Paper: Model Risk and Capital Reserves[1]

Introduction

Currently the financial institutions rely more and more on models to evaluate and predict the potential risks either from the market or the operational process, and the reliability of models they used should be considered once the accuracy of the results are doubted. Also, despite the extensive improvement made for the correct implication and quality of the models, the model risk regarding the failures in inadequately performing and measuring the quantitative information analyzed for a financial purpose is required to be kept into mind by professionals, as there is no 100% perfect model existing. In this case, due to the presence of the model risk and its varied significance in different markets, there is a need for the practitioners to get familiar with the products being traded and analyzed that refer to the model and the purpose for how such specific model is being used for. Here, this paper concentrates on the model risk in the computation of capital reserves, where the capital reserves are required to be allocated adequately to positions in the given market, based on the extent to the fact that this market can be modeled reliably.

Methodology

Distinguishment of the risk

According to the literature reviews for how the previous works investigated the model risk associating with the application of econometric methods, it claims that one common and useful effort made is to focus on the parameter variations on risk measures for a particular framework involved in the analytic procedure, and the data generating process with the setting of certain parameters which ensure the model can represent the actual situation and is simplified in a feasible manner also attract lots of researchers' attentions. However, this paper constructs classes of models to incorporate model risk into the risk measurement instead of only focusing on a single model, where the quantification of model risk is allowed on top of nominal market risk with the adjustments of the nominal market risk measure being made that depends on the expected shortfall to evaluate the market risk existing for a portfolio. In addition, the uncertainties in econometric modeling tends to be the target, and the stages of modeling leading to the different model classes and hence to different risk measuring adjustment then appear to be clarified, from the data generating processes to the characteristics contained in the model that three components have been determined to assist the measurement of the total model risk. These three components of model risk are recognized as the estimation risk, the misspecification risk, and the identification risk.

[1] Jeroen Kerkhof, Bertrand Melenberg, Hans Schumacher, 2010. "Model risk and capital reserves", Journal of Banking & Finance, vol. 34(1), pages 267-279, ISSN 0378-4266.

- Estimation risk: it refers to the risk caused by the inaccurate estimation of parameters.
- Misspecification risk: it refers to the risk caused by the incorrect model specification.
- Identification risk: it refers to the risk caused by the different results obtained by the indistinguishable models.

Model risk illustrated for a single model testing the market risk

Based on the tests applied separately to evaluate the three different components of model risk, the paper initially provides a simple example using the simulated data in order to illustrate how the model risk can be obtained with a single model taken into account. This model measures the market risk representatively, for better understanding the position in the market when the author turns to the capital reserves later. Furthermore, both VaR at level p and Expected shortfall are applied for the market position denoted as X_T, with the assumption made for the log return Y_{T+1} that it follows a normal distribution with mean μ and standard deviation σ when calculating the future position X_{T+1} at time T.

$$VAR_T(X_{T+1} - X_T) = X_T(1 - exp(z_p\sigma + \mu)$$

$$ES_T(X_{T+1} - X_T) = X_T(1 - \frac{1}{p}exp(\mu + \frac{1}{2}\sigma^2)\phi(z_p - \sigma))$$

The functions above exclude the measurement of potential model risks, and these risks may come from either the parameters used or the assumptions made. To be specific, when considering the practical situation that the mean and standard deviation are unknown that need to use the estimated values instead, an estimation error may arise. To deal with it, the authors use the confidence intervals for describing the VaR and ES, and the estimation risk is assumed to be evaluated by utilizing the gap between the upper bound of such confidence intervals and the actual nominal market risk. Nevertheless, as the normality assumption has been made for the distribution of log returns, it may state that there will have a misspecification risk towards this idea, where a distribution function G with arbitrary continuity and strictly increasing cumulativeness is involved here with the aim to find the difference caused by the supposed distribution that can represent the misspecification risk.

By implementing the simulation test, the authors find that the model risk may create a huge impact on the accuracy of the result, especially for the misspecification risk. In another word, if the future market risk follows an actual distribution other than the normal distribution assumed in the model, 42% and even 75% differences are found in the VaR and ES when including both estimation risk and

misspecification risk. In this case, an issue tends to be put forward as whether the past data can sufficiently support the prediction made for the future performances, and a stress test then is introduced by this paper into the risk measuring functions to determine the stability of equity.

$$VAR_T(X_{T+1} - X_T) = X_T(1 - exp(\alpha + \beta G^{-1}(p)))$$

$$ES_T(X_{T+1} - X_T) = X_T(1 - \frac{1}{p}\int_{(-\infty, G^{-1}(p))}^{exp(\alpha+\beta y)}(y)dG(y))$$

As for the identification risk, the difference between the upper bounds of the confidence intervals with the chosen range of α and β can be referred due to their unavailability of being retrieved from the past data. After this step, the total model risk can be obtained by summing up the estimation risk, the misspecification risk, and the identification risk.

Model risk in multiple models

Besides evaluating the model risk for a single model used to gain the market risks, the paper also gives a view of how the model risk can be gained from the multiple models representing the uncertainties in different stages of the modeling. It is necessary as the financial institutions should carry out their risk assessments using models of various natures; for example, in a case considering the positions that the capital reserves tend to be allocated in a quite sophisticated market. In this section, the authors pay their attention to a payoff happening at a fixed date, and the risk assessment takes place at the current time when the payoff happens. Similarly, both VaR and ES will be utilized for the evaluation, with a possibility space (Ω_m, F_m, P_m) representing the equivalence classes P_m of measurable functions F_m on model m. In addition, such random variables are assumed based on the modeling process discussed before as from the model proposing to the data generating, while the characteristic of data will also be tested as the process of evaluating the parameters.

$$VAR_p(m, X) = -inf\{x \in R | P_m(X \leq x) \geq p\}, \text{ where } X \text{ is a random variable.}$$

$$ES_p(m, X) = -\frac{1}{p}[E_{pm}X_{X \leq Q_p} + Q_p(p - P_m(X \leq Q_p))]$$

With the probabilistic uncertainty existing in each probabilistic nature $\Pi(m)$ that can be treated by the payoffs in terms of units of currency or a reference asset, the multiple model risk measurement can be generated with a risk measurement method mapping ρ and the worst-case approach to gain the differences.

$$Risk_{\rho,m}(\Pi) = sum\ \rho(m, \Pi(m))$$

Empirical application

The paper uses the dataset from the S&P 500 equity index and the £/$ exchange rate from 1984 to 2006, in order to test the model risk measurement approach used in the portfolios. Two main model classes, Gaussian and GARCH, are tested at this stage, where it finds that the misspecification risk does cause a significant impact, and a satisfactory result is more likely to be obtained without such type of model risk from the observation based on the performance of non-parametric Gaussian model. However, the estimation risk may enhance its influence on the accuracy of results if the confidence interval is set higher; for instance, from 1% level used by the S&P 500 to 2.5% tested as an experimental sample by this paper. Also, as the empirical application practiced in this paper only concerns the well established market, it is a regret of lacking the evaluation of the identification risk, which should also be taken into account as it plays an essential role in the model risk assessment associating with other two kinds of risks simultaneously.

Conclusion

The frameworks and evaluation approaches offered by this paper give the professionals a view of how to assess the model risk in single model regarding the three different components of risks from the processes of model proposing and data generating, and it also provides an available way to think of how to test the impacts of the model risks by looking at the model classes crossing multi-alternative models. The results generated allow the financial institutions to differentiate their capital requirements in a market which can be quantitatively and reliably modeled.

The empirical application is basically built on the limited investments for the tested portfolio, and it only contains the standard type of payoffs using the data from the S&P 500 to gain the result. Although it is able to get a consequence identifying the impacts of the estimation risk and misspecification risk, it may claim that the identification risk is ignored and the real situations faced by the financial institutions are more complicated with more intricate products included in the portfolio. Moreover, the markets that are less liquid should be tested in the further studies as which may allow the model risks to display a larger impacts, while the strategies of hedging should also be taken into consideration as a common method of transferring the risks and it should be curious to clarify whether it will place an influence on the model risk assessments.