

Comparison Of VaR For Credit Risk And OpVaR For Operational Risk

Joe Duarte, Universidad Anahuac Mexico Sur, Mexico

ABSTRACT

In this paper, we study the models for calculating credit risk and operational risk as a comparative review of determination among its models, features and applications according to international standards of regulation of financial markets.

Keywords: VaR, Credit Risk, OpVaR, Operational Risk

1. INTRODUCTION

In this article we review the models comparing VaR (Value at Risk) to measure credit risk and OpVaR (Operational Value at Risk) that aims to measure the operational risk of financial institutions, however it is possible extend its review by adding new models for both purposes.

Since the creation of financial systems has found an urgent need for mechanisms to identify the risk under which each institution participates and conducts its transactions with other institutions and stock investors, they have focused on the search for these models that allow value to their levels of risk under which it operates.

Not surprisingly, the first institution that implemented the VaR model was the financial intermediary, JP Morgan, who began their implementation in the early 70's, becoming a pioneer in calculating their total risk exposure. The risk optimized the use of operating parameters that were demanded of regulatory institutions, such as the minimum capital required under which, for each loan to \$1 dollar, should have as a financial reserve equivalent to 50%, or 50 cents.

Through this model, J.P. Morgan and many other financial intermediaries were able to identify strictly their exposure levels for each financial product operating in such a way that managed to reduce its minimum capital required, when testing the efficiency regulatory institutions in determining their actual risk exposure, particularly credit and thereby obtain permission to keep less contingency fund, since the probability of contingency also was lower.

Since the events in the capital market for the financial sector of the United States in 2000, with substantial financial fraud regulators recognized the gap in control, supervision and legislation of these complex financial processes. These controls allow them to efficiently and effectively act on the information that companies give to the authorities and the investors.

In September 2008, the United States continued to show the vulnerability of the financial system, experiencing a financial shock that becomes evident when filing the bankruptcy of the fourth largest bank in the United States and the first investment bank to collapse since 1990, Lehman Brothers.

This institution in May 2008 had assets valued at 658 billion dollars, but to the astonishment of the whole community of Wall Street and around the world, in September 2008, he informed the States Federal Reserve U.S., due to the instability that have presented in particular the institutions with which Lehman Brothers Inc. has contracts and investment security, make impossible the continued smooth operation of the business, then bankruptcy through Chapter 11 of the bankruptcy law of the U.S.¹.

¹ The applicability and scope of the bankruptcy law of the United States can be found on the next page of the Supreme Court of the United States:

This scandal, resulted in many more since that date: AIG insurance, Merrill Lynch Investment, Goldman Sachs, Bank of America, UBS Union Bank of Switzerland, Bernard L. Madoff Investment Securities, Allen Stanford for Stanford International Bank², among others.

But the crucial facts of which have not yet succeeded in identifying its origins are that: (1) the regulatory authority had no tools to prevent such financial disasters that are putting the global financial system into crisis in all countries in an unprecedented recession, (2) economic policy of free balance and free market, their capacity for self regulation and transparent information access for all market players, ceased operations today, (3) theories supporting the current financial risk calculations do not measure what we really need to assess

The list of possible questions can be impressively large and yet we are not likely to find answers because we are still dealing with the effects of this unprecedented economic crisis, which originated in the United States.

As a first response of the legislature of the United States in 2002 promotes the Sarbanes - Oxley (SOX) which contains a number of initiatives to legislate control of all the information from organizations operating in the U. S. financial markets, and their roles, responsibilities, organizational structure, levels of authority and oversight among several others.

This creates a structure with experts for the standardization of accounting practices and generating information from all organizations involved in the sector called PCAOB (Public Company Accounting Oversight Board).

The PCAOB is a nonprofit organization whose mission is to oversee auditors of public companies in order to protect the interests of investors and improve the preparation of information of public interest to do so fair, transparent and independent auditors' reports that generate (PCAOB, 2007).

One of the greatest contributions that created the PCAOB has been the formation of Corporate Governance, which lets you create a shared responsibility between the shareholders, the management board and the advisory board of public listed companies and participate in the financial sector in U.S.

Corporate governance influences every decision that the company take and execute, particularly financial ones, that have to do with the interests of public investors and not only preferred stockholders.

The regulatory arm in the capital market of the United States is known as the SEC (Security and Exchange Commission) which in addition to monitor and ensure the operability and stock market regulation, is responsible for observing the strict enforcement and time all the relevant provisions of the SOX Act and which defines and regularly reviews the PCAOB.

In Mexico the regulatory agency is homologous to the SEC is CNBV (National Banking and Stock Commission), which is a body under the Ministry of Finance (SHCP) who is responsible for monitoring and ensuring the stock market in Mexico, as well as the implementation of the Law on Securities Market (LMV, 2005)³.

The CNBV has indicated the urgent need to take the risk valuation models recommended by the Basel Committee by 2012 for every one of the participants in financial markets. The full document showing the forms of implementation of these valuation models is known as Basel II, within which there is a specific chapter for each type of risk that should be valued, credit risk, market risk and operational risk.

It is true that participants in the financial sector are more concerned to observe and care for their levels of exposure to risks of financial activity, it largely depends on its viability as a business, their stay in the market and their ability to overcome the contingencies that could affect the institutions (Cornalba & Giudici, 2004).

<http://www.uscourts.gov/bankruptcycourts/bankruptcybasics/chapter11.html> Retrieved February 18, 2009.

² To see the details of each of these cases, we recommend to access: <http://www.bloomberg.com/apps> Retrieved February 18, 2009.

³ Published in the Official Gazette on 28 January 2004 and applicable since 1st. January 2005 until today.

International regulatory boards of financial activities as the Basel Committee and the Organization for Economic Co-Operation and Development (OECD), have developed this set of guidelines and self-control assessment that allows financial sector institutions, adopt and use to address issues of uncertainty and risk.

The financial sector institutions have found in the VaR model a measuring and control their exposure to credit risk and market, however, has not been reached yet to develop widely OpVaR adoption of the model to supplement the risk management holistically (Basel Committee, 2005).

Precisely, this paper aims to show the characteristics of these models and their applications, have somehow integration is proposed for managing risk in any financial institution, which would lead to approval by regulatory authorities, in compliance with the Basel II agreement.

In the next section we present the OpVaR and VaR control models as well as its derivatives that have typically been used according to the characteristics of the information that financial institutions have.

2. CONTROL RISK MODELS

Credit Risk

The risk is defined as a set of undesired events that can cause losses. In the financial sector, all parties want to reduce, eliminate or transfer the risk of the assets being placed in any operation, so that allows a reasonable level of risk to a transaction that will yield some kind of recompense.

VaR is a model that identifies the maximum expected loss over a range of exposure time to a certain level of confidence. This helps to identify the two main variables that use the VaR model, time of exposure or effect and the percentage level of confidence that this risk is not present.

It is efficient to assume that financial variables operating in the VaR, follow a normal distribution, its basic principle is the determination of the point where the cumulative probability reaches the value of $1-\alpha$, where α is the confidence level.

To appraise the VaR of a portfolio, we can define as the initial investment I_0 and r and its corresponding yield rate. From the above we can say that the value of the portfolio at the end of elected period shall be $I = I_0 (1 + r)$, as for any normal distribution, the expected yield or return will be $E(X)$ or μ , volatility is defined as the standard deviation of the distribution is, $DS(X) \text{ o } \sigma$.

Whereas we have a probability distribution function (pdf) representing the behavior of the portfolio, then:

$$\int_{-\infty}^{VaR} f(s) ds = 1 - c \tag{1.1}$$

where:

c = confidence level.

$f(s)$ = probability distribution function of the portfolio future value.

VaR = the sample quantile of the distribution.

The area of $-\infty$ to VaR should add $1-c$ or any distribution, discrete, continuous, thin or extended.

Once it is considered that the *pdf* of the portfolio behaves like a normal distribution, the calculation of VaR can be considerably simplified; it is considered that this facility has enabled its widespread use in organizations (Jorion, 2007; Venegas 2007).

Initially we convert the function $f(s)$ in a normal function $\varphi(\varepsilon)$ where ε is zero mean and standard deviation as the unit, taking the following:

$$1 - c = \int_{-\infty}^{VaR} f(s) ds = \int_{-\infty}^d \varphi(z) dz = N(d) \tag{1.2}$$

where:

d = is the value of a standard normal variable, which we can place tables of the function of standard normal cumulative distribution.

Based on the above we can define the VaR as a multiple of the standard deviation of the distribution, multiplied by an adjustment factor, which is directly related to the level of confidence.

We define the time of exposure or effect in terms of generalized parameters σ and μ are defined as $\sigma\Delta t$, that since the increase of t would be expressed in years, and the confidence level is given by the value of the factor sigma found in tables, which we will call α .

As shown in Figure 1.1, for a confidence level of 5%, correspond a value of 1.65 times sigma, that is the standard deviation. Regularly the financial sector uses this level of confidence for the calculation of VaR, which would mean that 1 in 20 times the performance of the portfolio will fall above the VaR value in relation to expected yield or return, so the institution can consider accepting this chance and make the appropriate funding to address it.

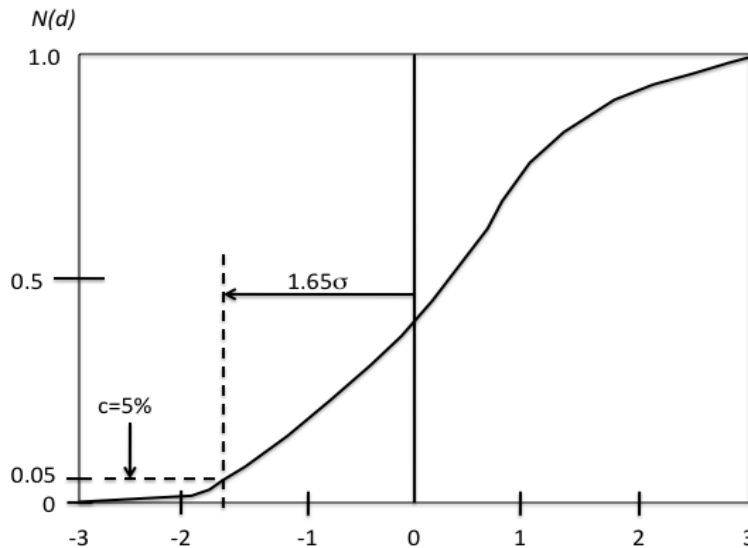


Figure 1.1 Cumulative normal probability distribution (Jorion, 2006; Chernovai, Rachev & Fabozzi, 2007).

There is an alternative way to calculate the VaR as follows:

$$VaR = \alpha \cdot \sqrt{\sigma^2 \cdot \Delta t} \tag{1.3}$$

where:

α s the factor that defines the area of loss of yields.

σ^2 s the variance of yields.

Δt is the period or duration of exposure for which VaR is calculated.

Throughout this review we are looking for which is the poorer performance of a portfolio in a given time horizon, for a specific confidence interval, that is the value at risk X to a level of confidence (1 – c) can be expressed as $-VaR_{1-c}^X$ for a horizon of [t,T].

The probability of generating the worst scenario for a risk value of X, which represents the asset portfolio, given a defined level of confidence, which we describe as:

$$P(-VaR_{1-c}^X \leq X) = 1 - c \tag{1.4}$$

Equation (1.4) is applicable to any random variable, both discrete and continuous, so it can also be expressed as follows:

$$VaR_{1-c}^X = - \inf\{x \in \mathbb{R} ; P(X \leq x) \geq 1 - c\} \tag{1.5}$$

However, understanding the normal course of the yields of portfolios, the calculation of VaR to become an expression very simple and easy to locate in most models in automated financial institutions.

Understanding that the change in value that can accrue a portfolio of assets during the defined time horizon in the range [t, T] is defined by X which is a continuous random variable and its probability distribution function *pdf* is define by *F*, we can then argue that $-VaR_{1-c}^X = F^{-1}(c)$, meaning that the quantile *c* of *F* is define by $-VaR_{1-c}^X$.

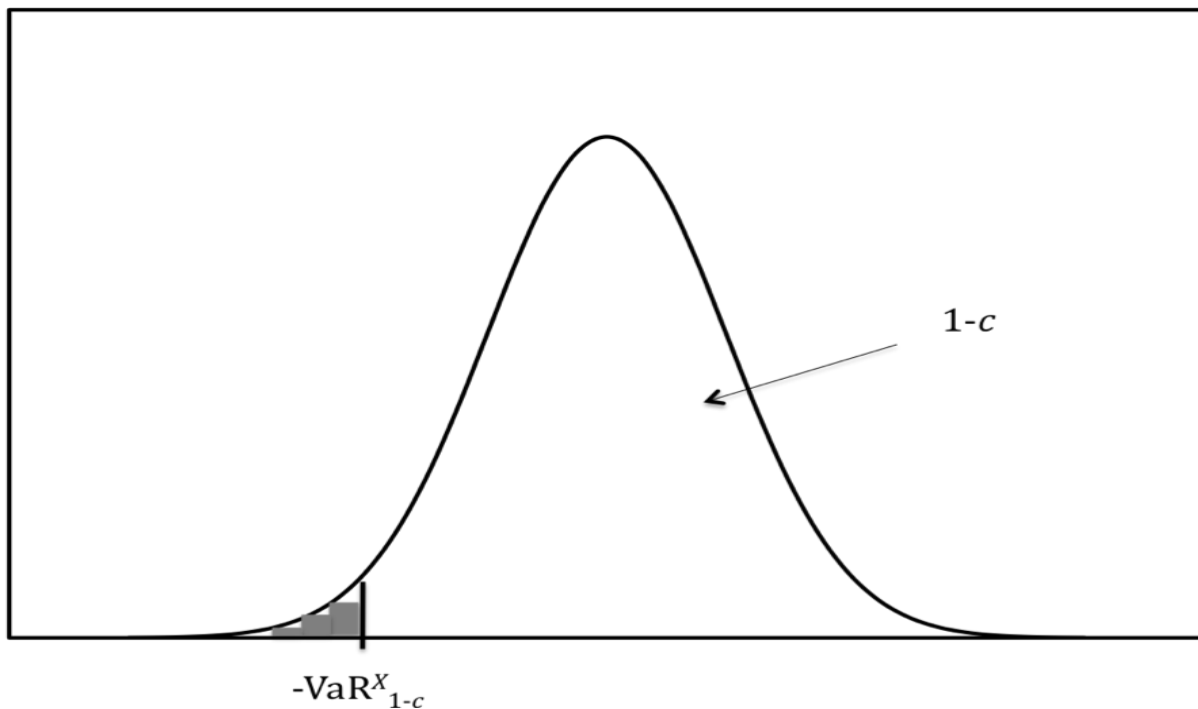


Figure 1.2 Value at risk from X to a confidence level 1 – c. (Venegas, 2007; Chernovai, Rachev & Fabozzi, 2007)

Finally we can understand $-VaR_{1-c}^X$ as a statistical evaluation of the performance of a portfolio X, with a confidence level 1-c, in such a way that allows to determine the investor and financial intermediary, a measure of risk on a group of identifying assets threshold poorer of the frequency distribution of X.

It should be noted, that has developed around the VaR models for specific financial products, such as the Incremental VaR, VaR average, C-VaR or Tail Conditional Expectation of VaR, VaR and the CAPM model known as diagonal, Delta-Gamma VaR, among many others, that this article aims to develop and therefore covered only to determining the parametric VaR and quantile function, which incidentally, is the most used in the financial sector for credit risk valuation.

Operational Risk

The operational risk is defined as the possibility that a loss this institution failures in management systems, internal procedures, human errors or external factors affecting the operation of the institution.

Regularly, these risks are more related to internal events such as fraud, theft, breach of trust, executive wrong decisions or failures in information and communication technologies, however, recently the Basel Committee has defined as high priority in all its valuation of the financial institutions registered and represented in this committee.

Through its review in 2006, the Basel Committee in 1988 had built a regulatory document known as Basel I, which provides the calculation of credit and market risk after 1996 introduced its new version known as Basel II where he developed and guidelines for calculating the operational risk assessment and its definition and structure (Hull, 2007).

This article presents some models of operational risk assessment in order to make a comparison with the parametric VaR model previously presented in order to serve as an additional tool for risk management functions.

In general, operational risk from two key variables, the frequency of occurrence of the risk and severity of it. You can then locate it to a credit institution, the risk of fraud is low frequency, high severity, but the risk of registration errors or lack of it due to technical problems can become very low frequency high impact severity (Basel Committee, 2005).

It is clear that each institution is free to qualify through these two variables each of the identified risks such as operations, so that can build a map of incidents and impacts that will make it very clear to risk managers and senior management, kinds of risks that may face and what kind of assets may affect.

They have developed through research of this type of risk, a series of frequency distributions of such operational failures both internal and external reality modeling allowing much more accurate.

A distribution that is widely used in the financial sector for its clarity and simplicity is known as the binomial $b(n, p)$ where n is identified as the total number of events that are permissible to an operating loss for a period of time the institution determines the horizon of exposure, of course, p is the probability of such event to develop or generate a loss (Venegas, 2007).

Whereas X is a random variable representing the number of events that an institution faces operational risk over a period of time, which we consider as a default value of one year.

We are also assuming that every one of these operational risk events are independent, there is no relationship between an event of loss sustained two days ago regarding an event of loss of yesterday or maybe tomorrow, we can then say that the probability that present any number of events classified as operational risk events is:

$$P(X = x) = \begin{cases} \binom{n}{x} p^x (1 - p)^{n-x}, & x = 0, 1, \dots, n, \\ 0, & \text{otherwise} \end{cases} \tag{1.6}$$

We can from now to make some immediate reflections of the binomial model, as it does not matter the number of risk events which may face, the chance always remains constant and its value is given by p , similarly, this model operates under the assumption that one must know beforehand the value of the number of events n along the horizon determined by the institution, otherwise it could not operate (Chernovai, Rachev & Fabozzi, 2007).

We can in any way, find that this model is derivable from a Poisson model $P(\lambda)$, under consideration have a sufficiently small probability p and a good number of events n , in this case then we can determine the value of $P\{X=x\}$ as follows:

$$P\{X = x\} = \begin{cases} \frac{n! e^{-n} p^x}{x! (n-x)!}, & x = 0, 1, \dots \\ 0, & \text{otherwise} \end{cases} \tag{1.7}$$

Note that for this model only requires a parameter called *intensity* and is represented by lambda (λ), which is defined as the average number of events representing a loss per unit time.

We can then take as a decision on which model to apply between the binomial and Poisson, the frequency parameter n , such that when presented with a low value it can refer to using the Poisson model and without the parameter n .

Also used the Lognormal distribution to model this type of operational risks, and like the Poisson distribution is widely used in the financial sector by the severity that it offers on the amount of loss, the distribution is defined as follows:

$$f(x) = \frac{1}{\sqrt{2\pi} \sigma x} \exp\left\{-\frac{1}{2\sigma^2} \left(\frac{\ln x - \mu}{\sigma}\right)^2\right\}, \quad x \geq 0 \tag{1.8}$$

where $\mu \in \mathfrak{R}$ and $\sigma > 0$ are the parameters of the distribution.

Given the above we can determine that if X is a random variable with Lognormal behavior then:

$$E[X] = \exp\left\{\mu + \frac{\sigma^2}{2}\right\} \quad \text{y} \quad VaR[X] = e^{2\mu + \sigma^2} (e^{\sigma^2} - 1) \tag{1.9}$$

Here you can see the Lognormal distribution for the parameters standard values for demonstration purposes only, either way, you can see that this distribution is skewed to the right and belongs to the curves are known as “fat tail”

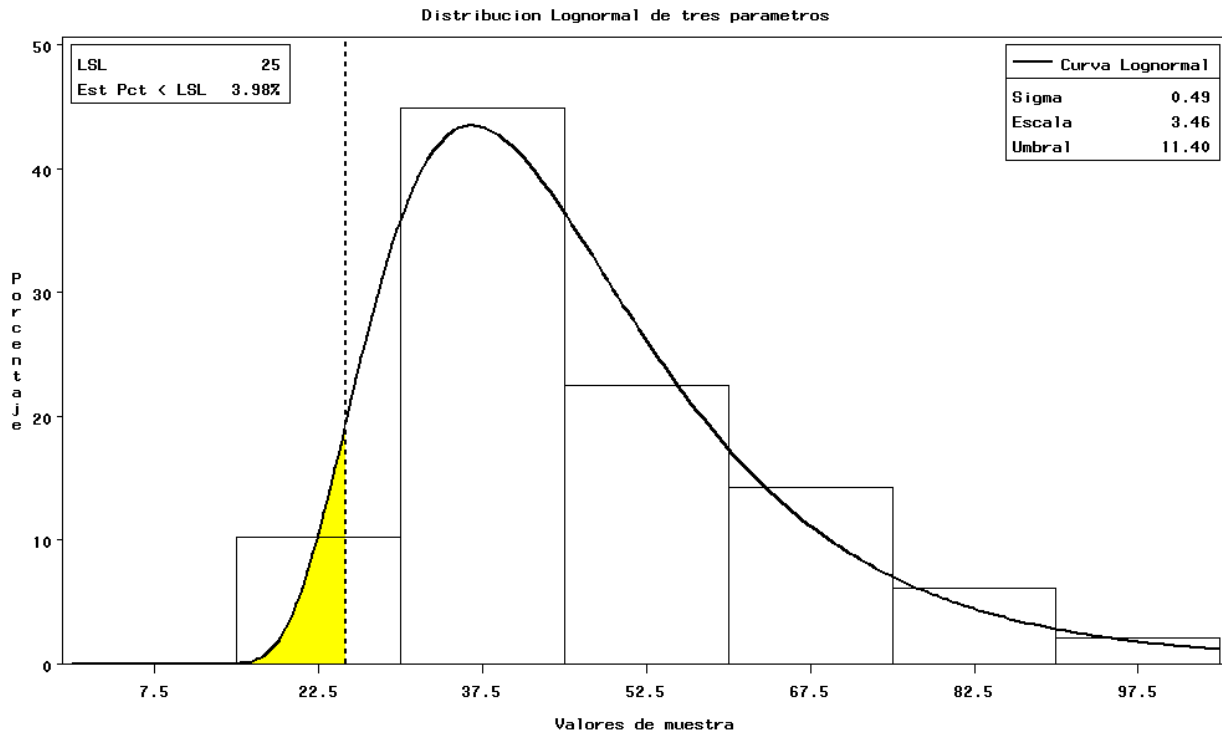


Figure 1.2 Graph of the density of the Lognormal distribution (by José Luis Tadeo Duarte Alcántara)

The Lognormal distributions are characterized by moderately heavy tails. To adjust the data to a normal distribution is to take the natural logarithm of the data set and then approach a normal distribution.

The estimate of the maximum likelihood (ML) is defined by:

$$\hat{\mu} = \frac{1}{n} \sum_{j=1}^n \log x_j, \hat{\sigma}^2 = \frac{1}{n} \sum_{j=1}^n (\log x_j - \hat{\mu})^2 \tag{1.10}$$

When some distributions have what is known as "severity", that is a considerable bias known as leptokurtosis typically is used then the Gamma distribution with the parameters α and β , for the function $G(\alpha, \beta)$, with the following density function:

$$f(x) = \frac{x^{\alpha-1} e^{-x/\beta}}{C(\alpha)\beta^\alpha}, x \geq 0, \tag{1.11}$$

where $C(\alpha)$ is the Gamma function.

It is important to consider that to fully utilize the measures of credit risk and operational risk that are presented in this paper (OpVaR and VaR), the estimation of the parameters depend on the size and quality of information loss shows that each institution has and, the record of its features that allow exactly what type of risk being modeled.

3. CONCLUSIONS

As we have seen over the exposure of these models, each responds to a set of specific parameters to achieve a model of loss events that an institution may face, particularly those located in the financial sector.

Thus, we can identify, that the traditional models for calculating VaR, can help assess the risk they are incurred directly in shaping the portfolio of assets and even for other products known as derivatives, having a set of tools derived from the initial model VaR calculation, which has allowed a wider use in the financial sector.

Determining the Value of Operational Risk, is a function of the number of events that may occur and the severity of these losses on committed.

We found then, that operational risk is identified with probability distributions known fat tail distributions, where biased in its distribution as opposed to credit risk, which show irregularities in their distribution as opposed to credit risk, which is much more common to find a better behavior to approximate normal distributions.

This allows us to observe, which is essential for proper risk management, the creation of an integrated strategy, so that it can identify and measure both exposure to credit, market and operational risk.

The choice of a model, which may depend entirely on risk behavior in the institution, the macroeconomic environment and the determination of the parameters, which account in the institution.

It should be noted the importance for all institutions to register each and every one of its operations and transactions in such a way that conforms a database of all types of losses that the institution across the periods of life you have.

This database of losses, will be the main factor that can determine the risk manager, the best model for the behavior of their exposures and historical finds, otherwise, you must use standard factors proposed in the document of Basel II, developed by the Basel Committee, however, precisely because it is a standard model has major deficiencies and may undervalue or overvalue get exposure to risk across the institution, leading it to make strategic decisions with incomplete or incorrect information.

Below is a comparison chart that allows the models reviewed in this paper.

Table 1.1 Comparative analysis of the models VaR and OpVaR

VaR	OpVaR
Basic Model $\int_0^{VaR} f(s) ds = 1 - c$	Binomial model $P(X = x) = \binom{n}{x} p^x (1-p)^{n-x}, \quad x = 0, 1, \dots, n,$ $0, \quad \text{otherwise}$
Normal Model $1 - c = \int_0^{VaR} f(s) ds = \int_0^d z(f) df = N(d)$	Poisson Model $P(X = x) = \frac{m^x e^{-m}}{x!}, \quad x = 0, 1, \dots$ $0, \quad \text{otherwise}$
Variance Model $VaR = a : \sqrt{v^2} : Dt$	Lognormal Model $f(x) = \frac{1}{\sqrt{2\pi} v x} \exp\left\{-\frac{1}{2} \left[\frac{\ln x - \ln a}{v}\right]^2\right\}, \quad x \geq 0$ with: $E[X] = \exp\left\{n + \frac{v^2}{2}\right\} \quad \text{and} \quad VaR[X] = e^{2n + v^2} (e^{v^2} - 1)$
Probabilistic Model $P(VaR_{1-c}^X \leq X) = 1 - c$ $VaR_{1-c}^X = - \inf\{x \in R; P(X \leq x) \geq 1 - c\}$	Gamma Model $f(x) = \frac{x^{a-1} e^{-x/b}}{\Gamma(a) b^a}, \quad x \geq 0,$

REFERENCES

1. BIS (2001a). Consultative Document: Operational Risk. Bank for International Settlements of Basel. Retrieved September 8, 2008, from <http://www.bis.org/pub/bcbsca.htm>
2. BIS (2001b). Working Paper in the Regulatory Treatment of Operational Risk. Bank for International Settlements of Basel. Retrieved September 8, 2008, from <http://www.bis.org/pub/bcbsca.htm>
3. BIS (2001c). Sound Practices for the Management and Supervision of Operational Risk. Bank for International Settlements of Basel. Retrieved September 8, 2008, from <http://www.bis.org/pub/bcbsca.htm>
4. Basel Committee (2005). International convergence of capital measurement and capital standards: a revised framework, (BASEL II). Bank for International Settlements of Basel. Retrieved September 8, 2008, from <http://www.bis.org/pub/bcbsca.htm>
5. Chernobai, A.S., Rachev, S.T., & Fabozzi, F.J., (2007). *Operational Risk: A guide to Basel II Capital Requirements, Models, and Analysis*. New Jersey: Wiley Finance, John Wiley & Sons, Inc.
6. Cornalba, C. & Giudici, P. (2004). Statistical Models for Operational Risk Management, Physical A: Statistical Mechanics and its applications. Retrieved April 12, 2007, from www.consorziocarma.com/pia/index.php?option=com_docman&task=doc_view&gid=11&Itemid=12
7. Hull, J. (2007). *Risk Management and Financial Institutions*. Canada: Ed. Pearson Prentice Hall, International Edition.
8. Jorion, P. (2007). *Value at Risk* (Third Edition), International Edition, Singapore, Ed. McGraw-Hill (Asia).
9. LMV (2005). Ley del Mercado de Valores. Comisión Nacional Bancaria y de Valores de México (CNBV), Retrieved September 15, 2008, from www.cnbv.gob.mx/recursos/LMV_2005.doc
10. Panjer, H.H., (2006). *Operational Risk: Modeling Analytics*. Hoboken, New Jersey: John Wiley & Sons, Inc.
11. PCAOB (2007). PCAOB Overview. Public Company Accounting Overseer Board, Retrieved September 15, 2008, from www.pcaob.org
12. Venegas, M. F. (2007). Riesgos Financieros y Económicos, productos derivados y decisiones económicas bajo incertidumbre, México D.F., Ed. International Thomson Editores.