below 30 cents as of 12/30/2012. This means that applying a default and a recovery rate of 30% actually increases the valuation of these bonds. This example was meant to illustrate a few points:

(a) Stress tests should always be run on a representative portfolio and its impact needs to be examined thoroughly before being adopted.

(b) Stress tests should be adapted so that they capture the major risks associated with a user's portfolio.

After looking at the results above the user may feel the need to revise the recovery rate assumption or add in other risk factors that may not be represented in the stress test.

Portfolio 2: MSCI Europe Index

Overall we noticed that this portfolio lost about 19% of its value. It's useful to recall that the stress test definition had as one of its core risk factors a shift of the EURO STOXX 50 down by 15%. So this result is within reason.

Looking at the loss on this portfolio across a few dimensions, a GICS® sector comparison reveals that Industrials and Financial stocks in the MSCI Europe Index were the hardest hit.

Comparison by GICS Sector

Name	Market Value Weight	Euro Stress Test PV Delta (% of Market Value)
Total	**100**	**-19**
Industrials	11	-23
Financials	18	-22
Consumer Discretionary	8	-21
Utilities	5	-21
Materials	10	-20
Energy	13	-18
Telecommunication Services	7	-18
Information Technology	3	-16
Health Care	12	-13
Consumer Staples	14	-13

If we then compare constituents of the MSCI Europe Index we see that stocks from Italy and Greece were the hardest hit. This is also reasonable to expect.

Comparison by Country

Name	Market Value Weight	Euro Stress Test PV Delta (% of Market Value)
Total	**100**	**-19**
IT	4	-28
GR	0	-25
SE	5	-24
FI	1	-24
ES	5	-24
NO	1	-24
AT	0	-23
FR	14	-23
DE	12	-22
NL	4	-22
IE	0	-21
PT	0	-20
BE	1	-19
CH	13	-16
DK	2	-14
GB	36	-13

Portfolio 3: MSCI USA Index

The results of the stress test on the constituents of the MSCI USA Index were quite muted with an overall loss of 3% across its constituents. Recall here that we haven't specified any shock to a US equity market risk factor in the stress test. This means that the results below are a direct result of the correlation structure observed during the year 2011. Clients who aren't convinced with the muted impact of the stress test on the US equity index should explore adding a US equity index shock in their predictive stress test.

Name	Market Value Weight	Euro Stress Test PV Delta (% of Market Value)
Total	**100**	**-3**
Materials	4	-7
Energy	12	-5
Consumer Discretionary	12	-4
Utilities	4	-4
Industrials	10	-4
Telecommunication Services	3	-4
Financials	13	-3
Health Care	11	-3
Consumer Staples	12	-2
Information Technology	19	-2

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