Solvency II and backtesting internal models

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SOLVENCY II: A LONG AND AMBITIOUS ROAD

Solvency II will come into force on January 1, 2016 after multiple delays in its application date, which stresses the ambition of the new regulatory framework. Directive 2009/138/EC set October 31, 2012 as the date for transposition and November 1, 2012 as the date of application of Solvency II; therefore, that date would have been the date of repeal of the existing insurance and reinsurance Directives (Solvency I). Successive delays in the application of Solvency II were mainly due to the debate generated around the Omnibus II Directive and products with long-term guarantees. The Omnibus II Directive, which modified certain aspects of the Solvency II Directive, involved the creation of a European Supervisory Authority (EIOPA or European Insurance and Occupational

Pensions Authority). Differences in the sector concerning how certain risks are treated, especially products with long-term guarantees, were approached by EIOPA in the so-called LTGA study. Finally, Directive 2013/58/EU of December 11, 2013 definitively set the date of application of the Solvency II Directive as January 1, 2016.

The new Solvency II regulatory framework consists of different levels of rules:

Level 1	**Directive 2009/138**
Level 2	**Implementation or enforcement measures**
Level 2.5	**Technical standards**
Level 3	**EIOPA guidelines**
Level 4	**Rigorous enforcement of Community legislation**

Table – Different levels of rules in Solvency II

- The Solvency II Directive establishes the general principles of the new framework, which is known as Level 1 rule or the highest level regulatory tier.
- Level 2 consists of the implementation or enforcement measures adopted by the Commission, based on the proposals submitted by EIOPA that supplement or amend certain non-essential elements of the Directive. The Solvency II Directive stated that the European Commission had power to adopt implementing measures of specified topics. The Omnibus II Directive changed the legal form, since Level 2 would have to follow the regulatory structure required by the EU Lisbon Treaty. Thus legally, the so-called Level 2 takes the form of a delegated regulation (Level 2 itself), and Regulatory Technical Standards or RTS and Implementing Technical Standards or ITS (Level 2.5). In this regard the Commission Delegated Regulation (EU) 2015/35 of October 10, 2014, completes the Solvency II Directive. The so-called Level 2.5 consists of Technical Standards (TS) prepared and proposed by EIOPA, which in legal terms will be European Commission legislation on the basis of advice received, where the so-called RTS and ITS are established. These standards are purely technical and do not imply strategic decisions or policy. In the case of internal models in late 2014, and as part of the so-called first ITS set, EIOPA published the so-called *"Draft ITS on the approval of an internal model"*.

In March 2015 the European Commission adopted the first set of Solvency II implementing regulations, and the Commission Implementing Regulation (EU) 2015/460 of March 19, 2015 establishes the implementing technical standards concerning the procedure on the approval of an internal model.

- In Level 3, the guidelines are included that are drawn up and approved by EIOPA for national supervisors and companies. They are not legally binding but in case of noncompliance, the reasoned logic will have to be explained. In this regard, the "Guidelines on Pre-Application of Internal Models" prepared by EIOPA in late 2013 for the so-called preparatory phase of Solvency II and the "Guideline on the use of internal models" published in February 2015 stand out. These guidelines aim to promote a gradual adaptation to the new framework.
- Finally, the fourth and final level concerns the rigorous enforcement of Community legislation, which will be monitored by the Commission.

INTERNAL MODELS: VALIDATION THEREOF

In Solvency II capital requirements may be calculated through a standard formula or, alternatively, by full or partial internal models approved by the regulatory authority. To provide a level of protection equivalent to the amount obtained in both cases, it should be determined as the financial capital insurance companies have to limit the probability of ruin to 0.5 percent over a one-year period (1 ruin every 200 years). In financial terms, this would be an amount equivalent to the value at risk (VaR) with a confidence level of 99.5 percent.

Different levels of rules establish the requirements that internal models must comply with to calculate capital requirements. We want to focus on the aspects relating to the validation of the models, ignoring other important aspects such as: the use test or integration in the activity and decision making of the company, documentation, etc.

Article 124 of the Solvency II Directive, *Validation Standards,* sets out that companies "shall have a regular cycle of model validation which includes monitoring the performance of the internal model, reviewing the on-going appropriateness of its specification, and testing its results against experience." This validation process "shall include an effective statistical process for validating the internal model which enables … to demonstrate to their supervisory authorities that the resulting capital requirements are appropriate." This statistical process is what is known in financial/actuarial literature as *backtesting* [1]. However, the different rules of Solvency II have not decided to establish a specific and detailed procedure for carrying this out, because, as stated by the Delegated Regulation (EU) 2015/35, "as internal models should be adapted to the specific business of the insurance and reinsurance undertaking, internal models may vary significantly with respect to their validation processes, among other things. Validation standards should therefore remain principle-based and include only specific minimum requirements." That is, the rules should leave companies a certain amount of leeway in establishing the process, although strong conditions are imposed on this process: independence, documentation, etc. Thus, for example Article 2.m of Commission Implementing Regulation (EU) 2015/460 states that, among the documentary evidence to be submitted with the application to use an internal model, the company must submit a "description of the independent validation process[2] of the internal model and a report of the results of the last validation."

While *backtesting* is one of the main tools for the validation of an internal model, it is not the only one but should be complementary to other techniques such as stress testing and reverse stress testing , scenario analysis, etc. Furthermore, the rules state that *backtesting* of internal models should be performed at least once a year. Thus, Article 242 of Delegated Regulation (EU) 2015/35 in which so-called *Validation tools* are set out states that companies "shall test the results and the key assumptions of the internal model at least annually against experience." Guideline 40 on the use of internal models, *Application of validation tools,* states that companies should consider "using quantitative or qualitative validation tools besides those referred to in Article 242 of the Implementing Measures" so that they should "choose the appropriate set of validation tools in order to ensure an effective validation process".

A key element when validating a model is described in the below section; this is *backtesting.* When a company uses an internal model that should be evaluated using *backtesting,* which under Solvency II can be defined as a tool for the validation process in quantitative terms of an internal model to analyze if it is appropriate, and compares the resulting risk estimates with past experience. This technique should be complementary to others, in order to verify the correct alignment of the internal model to determine capital charges under the new framework.

BACKTESTING AN INTERNAL MODEL

Backtesting is a statistical procedure used to validate a model by comparing actual results (empirical distribution of gains and losses) and the risk measures generated by the models. Internal models calculate capital charges for the various risks like the standard model by using the VaR *t* approach. Formally, VaR is the loss level such that there is a probability that losses are equal to or greater than:

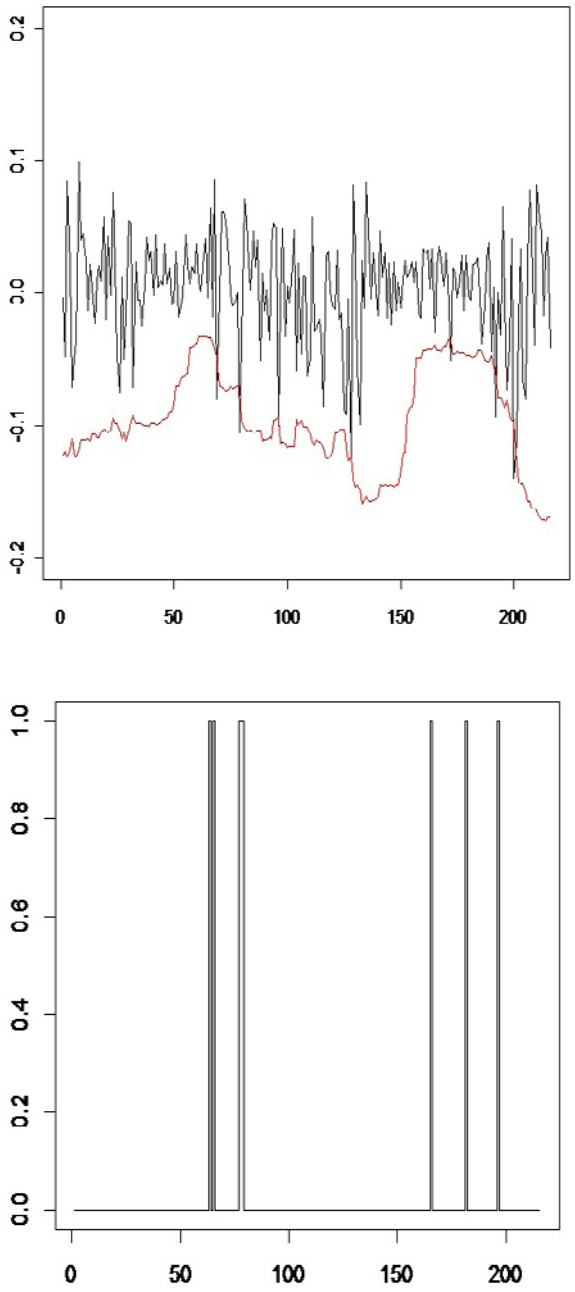
$$VaR_p(Y) = Prob(Y \geq Y^*) = p$$

Backtesting consists of analyzing the failures that the model has in relation to the level of failures that it should have. Therefore, a basic element of backtesting is the number of times the actual losses exceed the VaR in a given period. In this regard, to carry out backtesting, a sequence must be built that takes the value of "1" if the loss exceeds the VaR and "0" otherwise[3]:

$$I_{t+1}(\alpha) = \begin{cases} 1 & si\ x_{t+1} > VaR_t \\ 0 & si\ x_{t+1} \leq VaR_t \end{cases}$$

Where is the estimated loss for the time by using the information available in , is the loss observed in and is the indicator of the event of an exception, exceeded, failure or failed in . In this manner the result of applying the function of failures to a particular series will be a vector formed by a series of "1" and "0" indicating whether the losses obtained have exceeded the VaR. For example in the lower left graph an estimation of the estimated losses of an internal model is shown (red line) as well as the distribution of actual gains and losses (black line) so that when the actual losses exceed those estimated, an exceeded value is calculated, so the value of "1" ("0" otherwise) is obtained in the graph on the right. There are multiple different backtesting tests, and they can be grouped into large families, which can be implemented for model validation and will be discussed in the next section.

Graph.- *VaR estimation and function of failed values*



Source: prepared internally

BACKTESTING TESTING FAMILIES

There is no exclusive test against which to measure the validity of a VaR model, as in backtesting the models various desired properties can be measured. Therefore we can group different proposed tests into the following testing families:

- *Unconditional test coverage*

These tests focus exclusively on checking whether the estimated VaR is exceeded at a rate above the confidence level with which it was estimated (99.5 percent in Solvency II). The probability of a loss exceeding the VaR occurring must then be 0.5 percent. If losses occur at a higher rate, assuming that we have a large enough sample, the calculated VaR underestimates the portfolio risk. Otherwise, i.e. when the number of failures is very small, the model could be overestimating the risk.

- *Independence test*

Unconditional tests only take the number of exceptions into account, but not how they are distributed over time. Failed values should occur independently from each other, but bad models tend to produce sequences of consecutive exceeded values. The analysis of the independence can be done through implementing various tests that focus on checking whether there is any relationship between the failed values.

- *Independence and unconditional coverage test sets*

Test sets examine the properties of independence and unconditional coverage while making it possible to identify models that have shortcomings for failing either of the two properties. While these tests may seem more appropriate, since both properties are evaluated simultaneously, they have the limitation of being least able to detect VaR measurements that only fail to fulfill one of the two properties.

- *Test based on multiple VaR levels*

The above tests only analyze the adequacy of the VaR for a given confidence level. However, an accurate measurement of the VaR should be valid for any confidence level. This type of test assumes that if the calculation of the VaR is adequate, a 99.5 percent VaR should be exceeded in 0.5 percent of cases, a 97.5 percent VaR by 2.5 percent and so on. In addition, the failed values presented within a given level should also be independent of those presented at other confidence levels.

- *Test based on the loss function*

Instead of focusing solely on the number of exceeded values, like the previous tests, we could consider their amount or magnitude. In this respect, if we have two models with the same number of independent failed values, intuition tells us to choose the one in which the magnitude of the exceeded value is lower. As if the losses of a model are too large, this may be the result of the wrong model being used. There are several statistical tests in the specialized literature that consider the magnitude of the excess values when validating a model.

- *Other Tests*

Besides the above tests based on counting the number of exceptions at one or several confidence levels, their dependence or study of their size can be done by complementary analysis, such as analyzing the relationship between the VaR estimated by the model and the distribution of actual gains and losses, studies to identify the causes of exceptions, etc. We will now focus on the analysis of the relationship between returns and the estimated VaR, which is an aspect related to the efficiency of the VaR measurement. An appropriate risk measurement must not only be conservative enough, i.e. providing adequate coverage, but should also be closely related to risk exposure.

In this regard, it would be advisable for large VaR figures to be accompanied by large negative returns, while small VaR calculations must be associated with small negative returns or positive yields. Various tests may be used to verify whether this relationship is strong.

PRACTICAL APPLICATION

In this section we will show a simple application of a major backtesting test used in specialized literature to validate a model, by employing the case of equity risk. To do this, we analyzed the trend of monthly logarithmic returns of the FTSE-100 over an extended period of time (216 observations), by using an approach based on the normal distribution model. The backtesting conducted in this example will be made within the sample or in simple, which will make it possible to calculate the estimation of the risk made by the model at each time point with historical losses.

$$POF = -2ln\left(\frac{(1-p)^{T-x}P^{x}}{\left(1-\left(\frac{x}{T}\right)\right)^{T-x}\left(\frac{x}{T}\right)^{x}}\right) = -2ln\left(\frac{(1-0{,}005)^{216-4}0{,}005^{4}}{\left(1-\left(\frac{4}{216}\right)\right)^{216-4}\left(\frac{4}{216}\right)^{4}}\right) = 4{,}675$$

Under the null hypothesis, if the model is correct, POF it is distributed as a x2 with a degree of leeway, so that if the value of the statistic exceeds the critical value, the null hypothesis is rejected and the model is considered as inadequate. For a significance level of 5 percent the null hypothesis is rejected because the value of the statistic (4,675) exceeds the critical value (3.841), so the standard model is not considered appropriate under this test.

CONCLUSIONS

Internal models may be used by insurance companies to calculate the required capital requirements in Solvency II. To ensure that the models used are appropriate, the rules stipulate the requirement for a process to be put in place to validate them. Backtesting is a quantitative tool to check whether the resulting estimates of the model are in line with past experience. There are other tools that are required to complete the analysis, such as scenario analysis, stress tests, reverse stress tests, etc. Studying different backtesting techniques shows that there is no exclusive test against which to directly measure the validity of a VaR model. Since tests analyze different properties that failed values of a model should comply with, large families have been established addressing these complementary aspects of a series of failed values of a model to ensure that an insurance company uses an appropriate model. Finally we have shown a practical example of how the standard model is unsuitable for calculating the capital charge for the case of equity risk of the analyzed series, by using an unconditional coverage test.

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[1] The name *backtesting* was used by CEIOPS (2009) when discussing various tools to conduct the validation, but has not been subsequently used in the aforementioned rules.

[2] Independent validation refers to the fact that the people or organizational unit that carry out the validation process of the model should be free from the influence of those responsible for developing and the functioning of the internal model.

[3] The notation used means, for example, that a VaR of 25 percent corresponds to a 25 percent market decline.