Stress test methodologies

RM Office
Version 7.0
## Index

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreword</td>
<td>3</td>
</tr>
<tr>
<td>1. Methodology</td>
<td>3</td>
</tr>
<tr>
<td>2. Purpose</td>
<td>4</td>
</tr>
<tr>
<td>3. Equity and Equity Derivatives Sections Scenarios</td>
<td>6</td>
</tr>
<tr>
<td>a) Downside Scenario</td>
<td>6</td>
</tr>
<tr>
<td>i) Equity Section</td>
<td>6</td>
</tr>
<tr>
<td>ii) Equity Derivatives Section</td>
<td>6</td>
</tr>
<tr>
<td>b) Upside Scenario</td>
<td>8</td>
</tr>
<tr>
<td>i) Equity Section</td>
<td>8</td>
</tr>
<tr>
<td>ii) Equity Derivatives Section</td>
<td>8</td>
</tr>
<tr>
<td>4. Energy Derivatives Section Scenarios</td>
<td>9</td>
</tr>
<tr>
<td>a) Downside Scenario</td>
<td>9</td>
</tr>
<tr>
<td>b) Upside Scenario</td>
<td>9</td>
</tr>
<tr>
<td>5. Bond Section Scenarios</td>
<td>12</td>
</tr>
<tr>
<td>a) Yield Increase Scenario</td>
<td>12</td>
</tr>
<tr>
<td>b) Yield Decrease Scenario</td>
<td>13</td>
</tr>
</tbody>
</table>
Foreword

In order to preserve market integrity in case of insolvencies even under the most extreme conditions, CC&G – following international best practices and in line with the provisions of the “Risk Management Standards” agreed upon within the EACH framework in 2001, and subsequently included in the CPSS-IOSCO “Recommendations for Central Counterparties” issued in November 2004 – gauges the appropriateness of its Default Funds through stress test simulations.

The amount of the Default Funds is indeed established in such a way that CC&G is able to ensure the stability of the guarantee system also in case of simultaneous members’ defaults under stress conditions. Accordingly every Default Fund is gauged on the Non-Collateralised Exposure – as defined in the following paragraphs – of the most exposed Participants (customarily, three).

The stress tests are executed, at least on a monthly basis, separately for the Equity/Derivatives Sections, for the Energy Derivatives Section, for the Agricultural Commodities Derivatives Section and for the Bonds Section.

This document describes the methodology used by CC&G to execute its stress tests (point 1), exposing the purposes (point 2) and how the stress test Scenarios are defined for the different Sections (points 3 e 4).

1. Methodology

The stress tests executed by CC&G are intended to «gauging» the vulnerability – under extreme market circumstances – of its guarantee system in case of risk factors variations of exceptional magnitude – larger than those covered by the initial margining system – but nevertheless reasonably possible.

The stress test methodology adopted by CC&G allows to evaluate the consequences of the hypothesised event, but does not provide any indication regarding the «probability» that the event itself may actually happen. Unlike the initial margins system – which bases itself on the definition and on the application of «confidence intervals» – stress testing, being based on extreme circumstances, only allows for a limited use of common statistical tools. It is as a matter of fact mainly based on common sense

1 “The clearing house should maintain adequate, liquid resources to enable it to handle a default in which the initial margin requirement of the defaulter is insufficient to cover losses - so that it can ensure its ability to handle a default and protect the integrity of the market or markets that it clears.”

2 Cfr. Recommendation # 5: “A CCP should maintain sufficient financial resources to withstand, at a minimum, a default by the participant to which it has the largest exposure in extreme but plausible market conditions.”
hypotheses and experience with the aim of providing a risk measure for stress Scenarios from time to time defined.

In order to limit the use of subjective hypotheses, it has been deemed appropriate to adopt, in performing stress tests, an Historical Scenario3, which is, where necessary, duly integrated with an Hypothetical Scenario4. The adopted Scenarios are fully reexamined and revised – in line with the CPSS-IOSCO5 recommendations – at least once a year.

2. Purpose

The Purpose of the stress test is to determine – in the Stress Scenario from time to time applied – the «Non Collateralised Exposure» (NCE) for each Direct Participant, that is the amount that the Participant would be required to deposit with CC&G as a consequence of the new (initial and variation) margin call after the hypothesized price variations. The NCE is, as a matter of fact, the algebraic sum of the amounts needed to:

- mark-to-the-market open positions at the post stress hypothesized values; such amount therefore represents6 the losses CC&G would suffer in case of instantaneous liquidation of the insolvent’s positions;

- re-establish guarantees for the same open positions; such amount represents a new initial margin and it hence provides an indication of the further losses CC&G would suffer in case of adverse market movements during the liquidation of the insolvent’s positions.

In order to determine a single NCE amount for each Direct Participant, the calculation is implemented considering the rule that allows, in case of insolvency, to use possible house account excesses to cover losses in the client account, and at the same time

---

3 The Historical Scenario evaluates the consequences of an event, equal to the largest shock registered in a sufficiently long time span on the financial markets considered. In this respect CC&G includes in its equities stress test, price variations occurred in September 2001. This approach has the advantage of being extremely intuitive and of being based on transparent hypotheses; on the other hand it assumes that future risks are equal to those occurred in the past. Furthermore in some cases it is impossible to define a Historical Scenario as in the cases of those securities, which do not have a sufficiently long time history or in those cases where the features of market and/or of the financial instruments have changed in time to the point of making meaningless the original assumptions.

4 The Hypothetical Scenario evaluates the consequences of a number of hypotheses, which are considered realistic under extreme circumstances although lacking of historical precedents in recent times. On one hand this approach is not dependent on the availability of historical data, on the other hand the results are strongly dependent from the evaluations – in some measure necessarily subjective – of the entity conducting the stress test.

5 Recommendation # 5. … In addition, comprehensive stress tests involving a full validation of model parameters and assumptions and reconsideration of appropriate stress scenarios should be conducted at lead annually.

6 Variation Margins (for Futures) or Mark-to-Market Margins (for Cash Instruments and Options).
prohibiting the use of possible client account excesses to cover losses in the house account.

Being impossible to make reasonable assumptions both on the cash/security ratio of the guarantees deposited by the participants with CC&G and on the amount (if any) of excess guarantees, it is assumed that each Participant has deposited, at the start of the simulation, guarantees which are exactly equal to those required by CC&G as initial margins.
3. **Equity and Equity Derivatives Sections Scenarios**

For the Equity and Derivatives Sections, two stress test Scenarios are hypothesised: a Downside Price Variation Scenario and an Upside Price Variation Scenario. Such Scenarios are currently built as per the following description:

**a) Downside Scenario**

**i) Equity Section**

It is assumed that each security\(^7\) has a downside price variation equal to the worst of the following events:

a) the largest (both upside and downside) daily price variation actually occurred in a time horizon long enough to include September 11\(^{th}\), or

b) 1.20 times the size of the «Applicable Margin Interval\(^8\)», or

c) 4 times\(^9\) the standard deviation.

The hypotheses b) and c) enable us to determine a hypothetical (i.e. not historically observed) price shock also for those securities which, having been only recently listed, have not yet shown an actual significant price variation.

It is worth mentioning that the use of a multiple of the Margin Interval – besides using a multiple of the standard deviation – allows to account for the different behaviour of securities – although having similar standard deviation values – towards extreme price variations (statistically expressed by the kurtosis); this is taken into account in determining the Margin Interval.

**ii) Equity Derivatives Section**

Regarding derivatives, the following approach is followed:

---

\(^7\) Shares, convertible bonds, warrants, Closed-End Funds and ETFs.

\(^8\) The «Applicable Margin Interval» is defined as follows:

- for derivatives underlying securities: equal to the largest between the Margin Interval used for the Derivatives Section and the Margin Interval used for the Equity Section;
- for securities of the Equity Section, whose Margin Interval has been increased as a consequence of a trading suspension: the «Mathematical» Margin Interval, i.e. the value that provides a confidence interval of 97.50% for time spans longer that one year, and of 99% for shorter time spans;
- remaining securities: the Margin Interval used for the Equity Section.

\(^9\) Such value indicates that, if price variation were normally distributed, the event being considered has a probability of occurrence no larger than 0.01%.
a) Equity Futures prices and FTMIB Index Futures\textsuperscript{10} prices are assumed having a one-to-one price variation with their underlying;

b) FTMIB Index Dividend Futures prices are assumed having a price variation determined as above described for Equity Section;

c) Equity Options prices and FTMIB Index Options are recalculated using the stressed price of their underlying and attributing to each option an implied volatility equal to twice the implied volatility of the option, having the corresponding moneyness (the so-called «sticky delta» approach)\textsuperscript{11}.

Figure 1 provides an example of the construction of the implied volatility curve for an options expiry.

\textsuperscript{10} The FTMIB index value is calculated on the basis of the new post stress values of its components.

\textsuperscript{11} Example: It is assumed that XXX share drops −10\% (from € 20.00 to € 18.00). The option Strike 20.00 (At-The-Money) has in reality an implied volatility of 16\%; in the stress test the option Strike 18.00 (which in the stress test is At-The-Money) has an implied volatility of 32\%. 
b) **Upside Scenario**

i) **Equity Section**

It is assumed that each security has an upside price variation equal to the worst of the following events:

a) the largest (both upside and downside) daily price variation actually occurred in a time horizon long enough to include September 11\(^{th}\), or

b) 1.20 times the size of the «Applicable Margin Interval», or

c) 4 times the standard deviation.

The following table provides a summary of the hypotheses in the two Scenarios.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Downside</th>
<th>Upside</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>largest daily price variation (upside or downside) in a time horizon long enough to include September 11(^{th})</td>
<td>largest daily price variation (upside or downside) in a time horizon long enough to include September 11(^{th})</td>
</tr>
<tr>
<td>b)</td>
<td>1.20 the value of the «Applicable Margin Interval»</td>
<td>1.20 the value of the «Applicable Margin Interval»</td>
</tr>
<tr>
<td>c)</td>
<td>4 times the standard deviation</td>
<td></td>
</tr>
</tbody>
</table>

ii) **Equity Derivatives Section**

For the Derivatives Section the same approach as for the Downside Scenario is applied.
4. **Energy Derivatives Section Scenarios**

For the Energy Derivatives Section, two stress test Scenarios are hypothesised: a Downside Price Variation Scenario and an Upside Price Variation Scenario. Such Scenarios are currently built as per the following description:

**a) Downside Scenario**

It is assumed that each energy futures – with the exception of the delivery positions – has a downside price variation equal to the worst of the following events:

a) the smaller between the largest upside and the largest downside daily price variation, actually occurred in the whole time horizon available, or

b) the size of the «Applicable Margin Interval», or

c) 4 times\(^{12}\) the standard deviation.

**b) Upside Scenario**

It is assumed that each security – with the exception of the delivery positions – has an upside price variation equal to the worst of the following events:

a) the largest (both upside and downside) daily price variation actually occurred in the whole time horizon available, or

b) 1.20 times the size of the «Applicable Margin Interval», or

c) 4 times the standard deviation.

Regarding the delivery position, it is assumed – in both scenarios – that the cash settlement is due to a difference between the last future price and the average monthly PUN\(^{13}\) of the delivery month equal to 73%. That percentage is determined assuming that the average daily PUN – generally about € 60 – has a shock price to 500\(^{14}\) for three days.

\(^{12}\) Such value indicates that, if price variation were normally distributed, the event being considered has a probability of occurrence no larger than 0.01%.

\(^{13}\) Single National Price (PUN – Prezzo Unico Nazionale).

\(^{14}\) Hypothesis of highest price reached in an unexpected situation of crisis (eg power plant closure).
The following tables provide a summary of the hypotheses in the two Scenarios for the ordinary positions and for the delivery ones.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Downside</th>
<th>Upside</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>The smaller between the largest upside and the largest downside daily price variation in the whole time horizon available</td>
<td>largest daily price variation (upside or downside) in the whole time horizon available</td>
</tr>
<tr>
<td>b)</td>
<td>the size of the Margin Interval</td>
<td>1.20 the size of the Margin Interval</td>
</tr>
<tr>
<td>c)</td>
<td>4 times the standard deviation</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Downside</th>
<th>Upside</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>73%</td>
<td></td>
</tr>
</tbody>
</table>
5. **Agricultural Commodities Derivatives Section Scenarios**

For the Agricultural Commodities Derivatives Section simplified stress test scenarios are hypothesized, until enough statistically significant data will be available.

In particular two stress test Scenarios are hypothesized: a Downside Price Variation Scenario and an Upside Price Variation Scenario. Such Scenarios are currently built as per the following description:

**c) Downside Scenario**

It is assumed that each ordinary and delivery position has a downside price variation equal to:

a) 1.20 times the size of the «Margin Interval in Force»

**d) Upside Scenario**

It is assumed that each ordinary and delivery position has an upside price variation equal to:

b) 1.20 times the size of the «Margin Interval in Force»

The following tables provide a summary of the hypotheses in the two Scenarios for the ordinary positions and for the delivery ones.

<table>
<thead>
<tr>
<th>Ordinary and Delivery Positions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypotesis</td>
</tr>
<tr>
<td>-----------</td>
</tr>
<tr>
<td>a)</td>
</tr>
</tbody>
</table>
6. **Bond Section Scenarios**

For the Bond Section, two stress test Scenarios are hypothesized: a Yield Increase Scenario and a Yield Decrease Scenario. Such Scenarios, determined on the basis of the Eurozone and Italian yields curves, are currently built as per the following description:

**a) Yield Increase Scenario**

a) For each of the 45 vertices used in the construction of the Eurozone yield curve (from TN to 30Yrs), the largest yield variation is determined, defined as the highest value between the most extreme upside, downside, one-day, two-days, three-days, four-days and five-days yield variations registered since January 2\(^{\text{nd}}\), 1999 (introduction of the Euro);

b) For each of the 15 vertices used in the construction of the Italian yield curve (from 3M to 30 Yrs), the largest yield variation is determined, defined as the highest value between the most extreme upside, downside, one-day, two-days, three-days, four-days and five-days yield variations registered since January 2\(^{\text{nd}}\), 1999 (introduction of the Euro). In order to obtain a grid of vertices consistent with the Eurozone yield curve, the largest yield variations for the missing vertices of the Italian zero coupon bonds curve are determined by linear interpolation of the previous and next available vertices;

c) For each of the 41 vertices from 3 M to 30YRS the maximum value between the largest yield variation of the Eurozone zero coupon bonds curve and the largest yield variation of the Italian zero coupon bonds curve is determined;

d) For each government bond a yield variation, equal to the value resulting of the linear interpolation of the largest variation for the previous and next vertices to the duration of the bond (if the duration is not equal to any node), is determined;

e) For each government bond the new yield in the upside scenario is equal to the current yield plus the respective largest yield variation, determined as described above (d);

f) The bond prices are recalculated on the basis of the above-mentioned upside yield curve scenario;

g) For each bond belonging to classes of duration less than 3 months (available just for Eurozone yield curve), is determined the lower price
resulting from the yield increase scenario and the yield obtained by considering a downward price change equal to 1.2 times the margin interval (related to the class duration of the bond);

h) For Inflation Indexed Bonds, a downside price variation equal to 1.20 the Margin Interval is hypothesized;

i) For Corporate Bonds, a downside price variation equal to 1.20 the Margin Interval is hypothesized.

Figure 2 provides an example of a yield curve obtained according to the described procedure.

**Figure 2**

\[\text{Diagram of yield curve with two lines representing REAL YIELD and UPSIDE STRESS YIELD.}\]

**b) Yield Decrease Scenario**

a) For each of the 45 vertices used in the construction of the Eurozone yield curve (from TN to 30Yrs), the largest yield variation is determined, taken equal to the largest between the most extreme upside, downside, one-day, two-days, three-days, four-days and five-days yield variations registered since January 2\(^{nd}\), 1999 (introduction of the Euro);

b) For each of the 15 vertices used in the construction of the Italian yield curve (from 3M to 30 Yrs), the largest yield variation is determined, defined as the highest value between the most extreme upside, downside,
one-day, two-days, three-days, four-days and five-days yield variations registered since January 2\textsuperscript{nd}, 1999 (introduction of the Euro). In order to obtain a grid of vertices consistent with the Eurozone yield curve, the largest yield variations for the missing vertices of the Italian zero coupon bonds curve are determined by linear interpolation of the previous and next available vertices;

c) For each of the 41 vertices from 3 M to 30YRS the maximum between the largest yield variation of the Eurozone zero coupon bonds curve and the largest yield variation of the Italian zero coupon bonds curve is determined;

d) For each government bond a yield variation, equal to the value resulting of the linear interpolation of the largest variation for the previous and next vertices to the duration of the bond (if the duration is not equal to any node), is determined;

e) For each government bond the new yield in the downside scenario is equal to the current yield minus the respective largest yield variation, determined as described above (d)

f) The bond prices are recalculated on the basis of the above-mentioned downside yield curve scenario;

g) For each bond belonging to classes of duration less than 3 months (available just for Eurozone yield curve), is determined the higher price resulting from the yield decrease scenario and the yield obtained by considering an upward price change equal to 1.2 times the margin interval (related to the class duration of the bond);

h) For Inflation Indexed Bonds, an upside price variation equal to 1.20 the Margin Interval is hypothesized;

i) For Corporate Bonds, an upside price variation equal to 1.20 the Margin Interval is hypothesized.

Figure 3 provides an example of a yield curve obtained according to the described procedure.
The following breakdown provides a summary of the hypotheses in the two Scenarios.

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Yield Increase</th>
<th>Yield Decrease</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Curve</td>
<td>Largest between the largest upside and downside, one-day, two-days, three-days,</td>
<td>Largest between the largest upside and downside, one-day, two-days, three-days,</td>
</tr>
<tr>
<td></td>
<td>four-days and five-days yield variations.</td>
<td>four-days and five-days yield variations.</td>
</tr>
<tr>
<td></td>
<td>Yield Variations resulting of the linear interpolation of the largest variation</td>
<td>Yield Variations resulting of the linear interpolation of the largest variation</td>
</tr>
<tr>
<td></td>
<td>for the previous and next vertices to the duration of the bond.</td>
<td>for the previous and next vertices to the duration of the bond.</td>
</tr>
<tr>
<td>Inflation Indexed Bonds</td>
<td>1.20 the size of the Margin Interval</td>
<td>1.20 the size of the Margin Interval</td>
</tr>
<tr>
<td>Corporate Bonds</td>
<td>1.20 the size of the Margin Interval</td>
<td>1.20 the size of the Margin Interval</td>
</tr>
</tbody>
</table>