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# **Operational Risk Measurement**

A Critical Evaluation of Basel Approaches

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# Professional Profile

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### Education

PhD, MBA, LL.M, CFE, MA

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ECG, World Bank, KPMG, Commonwealth Development Corporation, SECP, London & Scottish Marine Oil, Unilevers, GoP – Ministry of Finance

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Maastricht University, Harvard Business School, USC, UCLA, NIBAF, NBS

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# **Evolution of Operational Risk**

# Risk recognition beyond insurance

- The concept of formal and structured risk management remained confined to insurance industry for a long time.
- Risk management was recognized as a structured concept by non-insurance sectors in 1980s when manufacturing firms introduced concept of total quality management.
- It was not until the 1990s that risk management received recognition for its importance in financial and nonfinancial corporations.
- Peter Bernstein's book in 1996, "Against the Gods: The Remarkable Story of Risk" triggered interest for risk management in general public.



# Operational risk – the late comer

- Banking industry, since the word go, acknowledged & concentrated on only two categories of risks i.e. market risk & credit risk
- Risks not attributable to either of these two risks were labeled “Other Risks” – Operational risk was simply a part of other risks!
- Failure of financial institutions in 1990s & early 2000 due to heavy losses which were neither market nor credit losses changed this mentality.
- Orange County in 1994, Barings Bank & Daiwa Bank in 1995, 9/11 in 2001, Allied Irish Banks in 2002, and MasterCard in 2005 caused a shift in paradigm.



# Conceptualization of operational risk

- The banking system ultimately recognized the painful reality that it is not sufficiently prepared to handle operational risk.
- Identity of operational risk evolved from being other risks and any risk not categorized as market and credit risk!
- The Committee of Sponsoring Organizations (COSO) was the first one to introduce the term of operational risk in its internal control framework in 1991.
- Since then, the term "operational risk" has undergone many changes and its contents differ according to different interpretations and uses.



# Late awakening of BCBS

- The first Advisory Directive of BCBS in 1988, commonly known as Basel I, addressed the issue of capital charge calculations on the basis of credit risk only, ignoring both market and operational risks of financial institutions.
- In 1993, BCBS issued its second Advisory Directive as an amendment to Basel I which added market risk component to credit risk but still ignored operational risk component.
- Finally, the third BCBS Advisory Directive of 2004 which is commonly known as Basel II recognized operational risk and included operational risk component in its capital charge calculations.





# Defining operational risk

- BCBS defined operational risk as “The risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events.”
- Practitioners believe that this definition is far from perfect and it excludes several operational risks, which daily threaten financial institutions.
- It is estimated that the definition in Basel framework reduces operational risk to about half of the actual size.
- For example, this definition excludes set of strategic and reputational risks, despite the fact that these risks meet the characteristics of operational risks.





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# **Challenges in Measuring Operational Risks**

# The relativity of wrong

- Risk is measured as a product of financial impact and its probability of happening – simple enough!
- Operational loss events being discrete value parameters are measured in terms of frequency which needs to be converted into probability at a later stage.
- Probability in theory requires historic data for its calculations – a suitably relevant concept as far as market and credit risks are concerned.
- But what about operational risk? Is history a logically valid parameter to predict potential future operational losses? Specially frequency!



# The relativity of wrong

- All operational risks are directly or indirectly related to people; as processes & systems are designed and operated by people.
- An operational risk event that happens today will be met by immediate counter measures reducing the probability of its happening again in the same manner.
- If something can happen and has not happened so far, then with every passing day, the probability of its happening increases!
- So, meta-theoretically, what has happened in past has less probability and what has not happened so far has greater probability of happening!



# Structural limitations in frequency calculation

- Frequency of operational loss events is generally country specific and particularly institution specific
  - No institution would have large history of operational losses or it would not be there!
- Therefore, internal data needs to be combined with external data in order to establish reliable probabilities – External operational data may distort complete calculations and calculated probabilities may reflect a picture which has nothing to do with institution!
- Even in presence of external data, frequency of high impact events is too low to model some credible statistical pattern – Tail prediction dilemma!



# Conceptual issues in impact calculation

- Every bank needs to establish a minimum threshold for recording operational risk impact – these thresholds may differ from bank to bank making internal and external data incompatible.
- A single operational risk event may have impact on several business lines which requires empirical distribution of impact value that may not be accurate.
- Empirical methods for operational risk impact distribution over different business lines may differ from bank to bank .
- Tail prediction dilemma stays with impact calculations too!





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**Issues with Basel Framework?**

# Why and why not

- The Basic Indicator Approach (BIA) requires “Gross Income” to be multiplied by an “Alpha Multiplier” of 15% to calculate operational risk capital charge – The rationale behind 15% is .....
- The Standardized Approach (TSA) requires “Gross Incomes of 8 Business Lines” to be multiplied by pre-decided “Beta Factors” for each business line. Beta Factors range from 12% lowest to 18% highest – The rationale behind these percentages is .....
- If gross incomes from all 8 business lines are equally distributed in terms of percentage, then the capital charge calculated using TSA will actually be equal to capital charge calculated using BIA as average beta factor is still 15%.





# Are we missing something here?

- Gross income is obviously calculated before any provisions - but write off in one year affects your gross income in next year!
- So will a badly managed bank with huge write offs and with reduced gross income subsequently, have a reduced capital charge under both BIA and TSA?
- And will a well managed bank with low operational risks and healthy gross income end up with bigger capital charge under these approaches?
- Gross income is a product of mainly your credit operations – Should operational risk be calculated as a percentage of income?



# Is Basel framework actually reducing risks?

- Basel framework is all about deleveraging banks' balance sheets with increased equity component in capital structure.
- But an increase in equity component means an increase in cost of capital.
- So if cost of capital is increased, bank will be compelled to invest in high return assets in order to maintain its economic profitability – In other way, if equity is increased, profitability has to increase in order to maintain return on equity!
- Investment in high return assets means high risks – So we reduced risk on one side of balance sheet and increased risk on other side of balance sheet!



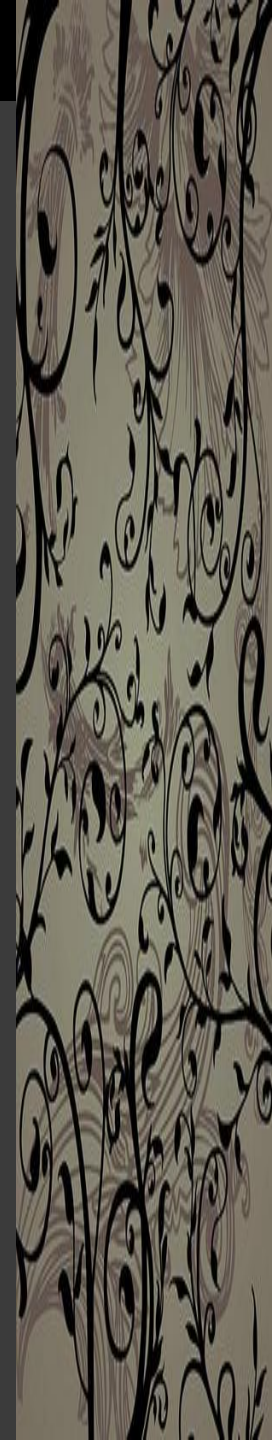
# Basel is seriously affecting banks profitability

- Now we have Basel III of 2010 which introduces new minimum capital requirements, two liquidity ratios, a charge for credit value adjustment and a leverage ratio, among other things.
- Basel II was founded on three pillars. Pillar I defined the regulatory rules. That pillar collapsed under the weight of the crisis before the plaster had even set.
- It is truly impressive that the 27 member countries of the Basel Committee have been able to agree on such a radical change of the rules of the game of banking.



# Basel III implications on profitability

- Basel III capital requirements will require an estimated increase of € 700 Billion in Tier I capital of European banking industry alone.
- Further the industry will require additional €2 trillion in highly liquid assets and €3.5 to €5.5 trillion in long-term funding.
- Overall, the proposals in Basel III would reduce the industry's ROE by 5 percentage points (before mitigating factors), or at least 30 percent of the industry's long-term average ROE, which is estimated at 15 percent.
- Out of this 5% reduction, 1% will be contributed by the maintenance of Basel III ratios.





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**Basel II Approaches for  
Operational Risk**

# BIA, TSA and AMA

- Basel framework suggests three methods for calculation of capital charge for operational risk ranging from very simple to very complex models.
- These methods include Basic Indicator Approach (BIA), The Standardized Approach (TSA) and Advanced Measurement Approaches (AMA).
- Basel framework requires financial institutions to select the simplest approach to start with and gradually step-up with an objective to reach advanced approaches in medium to long term.
- Banks are also allowed to use a combination of approaches for different business lines which is known as Partial Use.



# BIA, TSA and AMA

- However, once an advanced approach is chosen, a bank will not be permitted to revert to a less sophisticated approach.
- More sophisticated approaches should in theory permit greater benefits in terms of reduction in capital charge – Empirical evidence is limited.
- Transition from simple to advanced approaches technically requires availability of credible historic data as well as modeling & analytical expertise.
- In certain cases, banks require permission from regulator before adopting a particular advanced method.



# Basic indicator Approach - BIA

- Capital charge under Basic Indicator Approach (BIA) is calculated as percentage of previous three years average positive annual gross income.
- Gross income under BIA has a specific definition which differs from standard accounting definitions and its calculation follows a standard structure together with certain qualifications.
- BIA is regarded as the simplest method and there is no criterion or condition for a bank to use it.
- Capital Charge is equal 3 Years Average Gross Income X Alpha Multiplier 15%.
- Gross Income is sum of net interest income and net non-interest income for previous 3 years.





# Basic indicator Approach - BIA

- If the annual gross income is negative or zero for any year, figures for that year are excluded from both the numerator and denominator when calculating the average gross income.
- If a bank does not have the required historic information because it has been operational for less than three years, then the bank is allowed to use the gross income values assumed in its projected business plan.
- The incomes in formula are gross of any provisions including unpaid interest and gross of all other operating expenses including fees paid to outsourced service providers. Gross Income in formula also does not include profit & losses from the sale of securities.



# The Standardized Approach - TSA

- TSA is very similar to BIA, instead of taking total gross income of bank and multiplying it with 15% Alpha, separate gross incomes are calculated for all business line and multiplied by specific percentages which are called Beta Factors.
- The annual capital charge under this approach is the sum of the products of the relevant business line gross incomes and the beta factor.
- In order to qualify for the SA, banks need to comply with a set of minimum entry standards.
- Detailed criteria for using SA is defined in BIS document “International Convergence of Capital Measurement and Capital Standards, June 2004”, in paragraph 660- 663.



# The Standardized Approach - TSA

- For retail and commercial banking there is also an Alternative Standardized Approach (ASA) available, introduced to eliminate double counting of risks. In this case, the volume of outstanding loans will be multiplied by the beta factor and the result multiplied by 3.5%.

<b>NO</b>	<b>BUSINESS LINES</b>	<b>BETA %</b>
1	Corporate Finance	18%
2	Trading and Sales	18%
3	Payments & Settlements	18%
4	Commercial Banking	15%
5	Agency Services	15%
6	Retail Banking	12%
7	Asset Management	12%
8	Retail Brokerage	12%



# Advanced Measurement Approaches - AMA

- AMAs are fundamentally different from BIA and TSA. In case of the BIA and the SA, all the parameters are determined by a regulator when the capital requirement for operational risk is calculated. In case of AMA methods, bank's calculations and its real history of losses are taken into account.
- Banks wishing to use this approach need to meet certain conditions and require approval from their local regulators.
- Regulators give approval for the usage of AMA methodologies on the basis of bank's internal capabilities, soundness of risk management systems and strength of risk management framework.



# Advanced Measurement Approaches - AMA

- Once a bank has been approved to adopt AMA by a regulator, it cannot revert to a simpler approach without regulatory approval. Such approvals are given only in case of extra ordinary circumstances.
- The models developed under AMA approaches fall into following three categories depending upon underlying methodology:

Internal Measurement Approach – IMA

Loss Distribution Approach – LDA

Score Card Approach – SCA



# Advanced Measurement Approaches - AMA

- AMA model must be able to calculate capital charge as the sum of expected loss (EL) and unexpected loss (UL).
- AMA model must demonstrate that its operational risk measure meets a soundness standard comparable to that of the internal ratings-based approach for credit risk. This means model must be able to calculate capital charge for one year holding period with a 99.9th percentile confidence interval.
- AMA model must be sufficiently 'granular' to capture the major drivers of operational risk affecting the shape of the tail of the loss estimates.



# Advanced Measurement Approaches - AMA

- Capital charge calculated by AMA models should not be less than 75% of capital charge calculated under Standardized Approach. This floor needs to be maintained unless approved and allowed by the regulator.
- In order to develop an AMA model, banks need a 3 years historic database of Internal Loss data and External Loss Data as a minimum requirement. Banks collect this historic operational loss data and register it in a database which is called Loss Database.





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# **Data Modeling – Step Zero**



# Data Types & Requirements

- AMA model should ideally be based on 4 data sets which are called elements of AMA model. These data sets include internal data, external data, scenario analysis and business environment & internal control factors.
- Any AMA model must at least use internal & external data and scenario analysis as a minimum requirement.
- Internal data refers to bank's historical data of operational loss events. The data should have 2 components i.e. frequency and severity.
- Frequency represents the number of times a particular risk event occurred and Severity represents the financial impact of the risk.



# Data Types & Requirements

- The internal data needs to be ideally recorded across 3 timelines i.e. date of occurrence, date of discovery and date of accounting record.
- External data refers to either public data and/or pooled industry data. These external data should include data on actual loss amounts, information on the scale of business operations where the event occurred, information on the causes and circumstances of the loss events.
- A bank must have a systematic process for determining the situations for which external data is used and the methodologies used to incorporate the data e.g. scaling, qualitative adjustments etc.



# Data Types & Requirements

- Scenario analysis refers to assessment of plausible severe losses under assumed statistical loss distribution. A bank must use scenario analysis in conjunction with external data to evaluate its exposure to high-severity events.
- Scenario analysis should also be used to evaluate potential losses arising from multiple simultaneous operational risk loss events.
- Business environment and internal control factors refer to elements that are key drivers of risks. Any improvement in the control of these drivers will result in decrease of risk probability and any deterioration in the control will cause an increase of risk probability.



# Data Modeling

- Measurement of operational risk to determine the capital charge comes with a great challenge of collecting loss data. An operational risk is more difficult to measure than market or credit risk, due to the non-availability of objective data, presence of redundant data and the lack of knowledge of what to measure.
- The data requirements for measuring market risk are very straightforward, such as prices, volatility and other external data. These are packaged with significant history in large databases which are easily accessible and measurable. Similarly, credit risk relies on the assessment and analysis of historic and factual data, which is again easily available in banking systems.



# What is loss data?

- Operational loss databases are a collection of number of occurrence of operational risk events called “Frequency” and financial impact of these risks called “Severity”.
- The Frequency is divided into 3 categories of High frequency, Medium Frequency and Low Frequency.
- Similarly Severity is also divided into 3 categories of High Severity, Medium severity and Low Severity.
- This can be represented in a 9 cell matrix showing 9 combinations of frequency and severity on high, medium and low scale.



# What is internal loss data?

- Bank must decide a threshold for internal data collection which represents a minimum amount of severity and all risk events where severity is greater than the assigned threshold must be recorded.
- The appropriate threshold can vary between banks and even between business lines and event types within a bank.
- In addition to gross loss amounts relating to severity of risk events, banks must also collect and record information about the data of events and recoveries of gross loss amounts together with some descriptive information about the drivers and causes of the loss event.



# What is internal loss data?

- Operational risk losses that are related to credit risk and have historically been included in the credit risk database of bank are treated as non-operational losses.
- Operational risk losses that are related to market risk are treated as operational risk for the purpose of calculating minimum regulatory capital, and therefore are subject to the operational risk capital charge.



# What is internal loss data?

## NO REQUIREMENTS FOR RECORDING LOSS DATA

- |    |                                |
|----|--------------------------------|
| 1  | Date of Event Occurance        |
| 2  | Date of Event Discovery        |
| 3  | Date of Event Write Off        |
| 4  | Location of Event Occurance    |
| 5  | Name of Bank                   |
| 6  | Level 1 Type of Event Category |
| 7  | Level 2 Type of Event Category |
| 8  | Amount of Loss                 |
| 9  | Severity of Loss               |
| 10 | Loss Recovery Amount           |
| 11 | Loss Recovery Source           |
| 12 | Casue of Event                 |



# What is external loss data?

- It seems to be generally accepted in the finance industry that internal loss data alone is not sufficient for obtaining a comprehensive understanding of the risk profile of a financial institution.
- External loss data is basically collection of internal loss data of other financial institutions within the local industry. External loss data therefore should have same characteristics as of internal loss data described above.
- External data should include data on the actual loss amount, information on the scale of business operations where the event occurred, information on the causes and circumstances of the loss events.



# What is external loss data?

- There are many ways to incorporate external data into the calculation of operational risk capital.
- External data can be used to supplement an internal loss data set, to modify parameters derived from the internal loss data, and to improve the quality and credibility of scenarios.
- External data can also be used to validate the results obtained from internal data or for benchmarking.
- In LDA models, external data is used as additional data source for modeling tails of severity distributions. The reason is that extreme loss events at banks are so rare that no reliable tail distribution can be constructed from internal data only.



# What is loss data cleaning?

- Loss data collected from internal as well as external resources is generally dirty data which needs to be cleaned before its use in analytics.
- Internal data needs to be audited, classified, scaled, weighted and truncated and external data needs to be cleaned from scale bias, truncation bias and data capture bias.
- Data auditing is the process of checking accuracy of data points and incorporating missing values.
- Data classification refers to checking the distribution of loss in categories of business lines. This is especially relevant in case of Split Losses where one loss amount is distributed between two different business lines on the bases of weights.



# What is loss data cleaning?

- Data scaling refers to converting historic nominal loss amounts into real inflation adjusted amounts today. A 3 years earlier loss of \$100 will be recorded as \$100 plus compounded effect of 3 years inflation.
- Data weighing gives weights to historic data on a time scale basis. Last year data is considered more relevant and has more weight as compared to 10 years old data.
- Truncation is the process of establishing a minimum threshold of loss amount and ignoring all values that fall below established threshold.



# What is loss data cleaning?

- Scale bias refers to the fact that operational risk is dependent on the scale of operations of a financial institution. A bigger institution is exposed to greater operational failures and therefore to a higher level of operational risk.
- The actual relationship between the size of the institution and the frequency and severity of losses is dependent on the measure of size and may be stronger or weaker depending on the particular operational risk category.
- Truncation bias refers to fact that financial institutions collect data above certain thresholds which may be different from each other.



# What is loss data mapping?

- Once internal and external loss data is collected and cleaned, these databases need to be mapped. This process is done into 2 steps.
- First step involves distribution of collected loss data into 7 categories of Level 1 risk events.
- Level 1 risk events, mentioned include internal frauds; external frauds; employment practices and workplace safety; clients, products, and business practices; damage to physical assets; business disruption and system failures; and execution, delivery, and process management.



# What is loss data mapping?

- Second step involves distribution of collected loss data into 8 categories of business lines.
- Business lines, include corporate finance; trading & sales; payments & settlements; commercial banking, agency services; retail banking; asset management; and retail brokerage.



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# **Internal Measurement Approach**



# Structure of IMA Models

- IMA models are basically modified versions of Standardized Approach. Standardized Approach calculates capital charge by multiplying gross income of 8 business lines with pre-decided Beta Factors. IMA models are developed along the same lines.
- In the IMA Models, financial institution decides their own indicator of exposure i.e. gross income, number of transactions, trading volume etc. and determines individual capital charge for all 56 combinations of 8 business lines and 7 risk events.
- Total capital charge for operational risk is calculated as simple sum of 56 individual capital charges.



# Structure of IMA Models

- The capital charge is determined in IMA models as the product of three parameters: The Exposure Indicator (EI), Probability of Event (PE) , Loss Given the Event (LGE).
- The product  $EI \times PE \times LGE$  is used to calculate the expected loss (EL) for each business line/loss type combination.
- The EL is then rescaled to account for the unexpected losses (UL) using a parameter  $\gamma$  (gamma).
- Gamma is different for each business line/loss type combination and its values are predetermined by the supervisor.



# Structure of IMA Models

- Expected Loss = Exposure Indicator X Probability of Event X Loss Given the Event
- Exposure indicator = Values of gross income or number of transactions or trading volume etc.
- Probability of event = Statistical probability for risk event occurrence.
- Loss given event = Financial impact of risk event.
- Capital Charge = Sum of (Expected Loss x Gamma) for 56 business line & risk events combination.
- Gamma = Applicable % for each business line & risk type combination as decided by supervisor.



# Structure of IMA Models

- The main drawbacks of this approach are the assumptions that there is a perfect correlation between the business line/loss type combinations and there is a linear relationship between the expected and unexpected losses.
- IMA models, although are part of Basel recommended models, but are extremely unpopular in banking sector.



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**Score Card Approach**

# Structure of Score Card Models

- In the Score Card Approach, financial institutions first determine operational risk capital charges for each business line and then modified the amounts of these capital charges according to an operational risk scorecard.
- Scorecard approach differs from IMA and LDA approaches in a way that it relies less exclusively on historical loss data in determining capital amounts.
- After the size of the regulatory capital is determined, its overall size and its allocation across business lines are modified on a qualitative basis.



# Structure of Score Card Models

- However, historical operational risk loss data must be used to validate the results of scorecards.
- Operational risk capital charge in Score Cards models is calculated in 3 steps: Calculation of initial capital charge; Development of score card & risk scoring; and Adjustment of initially calculated capital charge on the basis of score card ratings.
- Under SCA, initial capital charge can be calculated by using a variety of methods that include Standardized Approach, Loss Distribution Approach, Benchmarking proportions of total capital e.g. 20%, Benchmarking vs. other peer institutions, Benchmarking vs. capital for other internal risk types etc.



# Structure of Score Card Models

- The choice of an appropriate method for the calculation of initial capital charge depends upon the basic risk profile of a financial institution. An essential prerequisite for such capital level to be “right” for a particular financial institution is that it must be accepted and used by the Executive Management of that financial institution.
- Development of score card is the most critical and time consuming issue in SC approach. Scorecards aim to measure the quality of key operational risk management processes within a bank.
- The scorecard procedure is based on questionnaires that require quantitative data, qualitative judgments or simple yes/no questions.





# Structure of Score Card Models

- These questionnaires are developed by experts with 2 key objectives which are assessment of firm's exposure to specified risk drivers and quality of firm's internal control system and processes to control these risk drivers.
- Separate questionnaires are developed for each of 8 business lines incorporating business line specific operational risk questions with each question having different weight.
- These scorecards questionnaires are completed by all business units using self-assessment and reviewed by an expert panel who determines the final score for each business unit.



# Structure of Score Card Models

- Let us assume an initial capital charge of \$10,000,000 using TSA and following score card.

QUESTIONS	AVERAGE SCORE	WEIGHTS	WEIGHTED SCORE
1	5.6	10%	0.56
2	7.2	20%	1.44
3	7.0	40%	2.8
4	7.0	20%	1.4
5	7.2	10%	0.72
<b>TOTAL</b>	<b>N/A</b>	<b>100%</b>	<b>6.92</b>

- As the Residual Risk Score of business unit is 6.92, therefore Capital Charge per RRS point can be calculated by dividing \$10,000,000 by 6.92 which comes to \$1,449,275.

# Structure of Score Card Models

- Let us further assume that Residual Risk Score of business unit changes to 6.2 in the scorecard exercise of next quarter.
- As capital charge per point was \$1,449,275 which was established in initial exercise, therefore new capital charge can be calculated by multiplying capital charge of per point of \$1,449,275 with new residual risk score of 6.2 which will generate new capital charge of \$8,985,507.
- As Score Card Approach combines quantitative as well as qualitative methods to calculate capital charge, the scorecard adjustment reflects the level of quality of control in a specific financial institution.





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**Loss Distribution Approach**

# Structure of LDA Models

- Loss Distribution Approach is a statistical approach which is very popular in actuarial sciences for computing aggregate loss distributions.
- This is also the most complicated approach among AMA models and it requires decent amount of quantitative and statistical skills.
- The LDA approach involves modeling of Loss Frequency Distribution and the Loss Severity Distribution separately and then combining these distributions via Monte Carlo simulations or other statistical techniques to form an Aggregate Loss Distribution for each loss type and business line combination, for a given time horizon.



# Structure of LDA Models

- Capital charge is then estimated by calculating the expected and unexpected losses from Aggregate Loss Distribution.
- The 5 sequential steps involved in the capital charge estimation from Loss Distribution Approach are as follows:

Modeling of Loss Frequency Distribution

Modeling of Loss Severity Distribution

Modeling of Aggregate Loss Distribution

Calculation of Expected and Unexpected Losses

Calculation of Capital Charge



# Modeling Frequency Distribution

- Frequency refers to the number of times an operational risk event has occurred during past.
- A minimum history of at least 3 years of frequency data is required for loss frequency modeling.
- A Frequency Distribution is a representation in a graphical form which displays number of times an event has occurred within a given interval over a time horizon.
- Loss Frequency Distribution is composed of Discrete Values which means its data will not contain any fractional numbers.



# Modeling Frequency Distribution

- Loss Frequency Distribution is modeled in 2 stages. In first stage a graph is constructed by using internal historic data of risk event occurrence with x-axis showing the intervals of time horizon and y-axis showing the number of risk events during those intervals.
- In stage two, frequency data is remodeled on the basis of some comparable statistical distribution pattern.
- The reasons why it is done is because loss data is not available in sufficient quantities in any financial institution to permit a reasonable assessment of exposure; therefore it is necessary to put in more data points to supplement loss data, in particular for tail events.





# Modeling Frequency Distribution

- These additional data points cannot be punched in randomly into existing data. They need to be generated on the basis of some formula or statistical function.
- There are a number of statistical functions or formulae that can generate data but the trick is to find a function that uses some parameter of existing data as input and then generate numbers that have pattern similar to existing data.
- The shape of frequency data graph will differ from institution to institution. Graph can be light tailed or heavy tailed, negatively skewed or positively skewed etc. therefore; statistical tests are conducted to determine which particular type of distribution function should be used to model data.



# Modeling Frequency Distribution

- Graphical plots are also used to determine whether the data show light-tailed or heavy-tailed behavior, it also shows whether certain data portions can be modeled using the standard empirical distribution and what the possible thresholds for modeling might be, and whether one dataset or cell needs to be divided into and modeled across multiple segments.
- Most popular statistical distributions to model loss frequency are Poisson Distribution & Binomial Distribution.



# Modeling Severity Distribution

- Severity refers to the financial impact of an operational risk event when it occurs.
- Severity modeling is quite a difficult task. One main reason is the lack of data.
- Loss data is not available in sufficient quantities in any financial institution to permit a reasonably accurate quantification of exposure, particularly in terms of quantifying the risk of extreme losses.
- Internal loss data covering the last 5 to 7 years is usually not sufficient for calibrating tails of severity distributions.



# Modeling Severity Distribution

- Tails of severity distributions represents loss events with extremely low loss probability but extremely high severity.
- It is obvious that additional data sources like external loss data and scenarios are needed to improve the reliability of the model. However, inclusion of this type of information immediately leads to additional problems, e.g. scaling of external loss data, combining data from different sources, etc.
- Even if all of the available data sources are used it is necessary to extrapolate beyond the highest relevant losses in the data base.



# Modeling Severity Distribution

- The standard technique is to fit a parametric statistical distribution to the available data and to assume that its parametric shape will provide at least a near realistic model for potential losses beyond the current loss experience.
- The choice of the statistical distribution is a not an easy task and it usually has a significant impact on model results.
- Sometimes it is not possible to identify a standard statistical distribution that provides reasonable fits to the loss data across the entire range.



# Modeling Severity Distribution

- The only solution to this problem is to use different statistical distribution assumptions for the body and the tail of these severity distributions. However, this strategy adds yet another layer of complexity to severity modeling.
- When internal data shows light-tailed behavior, the Beta, Chi-square, Exponential, Gamma, Inverse Gaussian, Log Normal, Normal, Weibull and Rayleigh distributions are considered for severity modeling.
- If internal data shows heavy-tailed behavior, the Burr, Cauchy, F-, Generalized Pareto, Generalized Extreme Value, Log Gamma, Log Logistic, Pareto and Student's t-distributions are used for severity modeling.



# Modeling Severity Distribution

- Once a standard statistical distribution is selected in line with data's tail behavior, various statistical tests are conducted to evaluate Goodness of Fit (GOF) to ascertain the appropriateness of selected statistical distribution.
- The most commonly used tests are Kolmogorov-Smirnov, Cramer von Mises, Anderson-Darling, Analysis of Fit Differences, Evaluation PP, Evaluation QQ, Chi-square Tests and Mean Square Error Estimates.
- Apart from statistical tests, a number of graphical tests are also used to supplement the GOF tests.



# Modeling Severity Distribution

- These include Probability-Differences Plots, Probability-Probability (PP) Plots and Quantile-Quantile (QQ) Plots. For QQ plots, Linear Scale QQ Plots, Logarithmic Scale QQ plots, Relative Error Plots and Absolute Error Plots.
- The final decision is made for the selection of most suitable statistical distribution after all the graphical and non-graphical GOF measures.
- And finally, Loss Severity Distribution is generated as the result of combining of the actual distribution of the low severity distribution portion created by internal loss data, and the selected standard statistical loss distribution for the high severity distribution portion created by scenario data.





# Modeling Aggregate Loss Distribution

- Once frequency and severity distributions are modeled, the next step is to model aggregate loss distribution.
- Aggregate loss is estimated by combining frequency and severity distributions.
- As frequency is a discrete distribution while severity is a continuous distribution, therefore frequency is converted into continuous probability during the process.
- Event categories are assumed to be independent of each other; therefore, one simulation per risk category for each business unit needs to be calculated. Therefore, this process is done for every risk category within each business line.



# Modeling Aggregate Loss Distribution

- In order to gauge the soundness of this process, each modeled risk is reviewed and analyzed for its reasonableness in terms of matching average loss of aggregated distribution with actual data and comparing 99.9% confidence levels with worst historic cases for similar businesses and risk event types.
- There are two commonly used ways to convolute/combine frequency and severity distributions i.e. simulation method and tabulation method.
- The most popular simulation method is Monte Carlo simulation.



# Modeling Aggregate Loss Distribution

- The expression "Monte Carlo Method" is actually very general. Monte Carlo (MC) methods are stochastic techniques meaning they are based on the use of random numbers and probability statistics to investigate problems.
- The Monte Carlo method was invented in the 1940s by John von Neumann, Stanislaw Ulam and Nicholas Metropolis during their work on nuclear weapon project named Manhattan Project.
- They gave it the code name of Monte Carlo after the city in Monaco, where the primary attractions are casinos that have games of chance like roulette, dice, and slot machines, which exhibit random behavior.



# Modeling Aggregate Loss Distribution

- The MC simulation randomly chooses an annual number of events from the frequency distribution.
- The most likely choice will always be equal to the mean, and the further a number is away from the mean, the less likely it is that the MC process will chose this number.
- This randomly selected number is the frequency for that iteration. The frequency is then used as the number of draws that the MC simulation selects from the severity distribution.
- Each of these draws from the severity distribution represents a loss event. All these drawn loss amounts are summed to create the aggregate annual loss amount.



# Modeling Aggregate Loss Distribution

- This process is repeated until the desired number of iterations is run.
- The aggregate loss amounts from iterations are sorted from low to high.
- The average of all the results is the mean of the aggregate loss distribution.
- Once the parameters for all the different risk categories are calculated, the combined Monte Carlo simulation is used to generate a total aggregate loss distribution for the business unit.
- During the simulation process, the loss amounts generated by the iterations are added together to create the amount of the combined distribution.



# Modeling Aggregate Loss Distribution

- Monte Carlo simulation provides a number of advantages over deterministic, or “single-point estimate” analysis.
- Results show not only what could happen, but how likely each outcome is.
- Because of the data a Monte Carlo simulation generates, it's easy to create graphs of different outcomes and their chances of occurrence.
- With just a few cases, deterministic analysis makes it difficult to see which variables impact the outcome the most. In Monte Carlo simulation, it's easy to see which inputs had the biggest effect on bottom-line results.



# Modeling Aggregate Loss Distribution

- In Monte Carlo simulation, it's possible to model interdependent relationships between input variables. It's important for accuracy to represent how, in reality, when some factors go up, others go up or down accordingly.

## LOSS DATA

Frequency	Probability	Severity	Probability
0	0.6	1,000	0.5
1	0.3	10,000	0.3
2	0.1	100,000	0.2

# Modeling Aggregate Loss Distribution

## LOSS TABULATION

No. of Losses	1st Loss	2nd Loss	Total Loss	Probability
0	0	0	0	0.6
1	1,000	0	1,000	0.15
1	10,000	0	10,000	0.09
1	100,000	0	100,000	0.06
2	1,000	1,000	2,000	0.025
2	1,000	10,000	11,000	0.015
2	1,000	100,000	101,000	0.010
2	10,000	1,000	11,000	0.015
2	10,000	10,000	20,000	0.009
2	10,000	100,000	110,000	0.006
2	100,000	1,000	101,000	0.010
2	100,000	10,000	110,000	0.006
2	100,000	100,000	200,000	0.004
<b>Total</b>				<b>1.00</b>



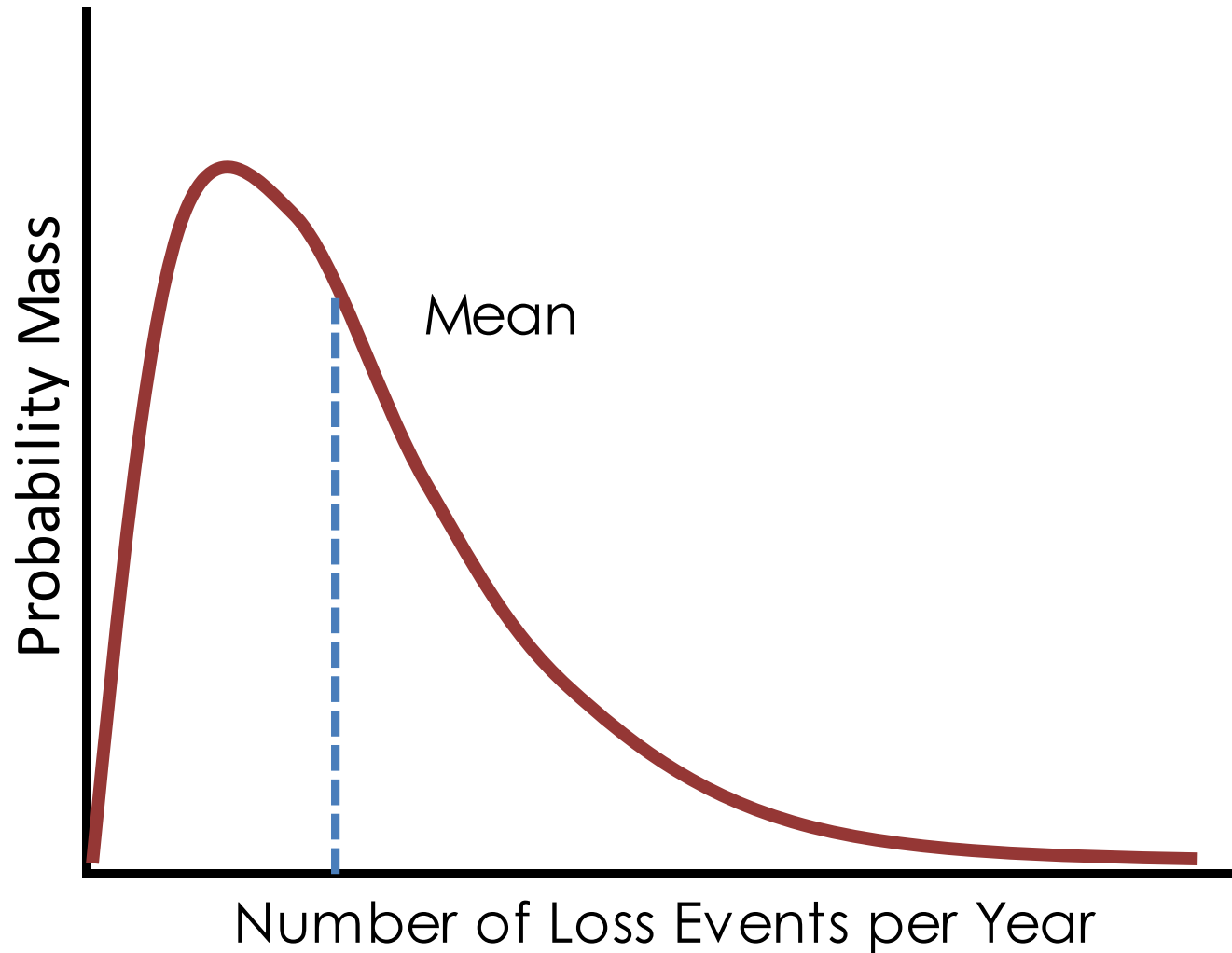
# Modeling Aggregate Loss Distribution

LOSS AGGREGATION	
Total Loss	Cumulative Probability
0	0.600
1,000	0.750
10,000	0.840
100,000	0.900
2,000	0.925
11,000	0.940
101,000	0.950
11,000	0.965
20,000	0.974
110,000	0.980
101,000	0.990
110,000	0.996
200,000	1.000



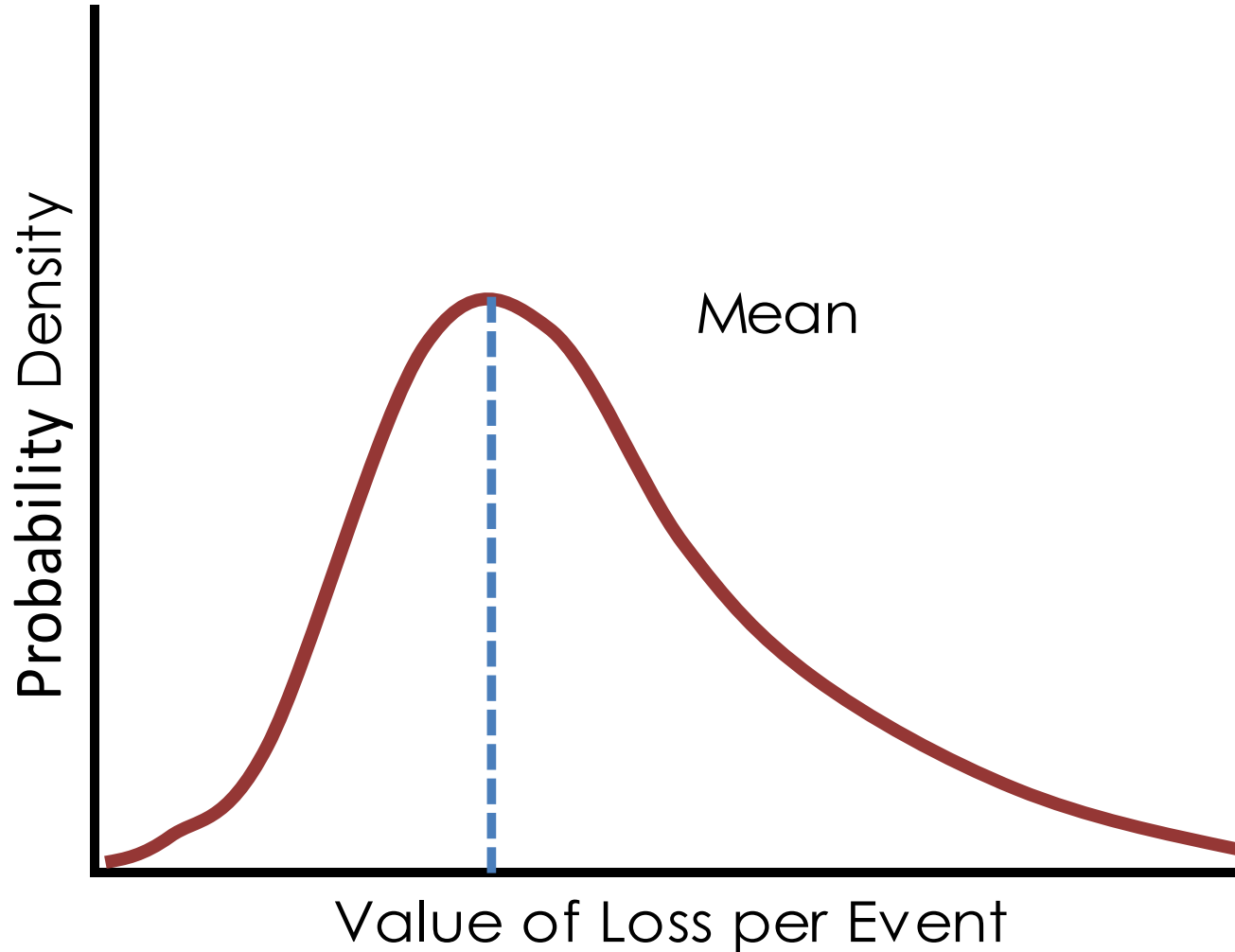
# Modeling Aggregate Loss Distribution

## LOSS FREQUENCY DISTRIBUTION

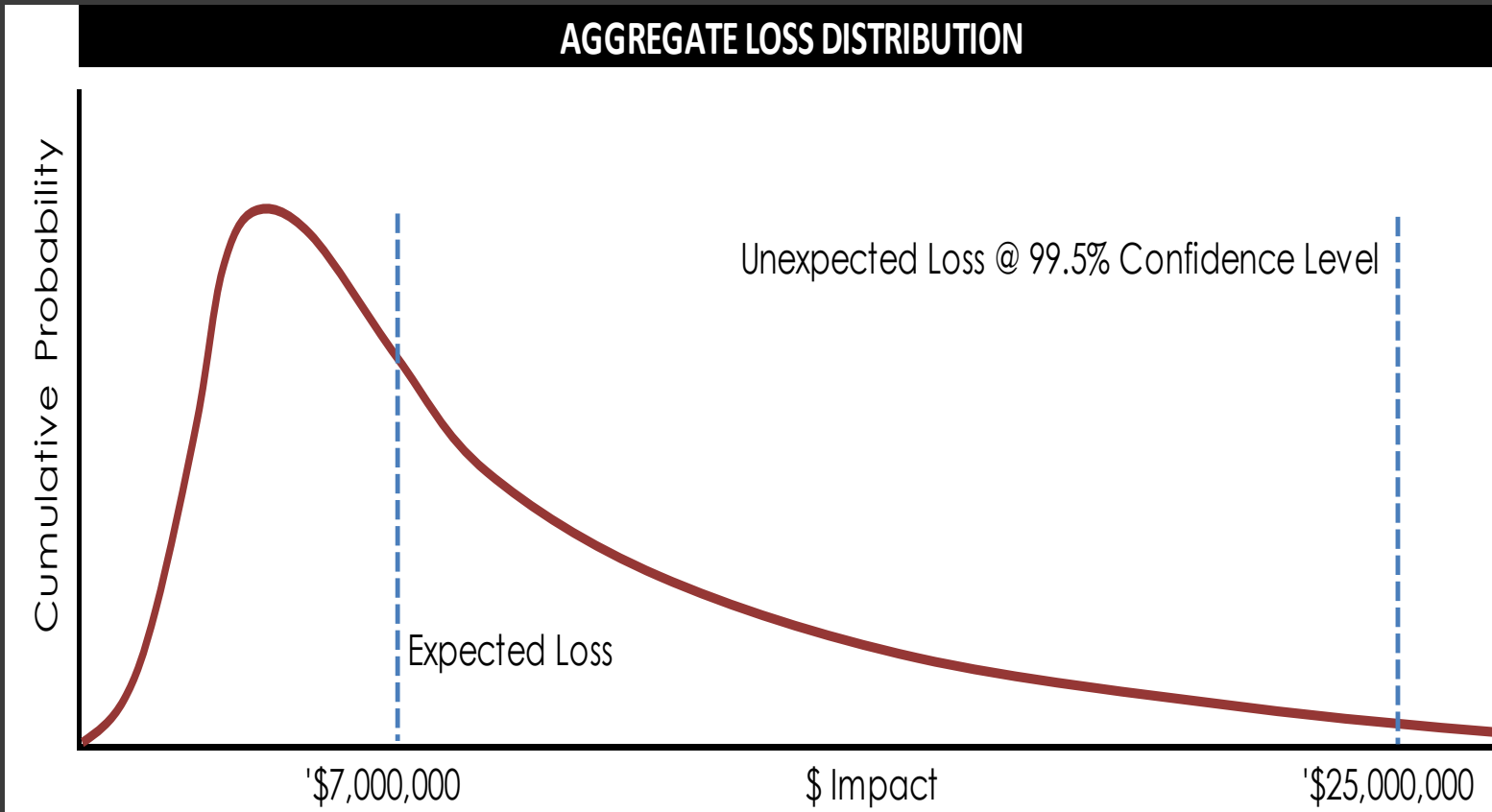


# Modeling Aggregate Loss Distribution

## LOSS SEVERITY DISTRIBUTION



# Modeling Aggregate Loss Distribution



# Calculation of Expected & Unexpected Losses

- Once aggregate loss distribution is established, calculation of expected and unexpected losses is a straight forward process.
- Expected losses are described as the “usual” or average losses that a bank incurs in its normal course of business, while unexpected losses are deviations from the average that may put a bank’s financial stability at risk.
- The first step involved in calculation of expected and unexpected level is to establish an appropriate confidence level.
- A confidence level is a statistical concept which corresponds to the probability that a bank will not go bankrupt due to extreme losses.



# Calculation of Expected & Unexpected Losses

- Theoretically ideal confidence levels should be close to 100 %.
- However, in practice, this is not possible since loss distributions are never perfectly identified using historical data, and even if these loss distributions are perfectly identified at 100% confidence level, the level of capital required would be too high and costly to maintain.
- The confidence levels used in risk management usually lie in the range from 95 % to 99 % and higher.



# Estimation of Capital Charge

- Operational Value at Risk (VAR) is obtained by taking the percentile of the aggregate loss distribution at the desired confidence level.
- Unexpected loss is the difference between VAR and expected loss.
- This is the amount of capital that the bank should establish to cover unexpected losses for operational risk corresponding to the desired confidence level.
- It should be noted that a prudential level of capital is allocated not for the entire bank as a whole but for specific types of loss events such as internal fraud, external fraud, etc.



**Thank You**

