Stress Testing Operational Risk

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OpRisk Advisory LLC

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OpRisk Advisory

OpRisk Advisory – Company Profile

OpRisk Advisory

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OpRisk Advisory is the world's leading operational risk management consulting firm. We provide the full range of services to help our clients develop highly-efficient, cost-effective operational risk management programs that meet or exceed industry best practices and satisfy the highest level of Basel II compliance.

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We have advised many of the world's largest banks, insurance companies, energy companies and regulators on the full range of operational risk measurement and management issues. As a result, we are able to share many valuable lessons – lessons learned the hard way – about what works, what doesn't work and how it all fits together.

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Modeling operational risk is far more challenging than modeling market or credit risk. For example, modeling operational risk requires both internal and external loss data, but internal data is insufficient and external data is not directly relevant (e.g., requires scaling for size, controls, data capture). Without addressing these two issues objectively and scientifically, it is difficult to see how the results could be meaningful. We have significant experience in addressing these types of issues and can offer you practical, theoretically valid solutions.

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Agenda

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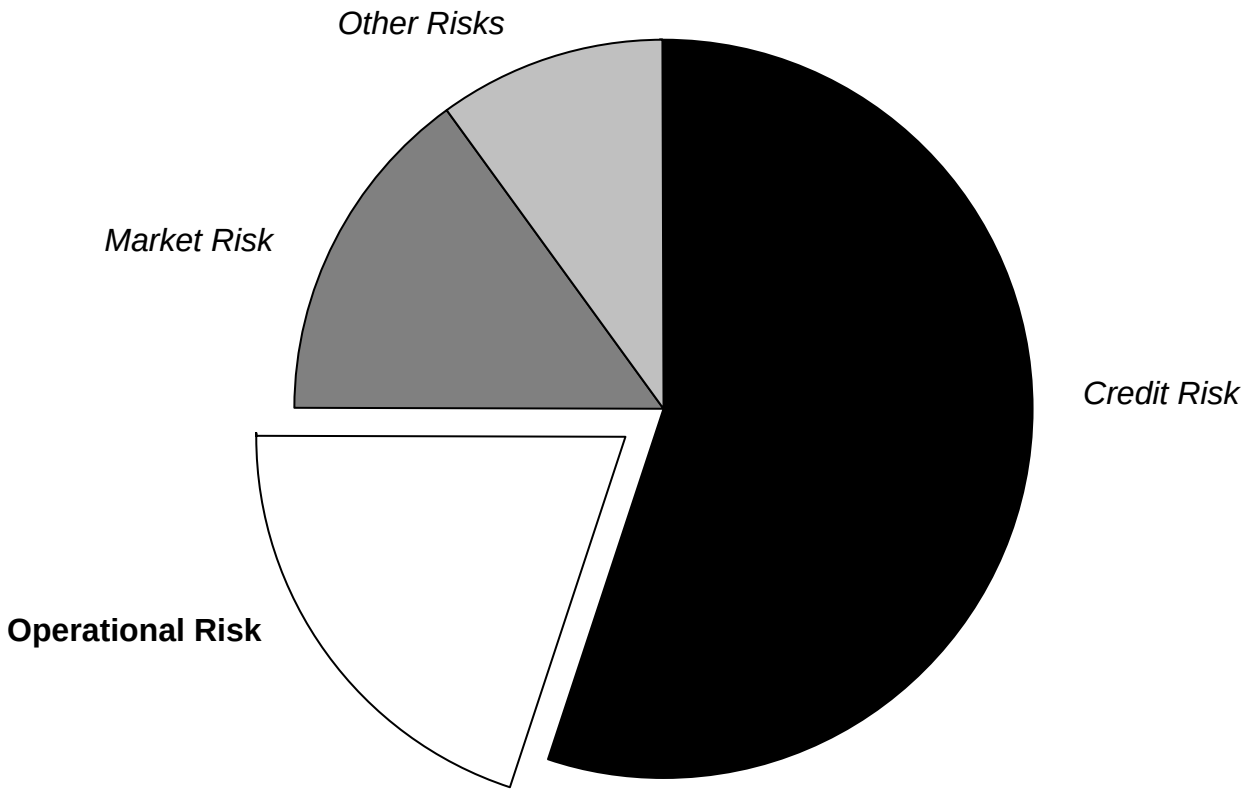
II. What is Operational Risk?
III. Defining & Classifying Operational Risks
IV. Risk Assessment
V. VaR Modeling in Operational Risk
VI. Stress Testing in the Context of Operational Risk Management
VII. Summary & Conclusions

INTRODUCTION

Operational risk is one of the three major risks that banks face. Credit risk is generally thought to be a bank's biggest risk.



But what's driving credit risk?

"More than 80% of our Credit Risk is really just Operational Risk."

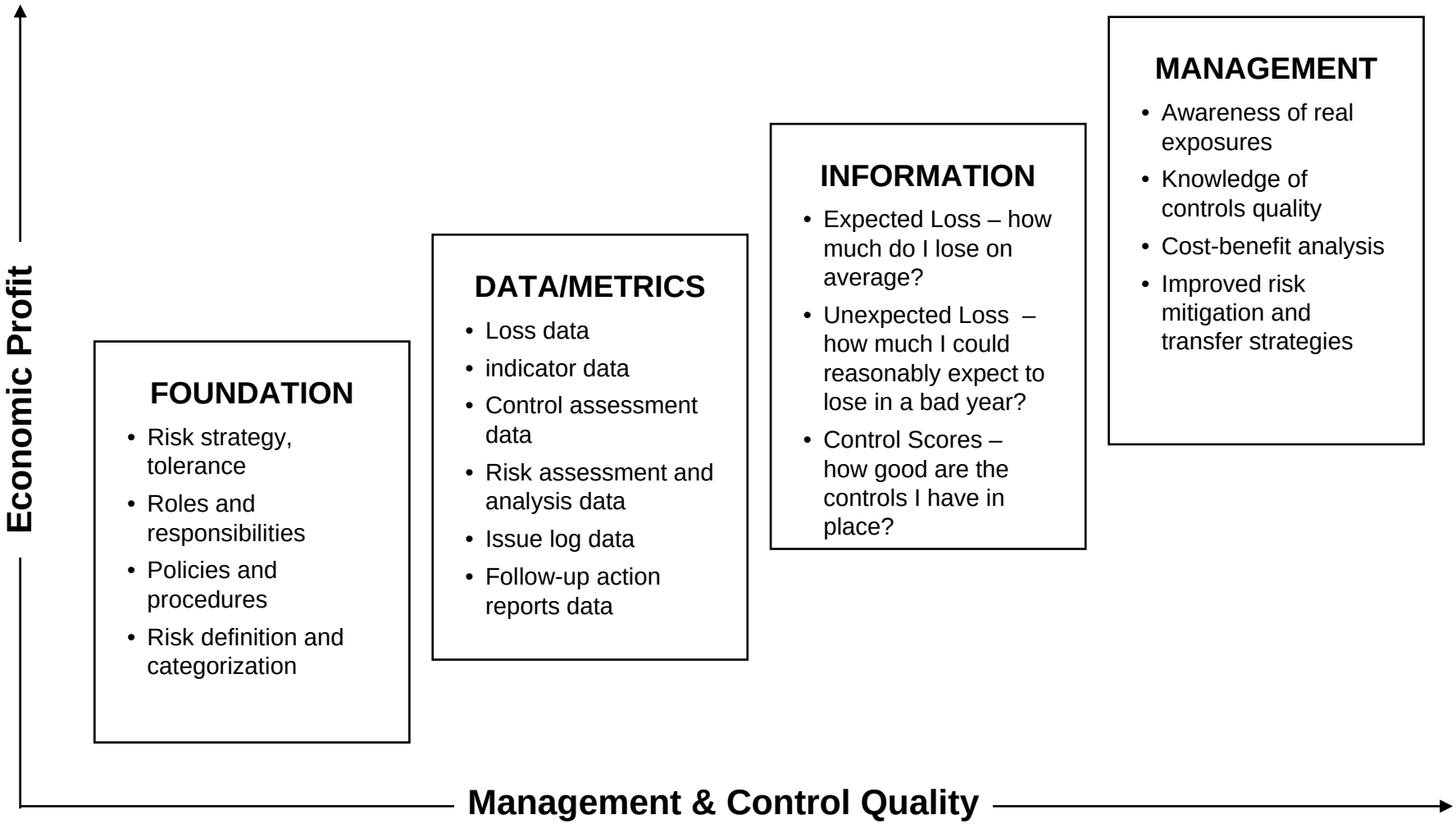
Senior Risk Officer, Large German Bank

Large headline losses have caused banks and regulators to realize that operational risk is one of the most significant risks that banks face.

FIRM NAME	BUSINESS LINE - LEVEL 1	LOSS AMOUNT ($M)	DESCRIPTION
Nomura Securities International Incorporated	Trading & Sales	47.90	In July 1998, Nomura Securities International Inc, the US brokerage unit of Nomura Securities of Japan, reported that it had agreed to pay $47.9M in settlement of charges stemming from the Orange County's bankruptcy lawsuit. The suit was filed against the firm for investing municipal county funds in high risk derivatives and municipal bond trading that was illegal under California law. The Securities Exchange Commission reported that Nomura was one of the brokerage firms responsible for the county's bankruptcy. Orange County claimed to have lost $1.64 billion. The SEC stated that Nomura had lent the county huge sums of money, which it reinvested in search of high returns. Nomura also supplied the risky securities favoured by then county Treasurer and Tax Collector Robert L. Citron that plunged in value when interest rates rose sharply in 1994. The SEC also charged the firm for its role in underwriting key bonds for the county and accused Citron of illegally investing in volatile securities that were unsuitable for public funds.
ABN Amro Holding NV	Agency Services	141.00	In November 1998, ABN Amro Holding NV, a Netherlands full services bank and Europe's eighth largest banking firm, reported that it had realized a loss of 174M guilders ($141M) due to forgery, embezzlement and fraud perpetrated by four of its former employees. The four allegedly committed about 600 fraudulent transactions, making improper use of about 30 client accounts. The bank said that after uncovering the irregularities, it fired the employees and notified law enforcement officials in February, 1997. The transactions took place within the bank's trust department, whose functions included maintaining bank accounts for 600 to 800 clients living abroad. Its products included numbered bank accounts for clients whose identities were known only within the department. Employees also executed orders solely on the basis of telephone instructions. The bank said that, upon inspection, some packages in custody that supposedly contained diamonds turned out to contain false diamonds, and diamond shipment orders given by clients were sometimes accompanied by falsified invoices.
Merrill Lynch & Company	Trading & Sales	100.00	In December 1997, Merrill Lynch & Co, a US broker-dealer, reported that it had agreed to pay $100M in fines to settle charges of price fixing on the Nasdaq stock market. The Securities and Exchange Commission fined 30 Wall Street firms more than $910M in this regard. The lawsuit alleged that as many as a million investors lost billions of dollars because of collusion among the firms between 1989 and 1994. This collusion caused an artificial widening of spreads, the gap between the purchase and selling prices of stocks, thereby adding to dealer profits. The settlement also required the firms to improve trading policies and procedures. The case began in 1994, when the SEC and the Justice Department accused major Nasdaq dealers of conspiring to fix the bid-ask spreads on stock quotes resulting in extra costs to ordinary investors on their stock trades. Under the settlement, the brokerage firms with the most alleged violations agreed to pay higher fines. In making its original case, the SEC charged that major Nasdaq dealers harassed or refused to trade with others who tried to offer investors a better price for a stock.
WGZ Bank	Trading & Sales	200.37	In October 1998, Westdeutsche Genossenschafts-Zentralbank AG (WGZ-Bank), a German commercial bank, reported that it had realised a loss of DM 377 ($200.4M) due to computer fraud perpetrated by two employees over the past sixteen months. The bank has initiated a case against the two employees, who used a loophole in the bank's computer system for currency derivatives. They entered unrealistic intermediary values, which the system failed to document and managed to realise the profits in their derivative securities. The fraud was only discovered after the installation of an updated system, required under a new law, which eliminates the opportunity for such manipulation.
Korea First Bank	Commercial Banking	93.00	In April 1998, Korea First Bank, a South Korean commercial bank with operations in the US, reported that it had agreed to pay $93M in settlement of a lawsuit that charged it with wrongfully dishonoring its irrevocable letter of credits. The New York Appellate Court ruled in favour of CalEnergy Company Inc, a global energy company that manages and owns an interest in over 5000 megawatts of power generation capability among various facilities in operation, construction and development worldwide. Casecnan Water and Energy Company Inc, a subsidiary of Calenergy was executing a power project in the Philippines. Hanbo Corporation had been acting as the turnkey contractor and guarantor for the Casecnan project.KFB's letter of credit was issued as financial security for the obligations of Hanbo. The contract with Hanbo Corp. was terminated by Casecnan due to Hanbo's insolvency and other misperformance in the project, at which time Casecnan made an initial draw on the KFB letter of credit securing Hanbo's performance under the contract. Furthermore, Casecnan had made three susbsequent draws on the letter of credit, all of which were opposed by Hanbo and draws under the letter of credit were dishonoured by Korea First Bank.
Citibank	Commercial Banking	30.00	In September 1999, Citibank, a US commercial bank with global operations and unit of Citigroup, reported that it had realized a loss of $30M due to credit fraud. The firm's UK branch was one of 20 financial institutions operating in the Middle East which were the victims of fraud. Madhav Patel, an Indian businessman, allegedly deceived the bank by using forged documents to secure letters of credit guaranteeing payment for bogus transactions. The alleged fraud came to light earlier this year when Patel's British registered firm, Solo Industries, ran into financial difficulties in the Middle East. Patel, who ran several metal smelting businesses in Dubai, secured letters of credit from the firm as well as other banks to guarantee payments on shipments of metal to the United Arab Emirates. Police believe the shipments were bogus and the money was diverted elsewhere. Patel moved to London after his business collapsed in May. He has since disappeared.

Source SAS OpRisk Global Data

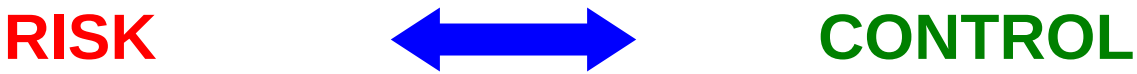
Effectively managing operational risk requires a framework designed to turn raw operational risk data into information that supports managerial decision making.



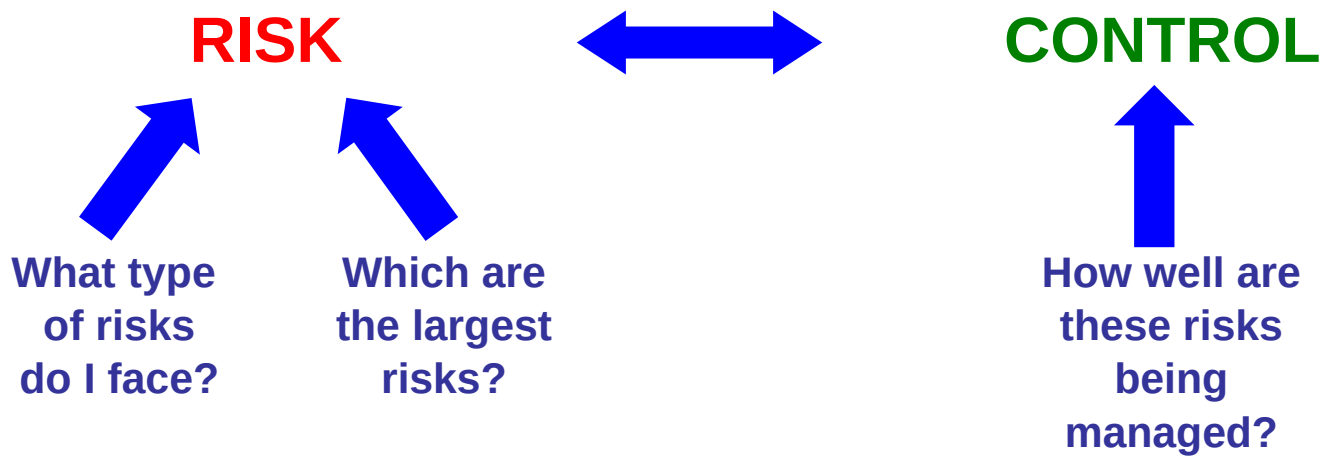
Risk management means first of all managing the risk reward relationship. When entering a new business one must consider reward in the context of risk.

RISK  **REWARD**

Once an organization has invested in a business, risk management involves managing the risk-control relationship in the context of cost benefit analysis.



Operational risk management is the process of optimizing the risk control relationship in the context of cost-benefit analysis.



To make clear what operational risk management is really all about, we need to express it in the context of a business problem.

Consider two risks: Unauthorized Trading and Money Transfer

- Past Audits reveal that both risks are under-controlled
- To address Unauthorized Trading risk one must improve segregation of duties and audit frequency. (Solution: hire four new staff; cost = $400,000 per year)
- To address Money Transfer risk one must improve the system (Solution: buy a new system; cost = $5 million)
- You have $4 million in your budget. Where do you invest your money?

WHAT IS OPERATIONAL RISK?

What is the “textbook” definition of risk? The best way to illustrate risk is through an example.

Security A	Guaranteed return of 10%
Security B	50% probability of a 0% gain 50% probability of a 20% gain
Security C	50% probability of a 10% loss 50% probability of a 30% gain

Which investment has the highest expected return?

Which investment has the most risk?

How much risk is there in each investment?

Which security is the best investment?

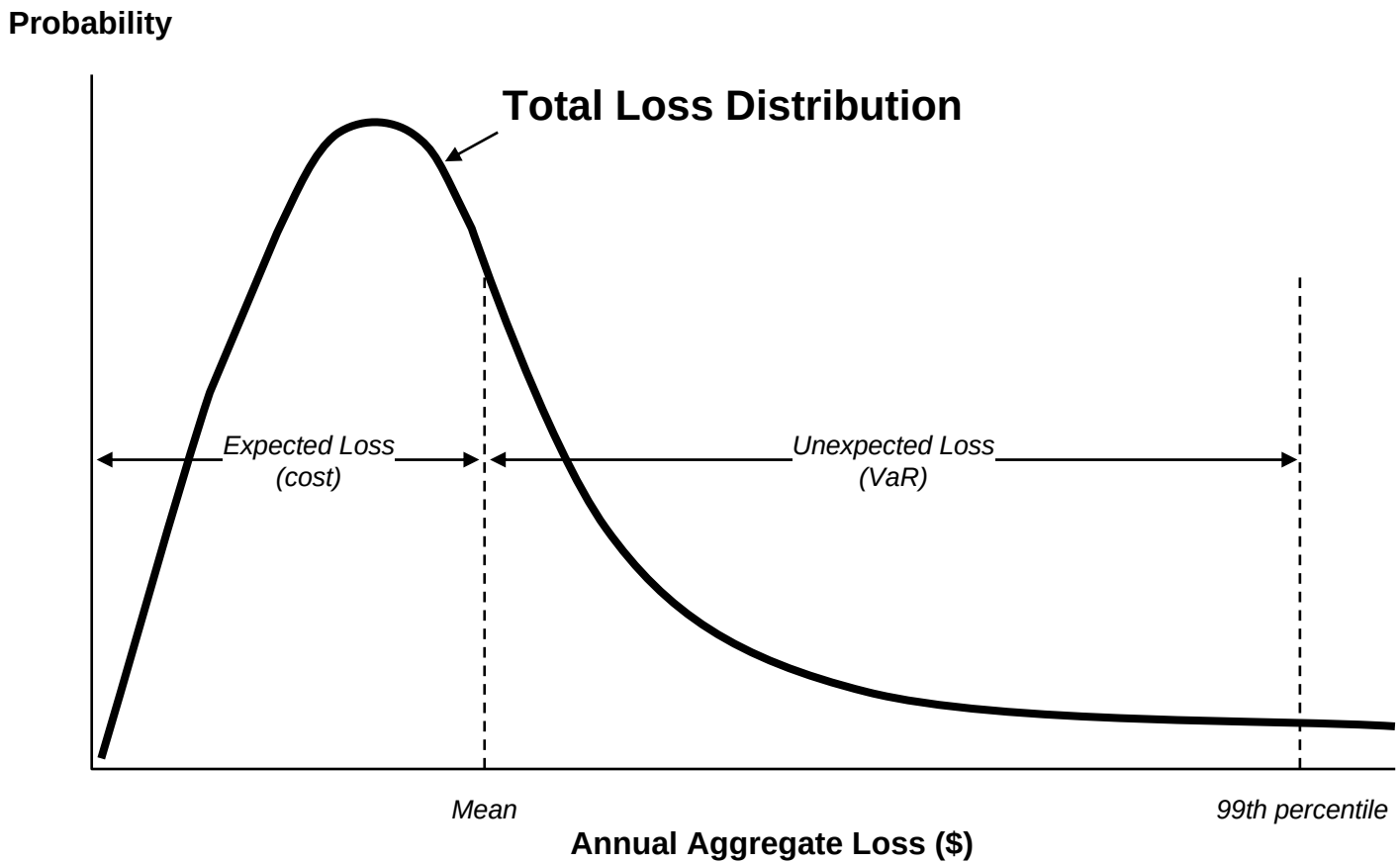
What can we conclude about risk?

- Risk has to do with uncertainty (where there is certainty there is no risk – Security A).
- Risk must be measured at a level of uncertainty (confidence level, e.g., 99%).
- However, it is often possible to ranks risks without specifying the confidence level.
  - We know that Security A is less risky than Security B which is less risky than Security C, even without knowing how much risk each investment poses at the 99% level.

What else do we know about risk?

- Risk is neither inherently good nor bad.
- A risk-neutral person will consider all three investments to be of equal value.
- A risk lover will choose Security C because it offers the higher possible return (30%) among choices with the same expected return (10%) and because risk increases his/her utility.
- Because most people are risk averse, they require more reward for assuming more risk, so will choose Security A. (Equal return with no risk).

Operational risk is the risk of a loss at a specified confidence level.

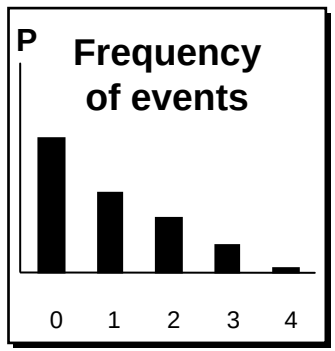


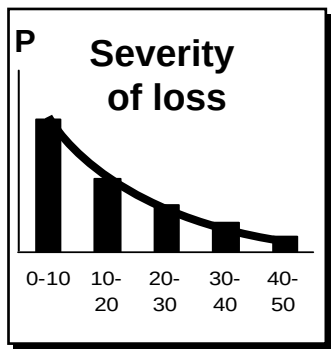
Since operational risk is measured in terms of the aggregate loss, there are two components to operational risk: Frequency and Severity. This is much more challenging than modeling market or credit risk.

INDIVIDUAL LOSS EVENTS | **RISK MATRIX FOR LOSS DATA** | **LOSS DISTRIBUTIONS** | **VAR CALCULATION** | **TOTAL LOSS DISTRIBUTION**

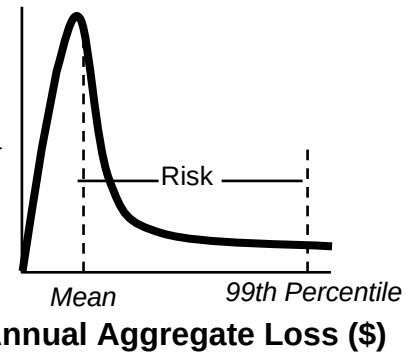
74,712,345
74,603,709
74,457,745
74,345,957
74,344,576
•
•
•
167,245
142,456
123,345
113,342
94,458

		INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES & WORKPLACE SAFETY	CLIENTS, PRODUCTS & BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	EXECUTION, DELIVERY & PROCESS MANAGEMENT	BUSINESS DISRUPTION AND SYSTEM FAILURES	TOTAL
Corporate Finance	Number	36	3	25	39	23	150	2	315
	Mean	56,458	52,056	3,456	56,990	56,784	1,246	89,674	42,215
	Standard Deviation	9,693	8,975	3,845	7,890	3,456	245	23,543	9,976
Trading & Sales	Number	56	4	30	49	40	210	3	441
	Mean	53,189	79,066	6,184	85,395	86,501	1,999	134,517	66,322
	Standard Deviation	8,541	12,493	5,766	11,835	5,184	388	35,315	10,464
Retail Banking	Number	46	4	32	49	42	189	3	397
	Mean	67,870	73,274	4,646	79,992	76,965	1,982	121,066	59,990
	Standard Deviation	7,897	12,116	5,191	10,462	4,969	331	31,783	9,417
Commercial Banking	Number	41	3	28	41	37	170	3	367
	Mean	63,092	62,248	4,199	69,121	66,992	1,924	108,968	53,721
	Standard Deviation	8,918	10,905	4,672	9,589	4,299	298	28,655	9,476
Payment & Settlements	Number	37	3	29	47	34	163	2	321
	Mean	58,774	56,923	3,779	62,209	62,029	1,263	98,063	48,349
	Standard Deviation	8,216	9,814	4,255	8,618	3,779	318	25,744	7,928
Agency Services	Number	44	4	31	44	40	184	3	386
	Mean	49,529	48,208	4,535	74,464	74,446	1,635	117,675	58,019
	Standard Deviation	7,472	11,777	5,049	10,352	4,535	321	30,893	9,154
Asset Management	Number	40	3	28	43	36	195	2	367
	Mean	61,876	61,477	4,081	67,186	67,062	1,472	106,908	52,217
	Standard Deviation	8,716	10,596	4,541	9,318	4,081	289	27,914	9,238
Retail Brokerage	Number	48	4	33	48	44	198	3	417
	Mean	60,242	72,773	4,898	80,423	80,402	1,766	127,066	62,660
	Standard Deviation	9569	12710	5438	11182	4898	347	33346	9886
Insurance	Number	43	4	30	43	39	179	2	376
	Mean	65,226	66,355	4,458	72,961	72,362	1,589	114,381	55,264
	Standard Deviation	7,242	11,647	4,964	10,063	4,458	312	30,029	8,897
Total	Number	435	36	302	435	396	1,812	24	3,806
	Mean	61,653	67,021	4,460	73,245	73,044	1,604	116,458	56,926
	Standard Deviation	7,331	13,535	4,960	10,198	4,459	316	30,351	8,981





VaR Calculator e.g., Monte Carlo Simulation Engine



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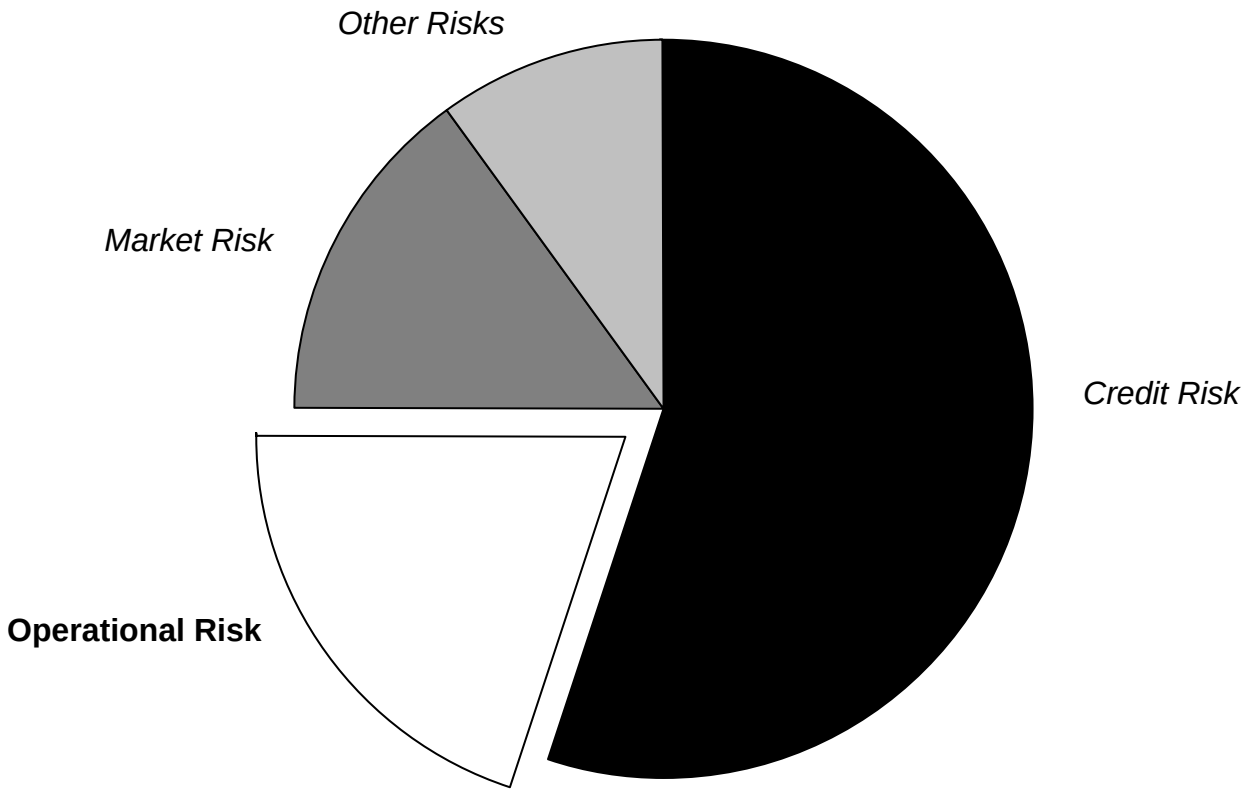
DEFINING & CLASSIFYING OPERATIONAL RISKS

REVIEW: Operational risk is one of the three major risks that banks face. Credit risk is generally thought to be a bank's biggest risk.



What comprises operational risk?

Transaction

Execution

Settlement

Technological

Inadequate Supervision

Information

Key Man

Lack of Resources

Reputation

Relationship

Theft

Criminal

Insufficient Training

Unauthorized Activities

Fraud

Rogue Trader

Compliance

Legal

Fiduciary

Physical Assets

Poor Management

Fixed Cost Structures

Customer

Sales Practices

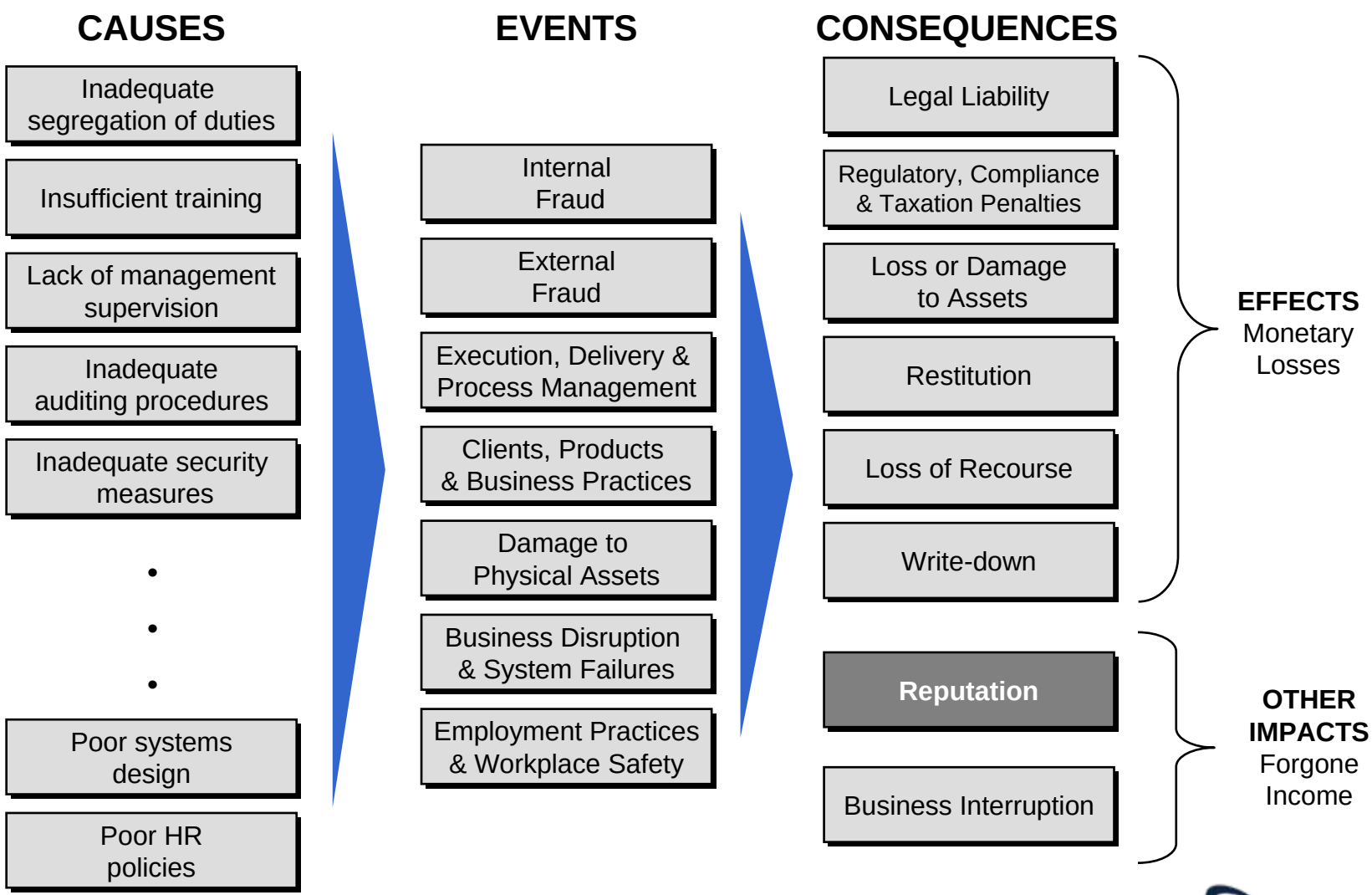
Business Interruption

People

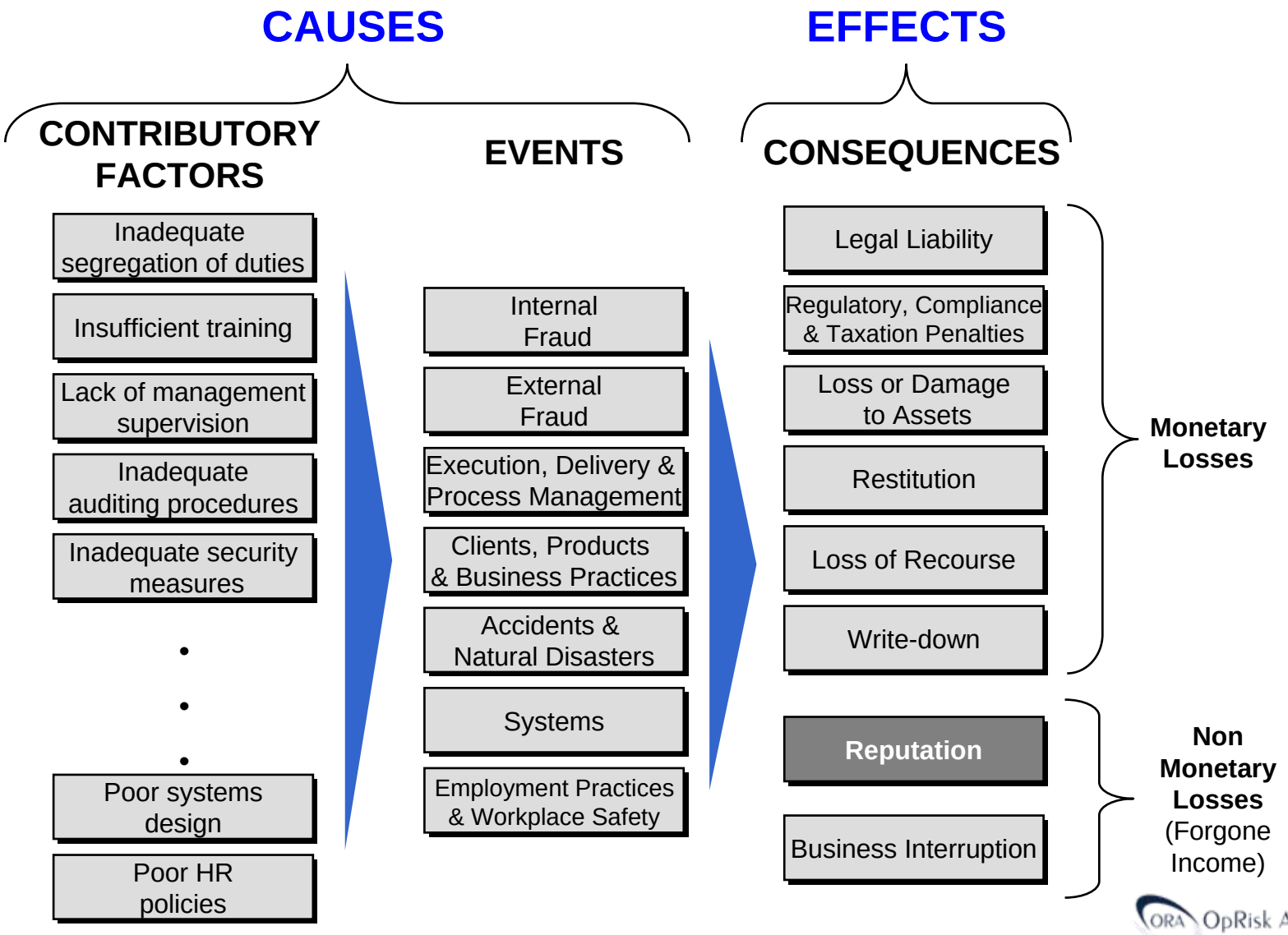
Effective ORM requires a structured way of thinking about risk – a meaningful way of conceptualizing the issues and a common language. What are the standards for defining and categorizing operational risk?

Management Information	Grouping of like items (homogenous risk types) to facilitate the management of similar risks which have similar controls
Statistical Consistency	Mutually exclusive (uncorrelated) and exhaustive (comprehensive) homogenous distributions
Logical Consistency	Must be based on natural boundaries; examples must be consistent with definitions

The universe of operational risk is best understood in terms of its three dimensions: causes, events and consequences.



Upon further analysis, it appears that “causes” consist of both contributory factors and events (contributory factors and events together cause losses).

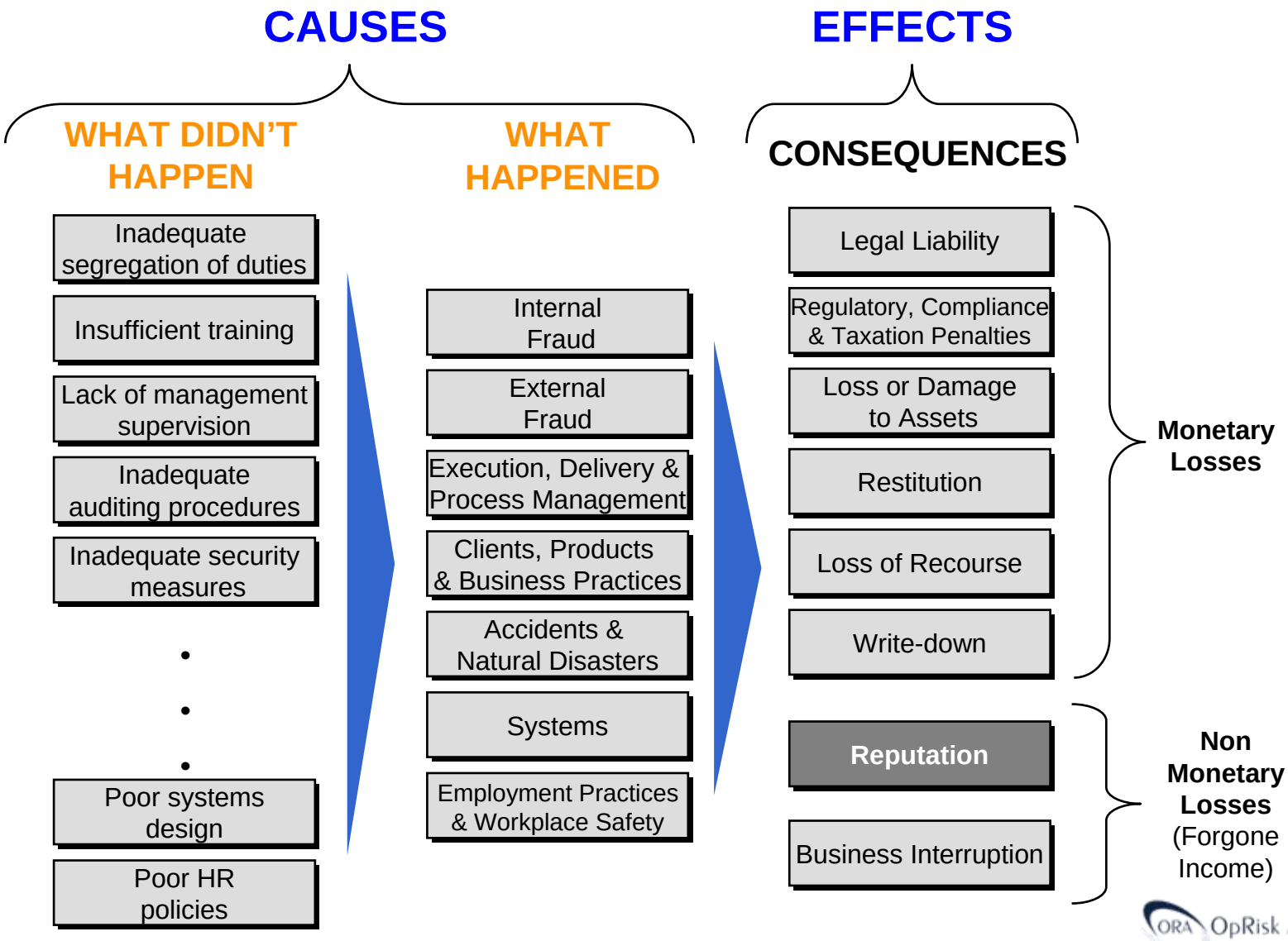


The starting point for diagnostic analysis is the business line event risk matrix.

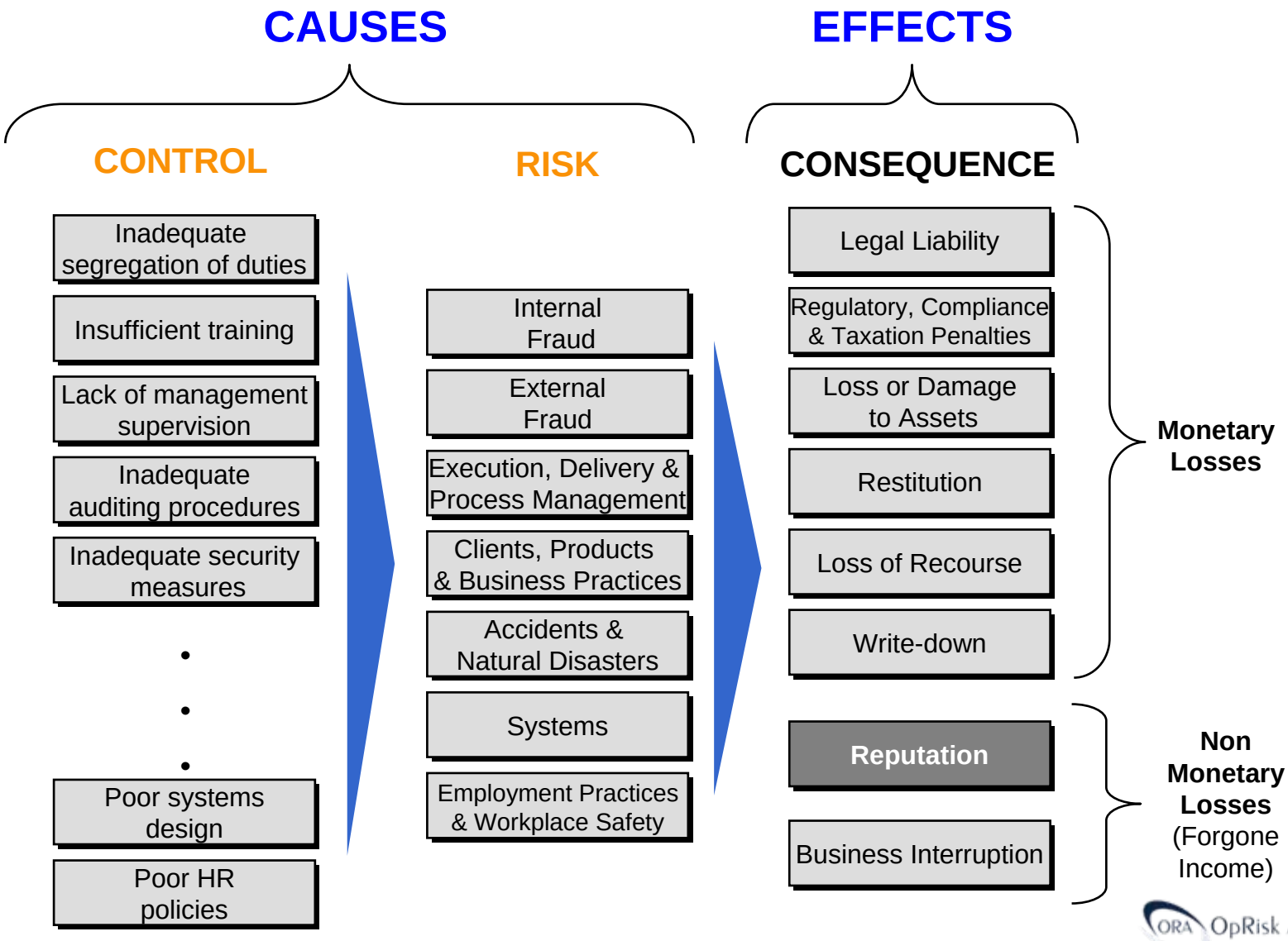
EVENT RISK MATRIX

		INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES & WORKPLACE SAFETY	CLIENTS, PRODUCTS & BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	EXECUTION, DELIVERY & PROCESS MANAGEMENT	BUSINESS DISRUPTION AND SYSTEM FAILURES	TOTAL
Corporate Finance	Number	362	123	25	36	33	150	2	731
	Mean	35,459	52,056	3,456	56,890	56,734	1,246	89,678	44,215
	Standard Deviation	5,694	8,975	3,845	7,890	3,456	245	23,543	6,976
Trading & Sales	Number	50	4	35	50	46	210	3	398
	Mean	53,189	78,084	5,184	85,335	85,101	1,869	134,517	66,322
	Standard Deviation	8,541	13,463	5,768	1[illegible]335	5,184	368	35,315	10,464
Retail Banking	Number	45	4	32	4[illegible]	42	189	3	360
	Mean	47,870	70,276	4,666	[illegible]802	76,591	1,682	121,065	59,690
	Standard Deviation	7,687	12,116	5,191	[illegible]	4,666	331	31,783	9,417
Commercial Banking	Number	41	3	28	[illegible]	37	170	2	322
	Mean	43,083	63,248	4,[illegible]	[illegible]121	68,932	1,514	108,959	53,721
	Standard Deviation	6,918	10,905	4,[illegible]	9,586	4,199	298	28,605	8,476
Payment & Settlements	Number	37	3	[illegible]6	37	34	153	2	292
	Mean	38,774	56,9[illegible]	[illegible]	62,209	62,039	1,363	98,063	48,349
	Standard Deviation	6,226	9,814	4,[illegible]05	8,628	3,779	268	25,744	7,628
Agency Services	Number	44	4	31	44	40	184	2	349
	Mean	46,529	68,308	4,535	74,651	74,446	1,635	117,675	58,018
	Standard Deviation	7,472	11,777	5,045	10,353	4,535	321	30,893	9,154
Asset Management	Number	40	3	28	40	36	165	2	314
	Mean	41,876	61,477	4,081	67,186	67,002	1,472	105,908	52,217
	Standard Deviation	6,725	10,599	4,541	9,318	4,081	289	27,804	8,238
Retail Brokerage	Number	48	4	33	48	44	198	3	378
	Mean	50,252	73,773	4,898	80,623	80,402	1,766	127,090	62,660
	Standard Deviation	8069	12719	5449	11182	4898	347	33365	9886
Insurance	Number	43	4	30	43	39	179	2	340
	Mean	45,226	66,395	4,408	72,561	72,362	1,589	114,381	56,394
	Standard Deviation	7,262	11,447	4,904	10,063	4,408	312	30,028	8,897
Total	Number	710	152	268	384	351	1,598	21	3,484
	Mean	45,653	67,021	4,450	73,245	73,044	1,604	115,459	56,926
	Standard Deviation	7,331	11,555	4,950	10,158	4,450	315	30,311	8,981

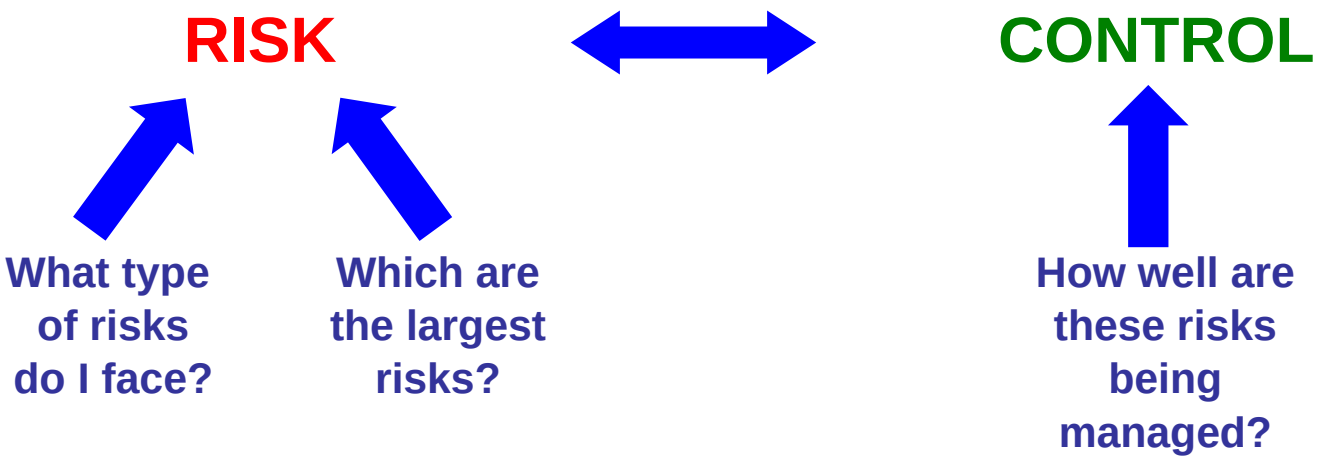
Contributory factors are things that should have been done, but weren't done (nothing has necessarily happened). Events represent something that happened (e.g., a loss).



Contributory factors are really control issues. Events represent classes of "inherent" risk types. Contributory factors and consequences can be controlled. Events are not controllable directly.



Operational risk management is the process of optimizing the risk control relationship in the context of cost-benefit analysis.



RISK ASSESSEMENT

Risk can also be assessed using a likelihood-impact approach. This approach has been well documented by the Committee of Sponsoring Organizations of the Treadway Commission (COSO).

Risk Assessment

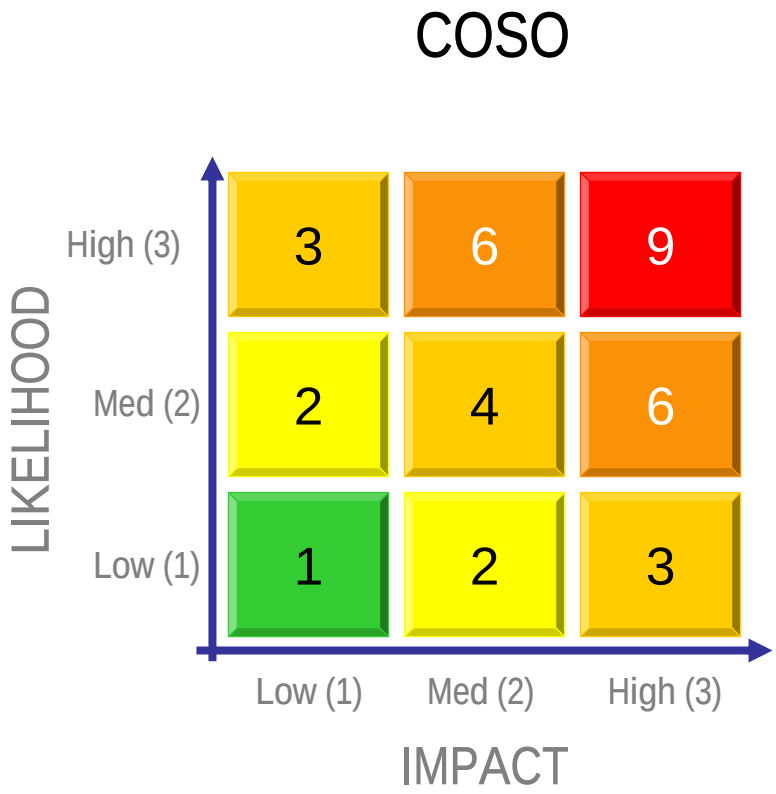
Risk assessment allows an entity to consider how potential events might affect the achievement of objectives. Management assesses events from two perspectives: likelihood and impact.

Likelihood represents the possibility that a given event will occur, while impact represents its effect should it occur. Estimates of risk likelihood and impact often are determined using data from past observable events, which may provide a more objective basis than entirely subjective estimates. Internally generated data based on an entity's own experience may reflect less subjective personal bias and provide better results than data from external sources. However, even where internally generated data are a primary input, external data can be useful as a checkpoint or to enhance the analysis. Users must be cautious when using past events to make predictions about the future, as factors influencing events may change over time.

An entity's risk assessment methodology normally comprises a combination of qualitative and quantitative techniques. Management often uses qualitative assessment techniques where risks do not lend themselves to quantification or when sufficient credible data required for quantitative assessments either are not practicably available or obtaining or analyzing data are not cost-effective. Quantitative techniques typically bring more precision and are used in more complex and sophisticated activities to supplement qualitative techniques. An entity need not use common assessment techniques across all business units. Rather, the choice of techniques should reflect the need for precision and the culture of the business unit. In any event, the methods used by individual business units should facilitate the entity's assessment of risks across the entity.

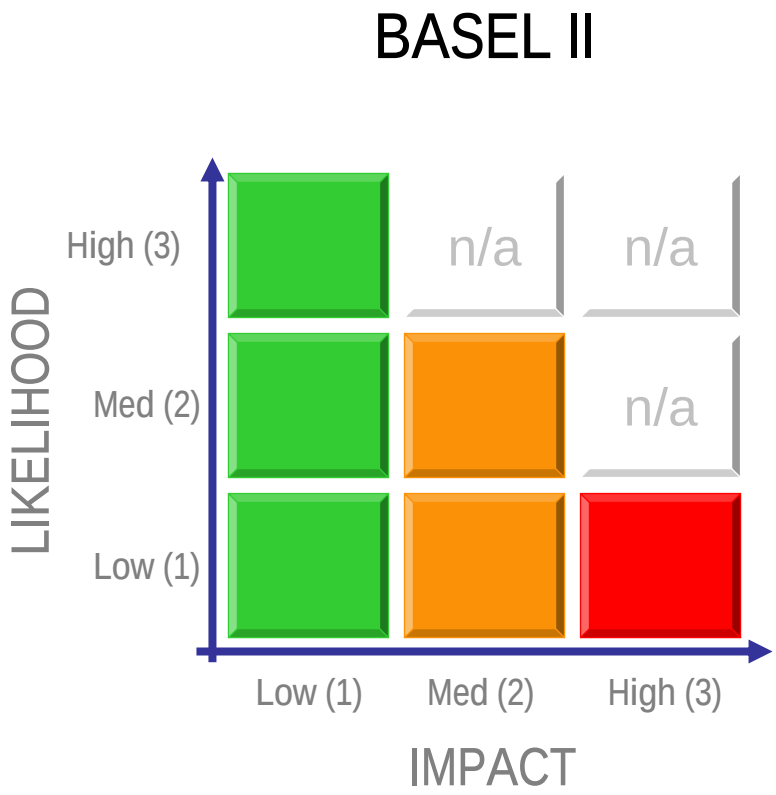
Source: COSO

The COSO view of risk assessment is based on the likelihood and impact of a specific type of event; the output is probability-weighted impact. The high risk area is in the top right corner of the matrix.



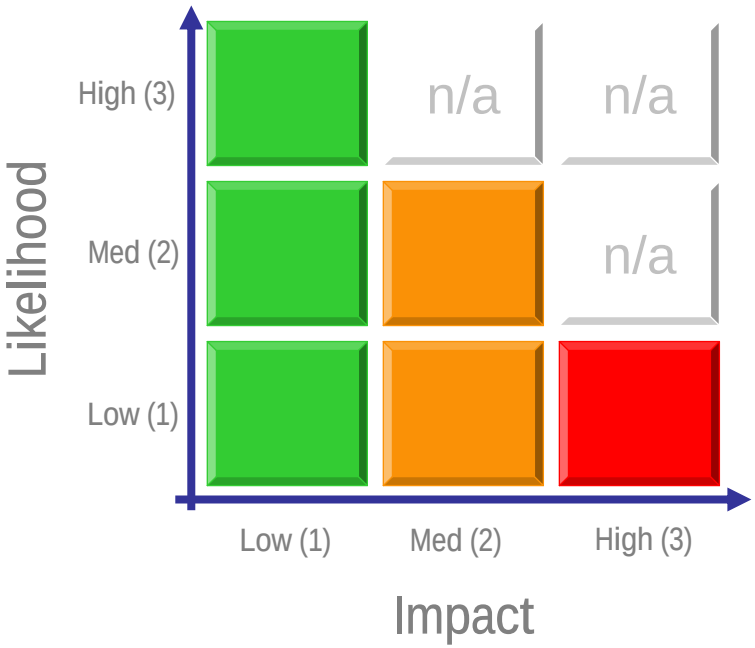
Likelihood x Impact = Risk

Under the risk management industry approach, the high risk area is the bottom right cell in the matrix.

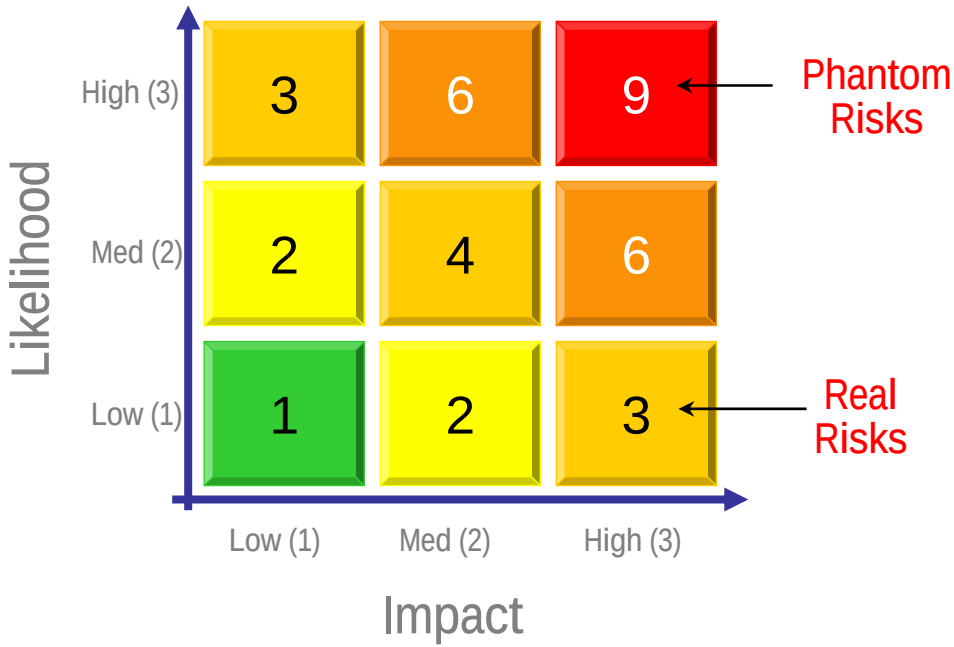


When compared, there are significant differences ….

BASEL II



COSO



Using likelihood-impact analysis one can calculate risk results.

Likelihood x Impact = Risk

Risk 1 : 10% x $10,000 = $1,000

Using likelihood-impact analysis one can calculate more than one outcome.

Likelihood x Impact = Risk

Risk 1 : 10% x $10,000 = $1,000
Risk 2 : 1% x $50,000 = $ 500

Using likelihood-impact analysis one can calculate multiple outcomes.

Likelihood x Impact = Risk

Risk 1 : 10% x $10,000 = $1,000
Risk 2 : 1% x $50,000 = $ 500

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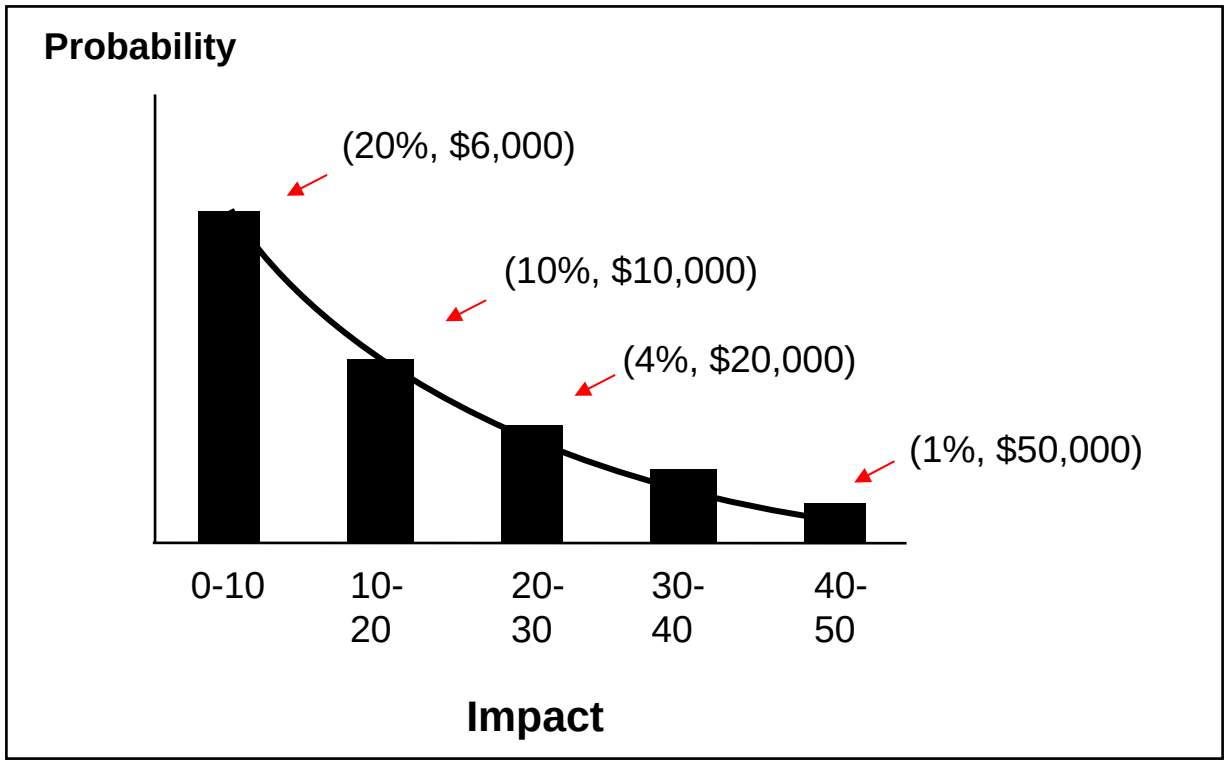
Risk 999 : 4% x $20,000 = $ 800
Risk 1000 : 20% x $ 6,000 = $1,200

The many probability and impact combinations represent a continuum.



The severity distribution is a plot of all likelihood and impact combinations; loss severity is only one component of aggregate loss.

INDIVIDUAL LOSS EVENTS | **RISK MATRIX FOR LOSS DATA** | **LOSS DISTRIBUTIONS** | **VAR CALCULATION** | **TOTAL LOSS DISTRIBUTION**

74,712,345
74,603,709
74,457,745
74,345,957
74,344,576
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167,245
142,456
123,345
113,342
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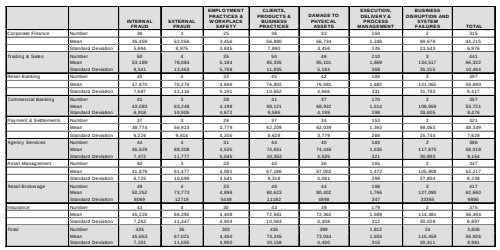

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Corporate Finance	Number	36	3	25	39	23	150	2	315
	Mean	56,438	52,056	3,456	56,990	56,734	1,246	89,674	42,215
	Standard Deviation	9,693	8,975	3,845	7,890	3,456	245	23,543	9,976
Trading & Sales	Number	56	4	39	58	44	210	3	441
	Mean	93,189	79,064	9,184	85,395	86,501	1,999	134,517	66,322
	Standard Deviation	8,541	12,493	5,766	11,835	5,184	588	35,315	10,464
Retail Banking	Number	46	4	32	49	42	189	3	397
	Mean	67,870	73,274	4,646	79,902	76,965	1,982	121,066	59,890
	Standard Deviation	7,697	12,116	5,191	10,402	4,666	331	31,783	9,417
Commercial Banking	Number	41	3	28	41	37	170	3	367
	Mean	63,090	62,248	4,199	69,121	66,902	1,514	108,968	53,721
	Standard Deviation	8,918	10,905	4,672	9,589	6,199	298	28,655	9,476
Payment & Settlements	Number	37	3	29	37	34	153	2	321
	Mean	58,774	56,923	3,779	62,209	62,039	1,363	98,063	48,349
	Standard Deviation	8,235	9,814	4,255	8,618	5,779	318	25,743	7,828
Agency Services	Number	44	4	31	44	40	184	3	386
	Mean	49,529	48,208	4,535	74,464	74,446	1,635	117,675	58,018
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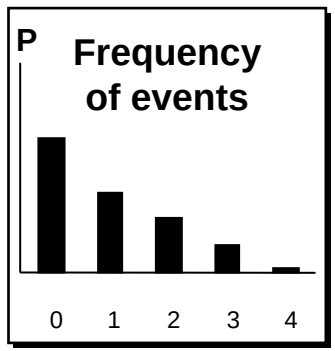
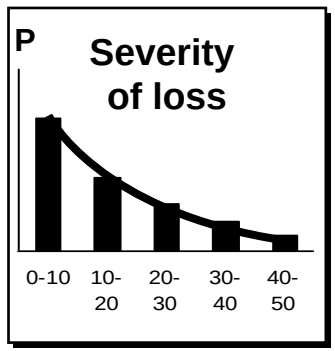
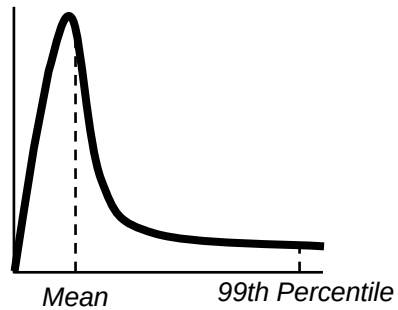
Asset Management	Number	40	3	28	40	36	165	2	347
	Mean	61,876	61,477	4,091	67,186	67,062	1,472	105,908	52,217
	Standard Deviation	8,716	10,596	4,541	9,318	6,061	289	27,814	8,238
Retail Brokerage	Number	48	4	33	48	44	198	3	417
	Mean	60,242	72,773	4,898	80,823	80,402	1,766	127,066	62,660
	Standard Deviation	8989	12710	5438	11182	6898	347	33346	9886
Insurance	Number	43	4	30	43	39	179	3	371
	Mean	65,226	66,355	4,458	72,961	72,362	1,589	114,381	55,264
	Standard Deviation	7,242	11,047	4,904	10,063	6,408	312	30,029	8,897
Total	Number	435	36	302	435	396	1,812	24	3,806
	Mean	61,653	67,015	4,450	73,245	73,044	1,604	116,458	56,926
	Standard Deviation	7,331	13,535	4,960	10,198	6,450	316	30,351	8,981





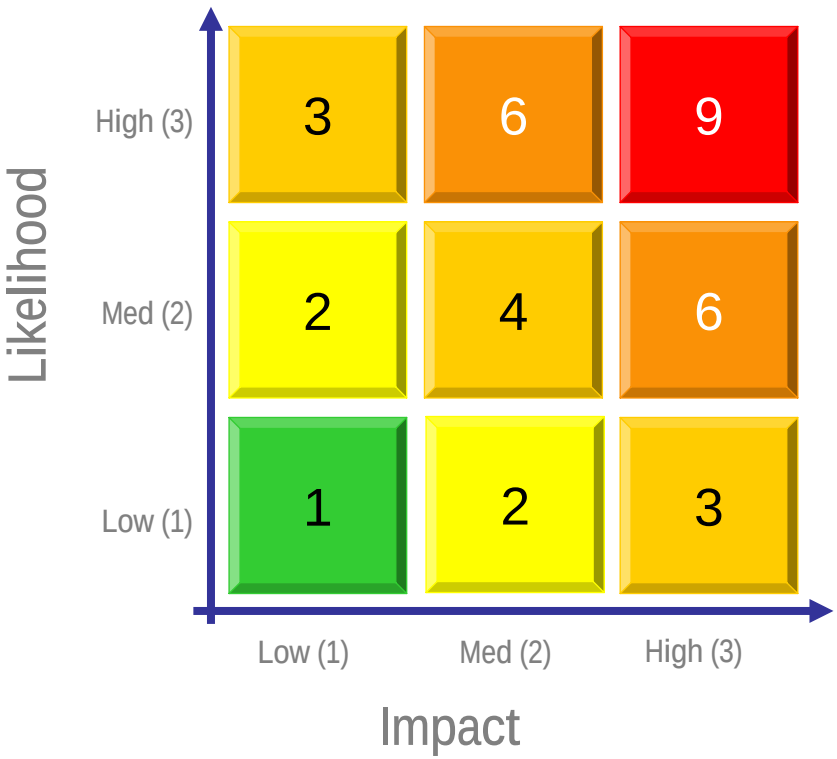
VaR Calculator e.g., Monte Carlo Simulation Engine



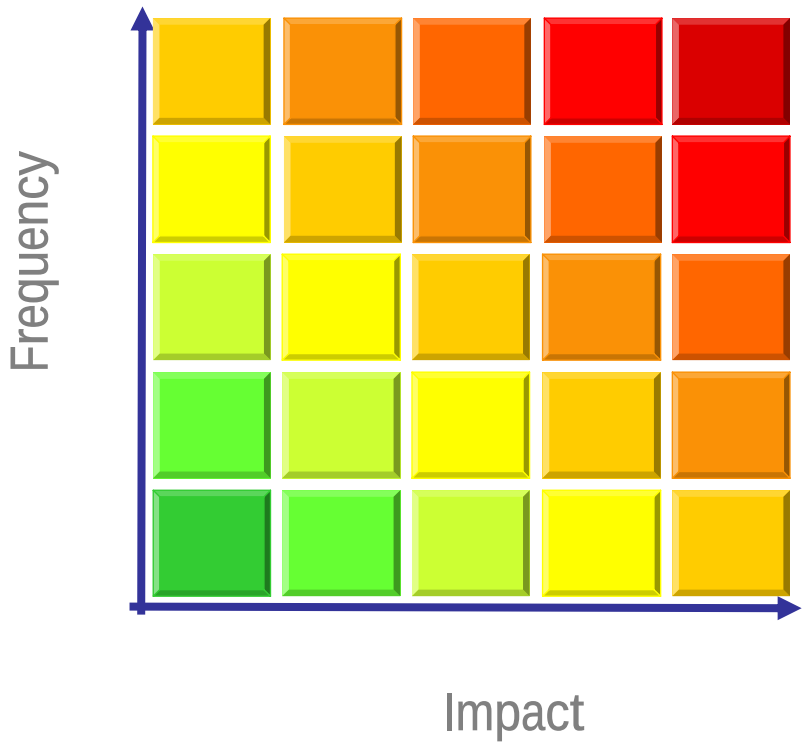
ORA OpRisk Advisory

What is the difference between the COSO and AS/NZS 4360?

COSO



AS/NZS 4360



Additional comments about likelihood-impact analysis.

- What's the difference between a risk event and a loss event?

  There is no such thing as a risk event. An event is an incident that has happened; if it results in a loss then it becomes a loss event. Risk is the level of uncertainty surrounding an event or series of events.

- Likelihood-impact analysis allows you to measure the probability weighted damage from a specific event – the cost – not the risk surrounding the event and certainly not the aggregate risk from a class of events.

- Likelihood-impact analysis is more appropriate for crisis management than risk management. In crisis management one is trying to measure the magnitude of a potential loss from a specific, pre-defined event that is on the verge of taking place.

A high likelihood – high impact scenario: You are standing on the train tracks. 90% chance you will be hit by a train; impact $1,000,000.

- There can be a high likelihood-high impact scenario situations, but not a high likelihood-high severity class of events.
- Likelihood-impact analysis allows you to measure the probability weighted impact of a specific event – in other words the cost or damage from the event ($900,000).
- The risk represents the uncertainty surrounding the $900,000 damage estimate.
- As likelihood approaches 1.0 (100%), the event becomes certain and the risk goes to zero.
- *Likelihood* and *Frequency* mean two very different things.

The actuarial approach.

INDIVIDUAL LOSS EVENTS

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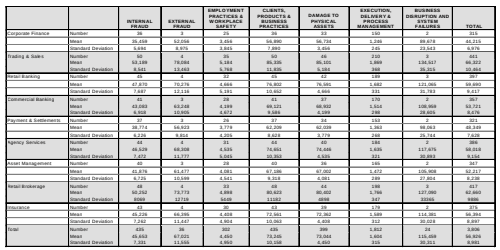
RISK MATRIX FOR LOSS DATA



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	Standard Deviation	9,693	8,975	3,845	7,890	3,456	245	23,543	9,976
Trading & Sales	Number	56	4	30	49	44	210	3	441
	Mean	53,189	79,064	6,184	85,395	86,501	1,999	134,517	66,322
	Standard Deviation	8,541	12,493	5,766	11,835	5,184	568	35,315	10,464
Retail Banking	Number	46	4	32	49	42	189	3	397
	Mean	67,870	73,274	4,646	79,992	76,565	1,982	121,066	59,990
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	Mean	63,092	62,248	4,199	69,121	66,902	1,514	108,968	53,721
	Standard Deviation	8,918	10,905	4,672	9,589	6,299	298	28,655	9,476
Payment & Settlements	Number	37	3	29	37	34	153	2	321
	Mean	58,774	56,923	3,779	62,209	62,029	1,363	98,063	48,349
	Standard Deviation	8,235	9,814	4,255	8,618	5,779	269	25,744	7,828
Agency Services	Number	44	4	31	44	40	184	3	386
	Mean	49,529	48,208	4,535	74,464	74,446	1,635	117,675	58,018
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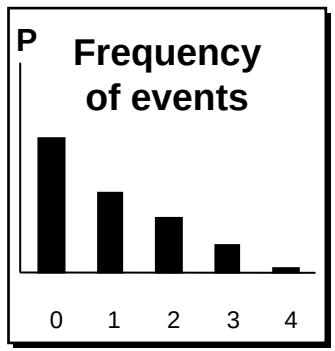
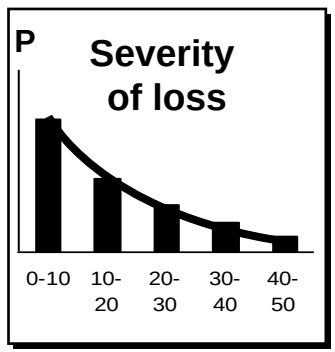
Asset Management	Number	40	3	28	40	36	165	3	347
	Mean	61,876	61,477	4,091	67,186	67,062	1,472	105,908	52,217
	Standard Deviation	8,716	10,596	4,541	9,318	6,061	289	27,804	8,238
Retail Brokerage	Number	48	4	33	48	44	198	3	417
	Mean	60,242	73,773	4,898	80,623	80,402	1,766	127,066	62,660
	Standard Deviation	9569	12710	5438	11182	6898	347	33346	9886
Insurance	Number	43	4	30	43	39	179	3	376
	Mean	65,226	66,355	4,404	72,561	72,362	1,589	114,381	56,394
	Standard Deviation	7,742	11,447	4,904	10,063	6,809	312	30,029	8,997
Total	Number	435	36	302	435	396	1,812	24	3,806
	Mean	60,650	67,025	4,450	73,245	73,044	1,604	116,458	56,926
	Standard Deviation	7,931	13,555	4,960	10,198	6,459	315	30,351	8,981

LOSS DISTRIBUTIONS

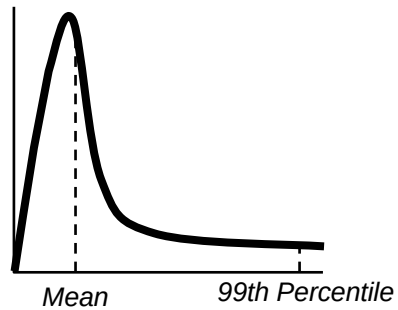




VAR CALCULATION

VaR Calculator e.g., Monte Carlo Simulation Engine

TOTAL LOSS DISTRIBUTION



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Likelihood-impact analysis viewed in an actuarial context.

INDIVIDUAL LOSS EVENTS | **RISK MATRIX FOR LOSS DATA** | **LOSS DISTRIBUTIONS** | **VAR CALCULATION** | **TOTAL LOSS DISTRIBUTION**

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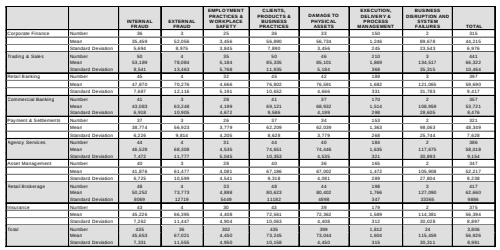

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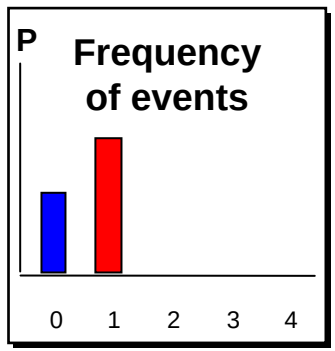
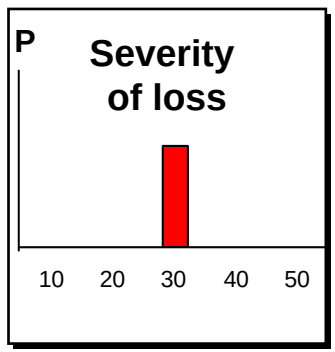
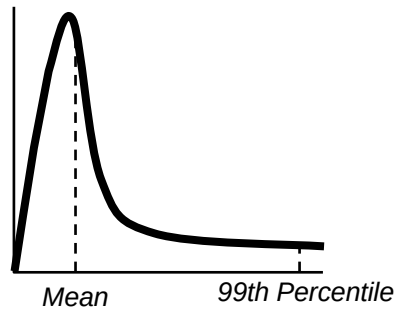
Corporate Finance	Number	36	3	25	39	23	150	2	315
	Mean	35,459	52,056	3,456	56,990	36,734	1,246	89,674	41,215
	Standard Deviation	5,693	8,975	3,845	7,890	3,456	245	23,543	6,976
Trading & Sales	Number	56	4	30	49	44	210	3	441
	Mean	53,189	79,084	5,184	85,395	55,101	1,999	134,517	66,322
	Standard Deviation	8,541	12,063	5,766	11,835	5,184	368	35,315	10,464
Retail Banking	Number	46	4	32	55	42	189	3	397
	Mean	67,872	73,274	4,646	75,902	76,565	1,662	121,065	59,690
	Standard Deviation	7,697	12,116	5,191	10,402	4,646	331	31,783	8,417
Commercial Banking	Number	41	3	28	41	37	170	3	367
	Mean	43,092	62,248	4,199	69,121	66,902	1,514	108,968	53,721
	Standard Deviation	6,918	10,905	4,672	9,369	4,199	298	28,655	9,476
Payment & Settlements	Number	37	3	29	37	34	153	2	321
	Mean	38,774	56,923	3,779	62,209	62,039	1,363	98,063	48,349
	Standard Deviation	6,231	9,814	4,255	8,418	3,779	269	25,744	7,828
Agency Services	Number	44	4	31	44	40	184	3	386
	Mean	49,529	68,208	4,535	74,464	74,446	1,635	117,675	58,018
	Standard Deviation	7,472	11,777	5,049	10,352	4,535	321	30,893	9,154
Asset Management	Number	40	3	28	40	36	165	2	347
	Mean	41,879	61,477	4,081	67,186	67,002	1,472	105,908	52,217
	Standard Deviation	6,726	10,596	4,541	9,318	4,081	289	27,804	8,238
Retail Brokerage	Number	48	4	33	48	44	198	3	417
	Mean	50,292	72,773	4,898	80,423	80,402	1,766	127,090	62,960
	Standard Deviation	8069	12710	5438	11182	4898	347	33345	9886
Insurance	Number	43	4	30	43	39	179	2	370
	Mean	45,224	66,355	4,404	72,361	72,362	1,589	114,381	55,264
	Standard Deviation	7,242	11,447	4,914	10,063	4,404	312	30,029	8,897
Total	Number	435	36	302	435	396	1,802	24	3,806
	Mean	49,650	67,015	4,460	73,245	72,564	1,604	116,488	56,936
	Standard Deviation	7,331	11,535	4,960	10,198	4,459	315	30,351	8,961





VaR Calculator e.g., Monte Carlo Simulation Engine



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VAR MODELING IN OPERATIONAL RISK

The two relevant outputs are the aggregate mean (EL) and the aggregate Value at Risk (VaR or UL).

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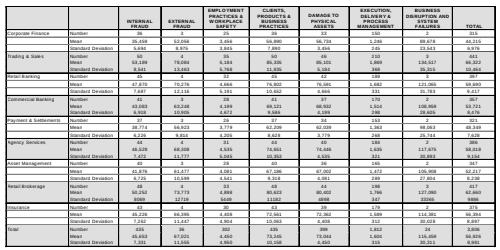

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Trading & Sales	Number	56	4	30	49	44	210	3	441
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Payment & Settlements	Number	37	3	29	47	34	163	2	321
	Mean	58,774	56,923	3,779	62,209	62,039	1,363	98,063	48,349
	Standard Deviation	8,216	9,814	4,255	8,618	3,779	318	25,744	7,828
Agency Services	Number	44	4	31	44	40	184	3	386
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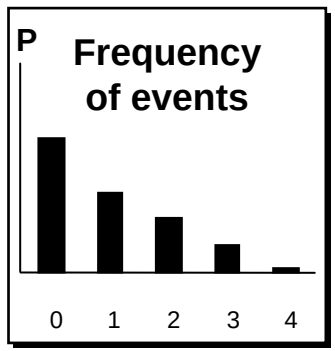
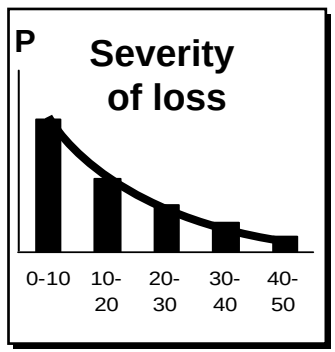
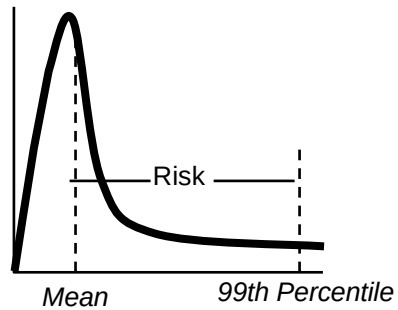




VaR Calculator e.g., Monte Carlo Simulation Engine



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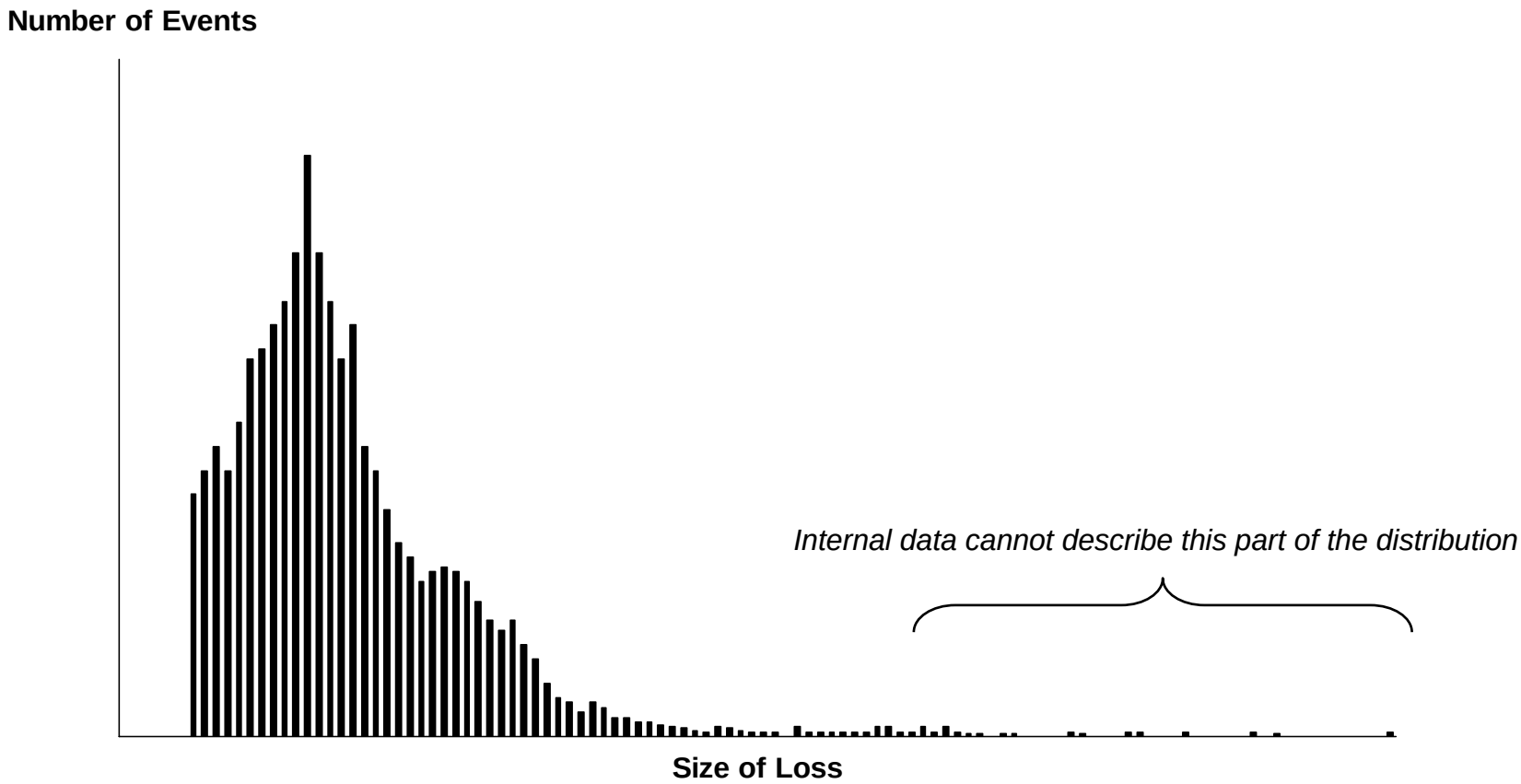
Internal data generally does not contain a sufficient number of the tail events to accurately describe that part of the distribution, therefore one needs to supplement internal data with external data.



What issues are present in external loss data?

Data Capture	In publicly reported data, the larger losses are more likely to be reported than smaller losses.
Size	Larger institutions (and businesses) are likely to experience more losses than smaller institutions. These institutions are also likely to suffer larger losses.
Control	Institutions with weak controls are more likely to be represented in the database because they experience more losses. These institutions are also likely to suffer more large losses than well-controlled institutions.
Geography	Risk profiles vary from region to region. Some events will be less relevant than others outside their region.
Media	Large losses are more likely to be printed than small losses.
Legal Environment	The legal system in certain countries may lead to more frequent and/or larger losses.

Loss data needs to be adjusted for inflation and scaled for size.

Inflation Adjustment:

$10 million loss in 1990 = $12.4 million loss in 2001

Scale Adjustment:

$10 million loss when a $2 billion (revenue) bank = $13.2 million loss when a $6 billion bank[1]

$$Scaled\ Loss = L_{DB}\left[\frac{R_{\text{int}}}{R_{\text{ext}}}\right]^{n}$$

L_{DB} = Actual Loss experienced by bank

R_{ext} = Revenue of external firm

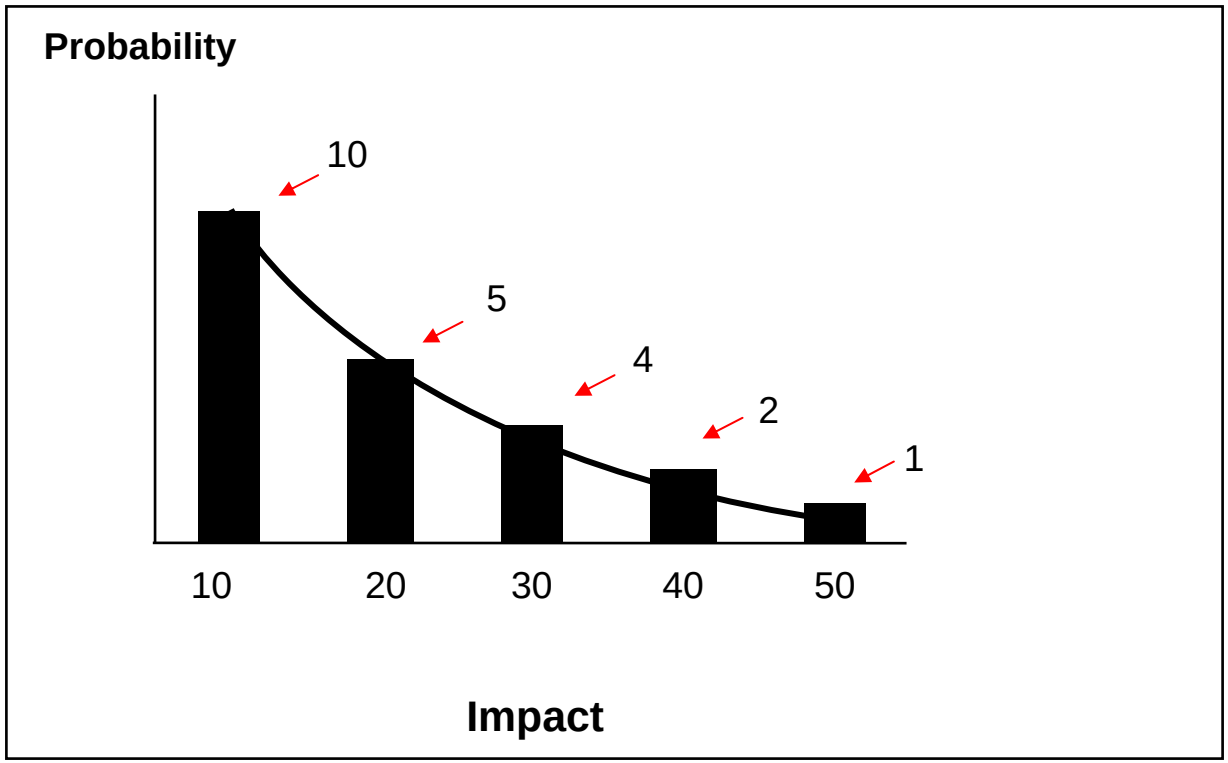
R_{int} = Revenue of firm

n = Scaling co-efficient determined by regression analysis

[1] Shih, J., A. Samad-Khan and P. Medapa, "Is the Size of an Operational Loss Related to Firm Size?" *Operational Risk Magazine* (January 2000)

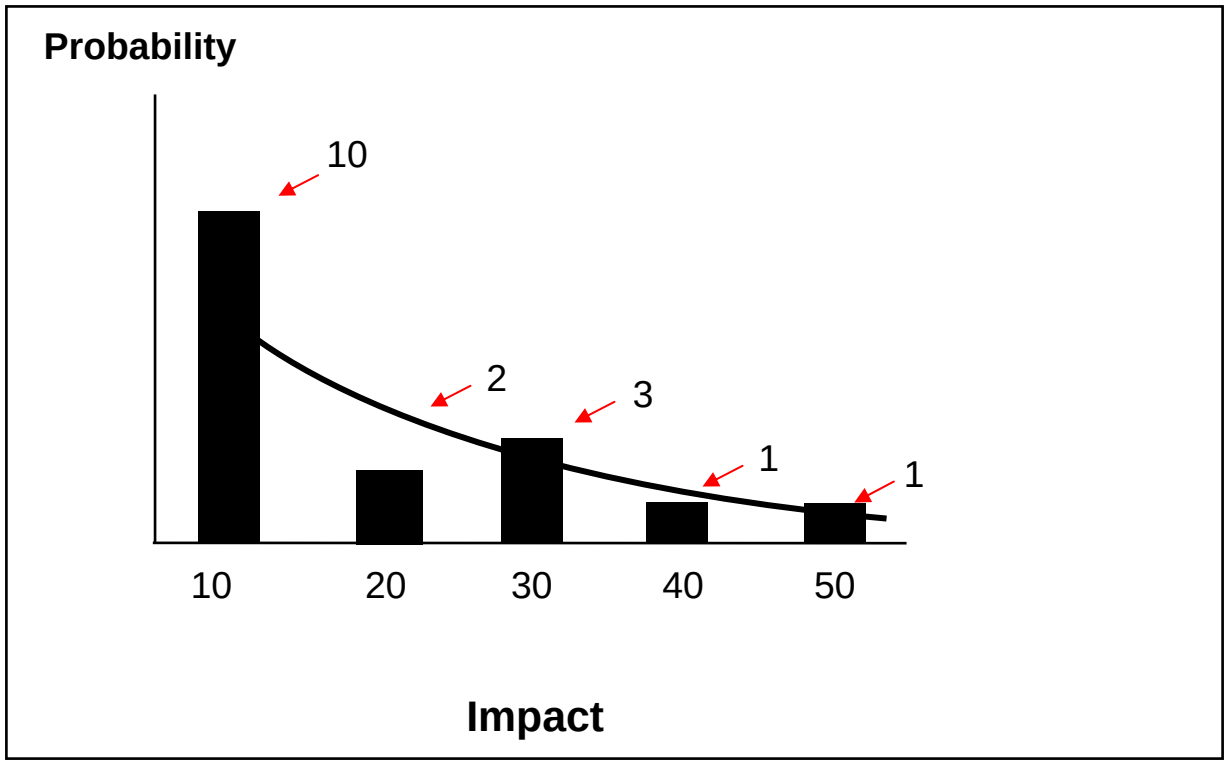
Loss data contains two integrally connected pieces of information; the loss magnitude and the relative probability of the loss in the context of the distribution from which it was drawn.

Before Relevance Adjustment

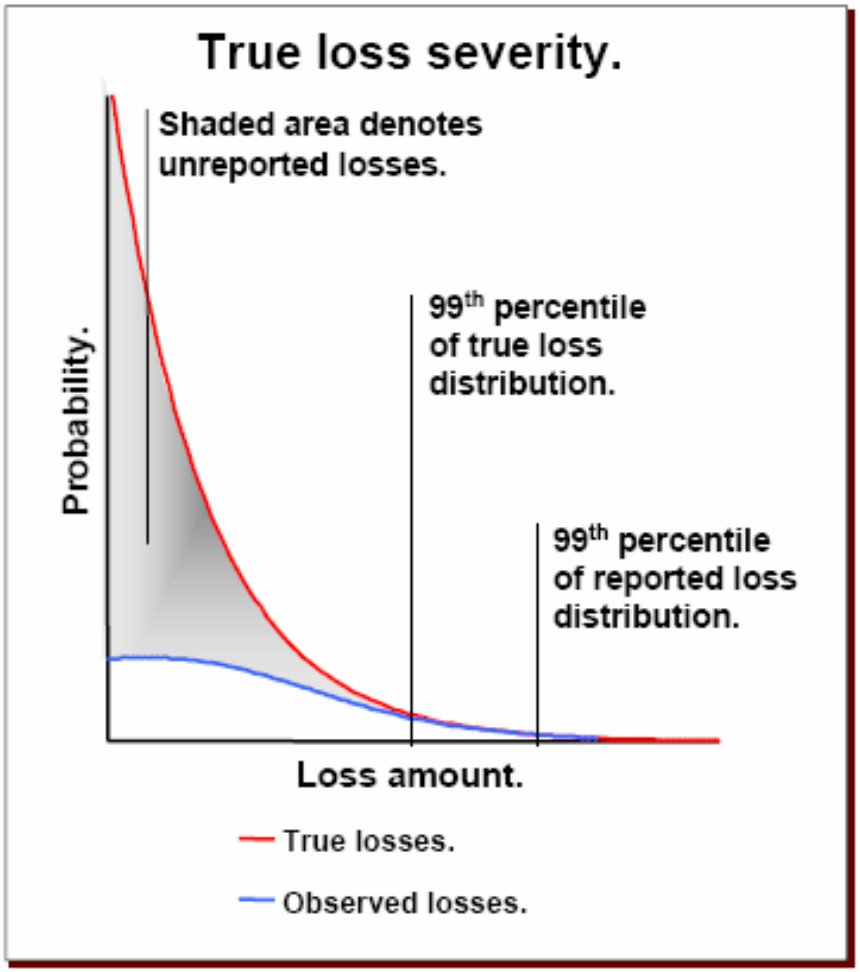


Selecting “relevant” loss data points in an unscientific manner causes any information contained in the data to be lost. Modeling is about applying relevant data sets not manipulating relevant data points.

After Relevance Adjustment



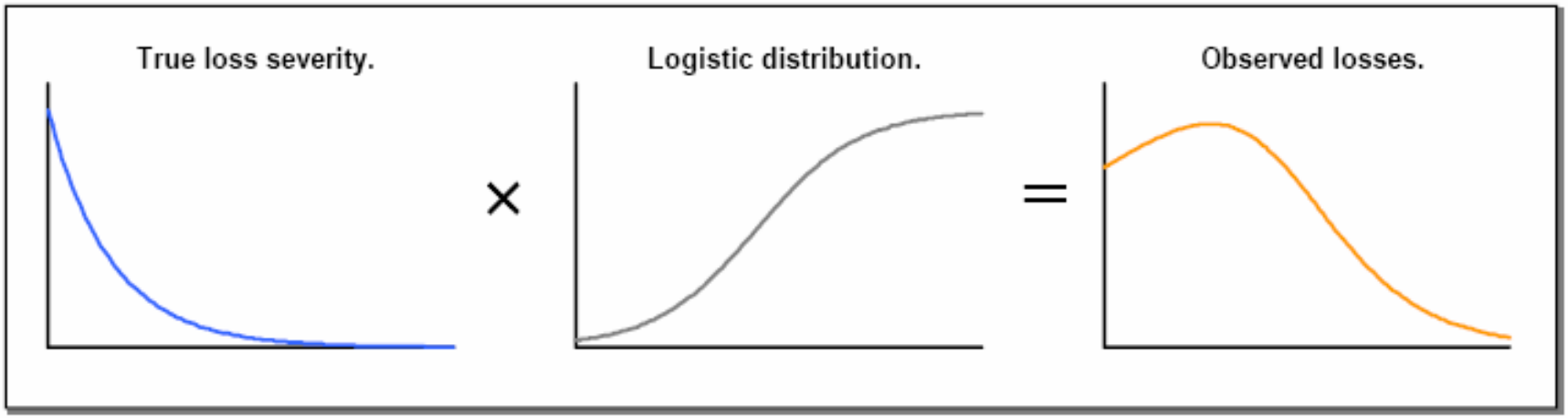
Vendor Data:
Reporting bias



- Not all losses are reported
- Reporting probability increases with loss amount
- Loss severity estimates are biased upwards
- Percentiles from the severity distribution also biased upwards
- Capital estimates will likely be too high

Source FRB Boston

Using Vendor Data in LDA:
Correcting for reporting bias



- The observed loss distribution equals the "true" loss distribution times the reporting probability distribution
- EVT motivates choice of severity distribution
- Normality motivates choice of reporting distribution

Source FRB Boston

The LDA:
Modeling the severity distribution

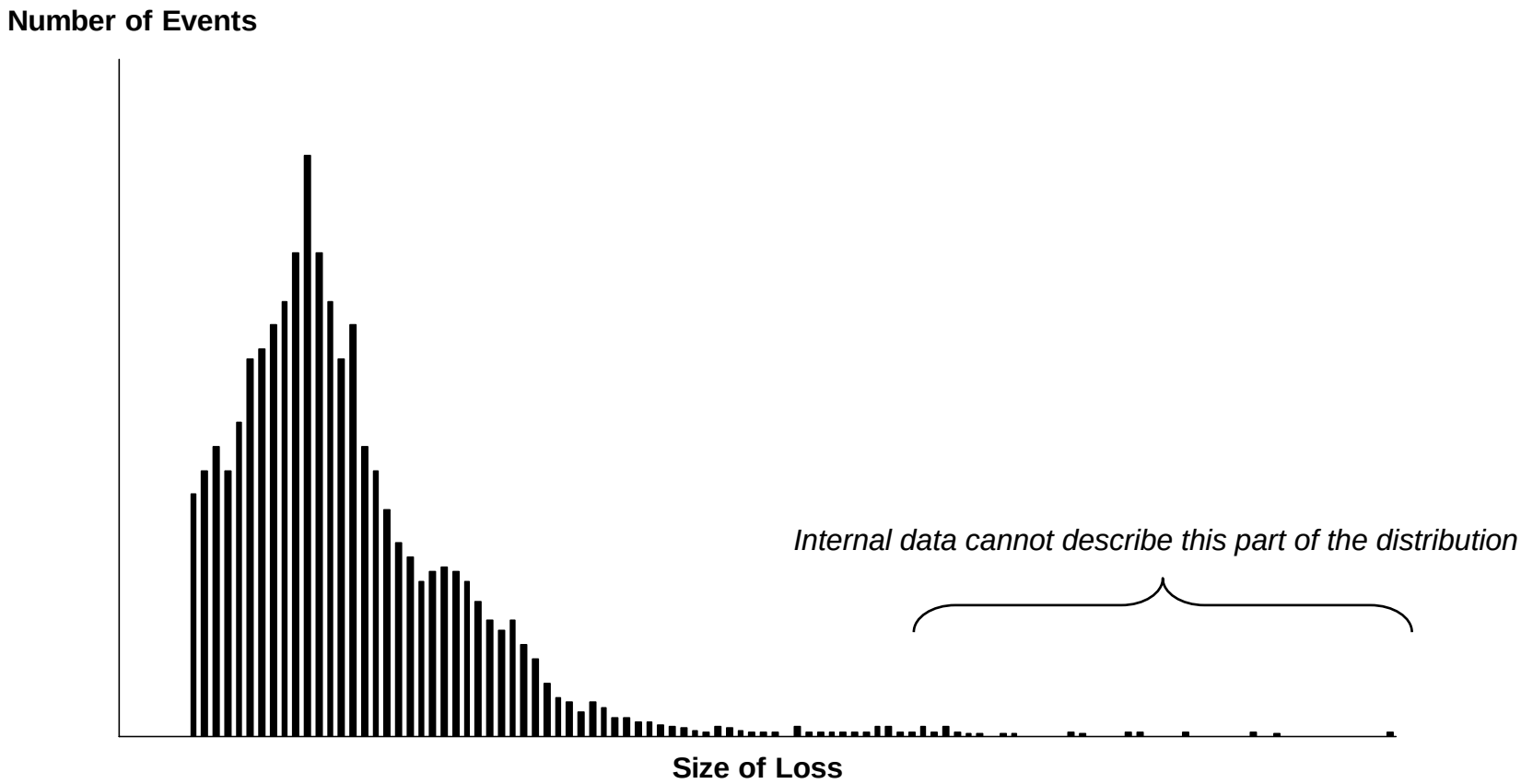
- EVT shows that "excesses" over a high threshold converge to a Generalized Pareto Distribution (GPD) as the threshold increases:

$$\mathrm{GPD}_{\xi,b}(x) = \begin{cases} 1 - (1 + \xi x/b)^{-1/\xi} & \xi > 0 \\ 1 - \exp(-x/b) & \xi = 0 \end{cases}$$

- To reduce the number of parameters, we work with log losses, and use the exponential distribution

Source FRB Boston

Internal data generally does not contain a sufficient number of the tail events to accurately describe that part of the distribution, therefore one needs to supplement internal data with external data.

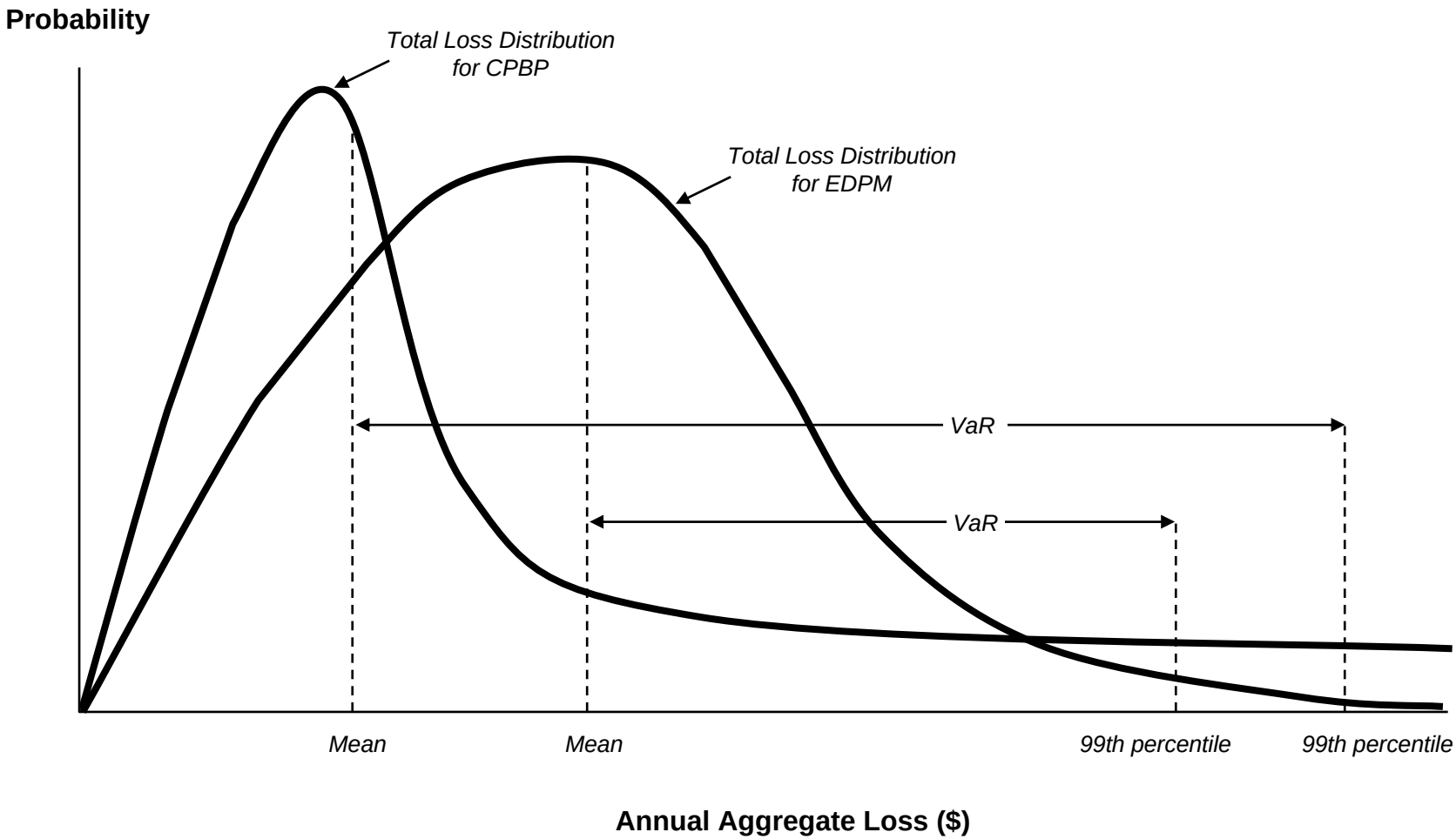


From internal data we seek pivot cells – those cells that have enough information to reliably calculate severity parameters.

INTERNAL
EVENT RISK MATRIX

		INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES & WORKPLACE SAFETY	CLIENTS, PRODUCTS & BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	EXECUTION, DELIVERY & PROCESS MANAGEMENT	BUSINESS DISRUPTION AND SYSTEM FAILURES	TOTAL
Corporate Finance	Number	36	3	25	36	33	234	2	731
	Mean	35,459	52,056	3,456	56,890	56,734	3	89,678	44,215
	Standard Deviation	5,694	8,975	3,845	7,890	3,456	2	23,543	6,976
Trading & Sales	Number	50	4	35	50	46	210	3	398
	Mean	53,189	78,084	5,184	85,335	85,101	1,869	134,517	66,322
	Standard Deviation	8,541	13,463	5,768	11,835	5,184	368	35,315	10,464
Retail Banking	Number	45	4	32	[illegible]	42	189	3	360
	Mean	47,870	70,276	4,666	[illegible]	6,591	1,682	121,065	59,690
	Standard Deviation	7,687	12,116	5,191	[illegible]	4,666	331	31,783	9,417
Commercial Banking	Number	41	3	28	[illegible]	37	170	2	322
	Mean	43,083	63,248	4,199	[illegible]	68,932	1,514	108,959	53,721
	Standard Deviation	6,918	10,905	4,6[illegible]	[illegible]	4,199	298	28,605	8,476
Payment & Settlements	Number	37	3	[illegible]	37	34	153	2	292
	Mean	38,774	56,9[illegible]	[illegible]	62,209	62,039	1,363	98,063	48,349
	Standard Deviation	6,226	9,814	[illegible]	8,628	3,779	268	25,744	7,628
Agency Services	Number	44	4	31	44	40	184	2	349
	Mean	46,529	68,308	4,535	74,651	74,446	1,635	117,675	58,018
	Standard Deviation	7,472	11,777	5,045	10,353	4,535	321	30,893	9,154
Asset Management	Number	40	3	28	40	36	165	2	314
	Mean	41,876	61,477	4,081	67,186	67,002	1,472	105,908	52,217
	Standard Deviation	6,725	10,599	4,541	9,318	4,081	289	27,804	8,238
Retail Brokerage	Number	48	4	33	48	44	198	3	378
	Mean	50,252	73,773	4,898	80,623	80,402	1,766	127,090	62,660
	Standard Deviation	8069	12719	5449	11182	4898	347	33365	9886
Insurance	Number	43	4	30	43	39	179	2	340
	Mean	45,226	66,395	4,408	72,561	72,362	1,589	114,381	56,394
	Standard Deviation	7,262	11,447	4,904	10,063	4,408	312	30,028	8,897
Total	Number	710	152	268	384	351	1,598	21	3,484
	Mean	45,653	67,021	4,450	73,245	73,044	1,604	115,459	56,926
	Standard Deviation	7,331	11,555	4,950	10,158	4,450	315	30,311	8,981

It is generally understood, for example, that trading and sales is inherently high-risk, whereby retail banking is inherently high-cost.



To capture these relationships we estimate severity parameters across all event risk classes.

EXTERNAL
EVENT RISK MATRIX
SEVERITY PARAMETERS IN LOG TERMS

		INTERNAL FRAUD	EXTERNAL FRAUD	EXECUTION, DELIVERY & PROCESS MANAGEMENT
Corporate Finance	Number	362	123	150
	Mean	9	6	6
	Standard Deviation	6	4	2

EXTERNAL
EVENT RISK MATRIX
SEVERITY PARAMETERS IN RELATIVE TERMS

		INTERNAL FRAUD	EXTERNAL FRAUD	EXECUTION, DELIVERY & PROCESS MANAGEMENT
Corporate Finance	Number	362	123	150
	Mean	1.5	1	1
	Standard Deviation	3	2	1

From internal data we seek pivot cells – those cells that have enough information to reliably calculate severity parameters.

INTERNAL
EVENT RISK MATRIX

		INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES & WORKPLACE SAFETY	CLIENTS, PRODUCTS & BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	EXECUTION, DELIVERY & PROCESS MANAGEMENT	BUSINESS DISRUPTION AND SYSTEM FAILURES	TOTAL
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	Standard Deviation	7,331	11,555	4,950	10,158	4,450	315	30,311	8,981

Using the pivot cell and relative parameter ratios from external data we can estimate severity parameter for all cells in a business line.

INITIAL INTERNAL EVENT RISK MATRIX

		INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES & WORKPLACE SAFETY	CLIENTS, PRODUCTS & BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	EXECUTION, DELIVERY & PROCESS MANAGEMENT	BUSINESS DISRUPTION AND SYSTEM FAILURES	TOTAL
Corporate Finance	Number						234		
	Mean						3		
	Standard Deviation						2		

PARAMETER RATIOS FROM EXTERNAL EVENT RISK MATRIX

		INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES & WORKPLACE SAFETY	CLIENTS, PRODUCTS & BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	EXECUTION, DELIVERY & PROCESS MANAGEMENT	BUSINESS DISRUPTION AND SYSTEM FAILURES	TOTAL
Corporate Finance	Number								
	Mean	1.5	1				1		
	Standard Deviation	3	2				1		

FINAL INTERNAL EVENT RISK MATRIX

		INTERNAL FRAUD	EXTERNAL FRAUD	EMPLOYMENT PRACTICES & WORKPLACE SAFETY	CLIENTS, PRODUCTS & BUSINESS PRACTICES	DAMAGE TO PHYSICAL ASSETS	EXECUTION, DELIVERY & PROCESS MANAGEMENT	BUSINESS DISRUPTION AND SYSTEM FAILURES	TOTAL
Corporate Finance	Number						234		
	Mean	4.5	3				3		
	Standard Deviation	6	4				2		

STRESS TESTING OPERATIONAL RISK

What is stress testing in the context of operational risk management?

- Stress the assumptions of the model?
  - Distribution Assumptions
  - Data Transferability
  - Data Sufficiency
  - Sources of Data
  - Selection of Data Points
  - Weights Based on “Expert” Judgment

SUMMARY & CONCLUSIONS

Stress testing is important, but there are many more serious issues we face in ORM today.

- Many people who work in operational risk management don't understand elementary risk management concepts.
- Following the advice of numerous "experts" most banks have developed ORM frameworks based on a convoluted blend of traditional and modern ORM.
- Traditional ORM and Modern ORM are based on entirely different definitions, approaches, processes and methodologies.
- These immature methodologies are highly subjective, resource intensive and generate a huge catalog of unmanageable 'risks.'
- Any prioritization of controls based on this spurious and misleading information may lead managers to enhance controls in areas that are already over-controlled and at the same time ignore areas of major control weakness.

Where do things stand today?

- Many banks know their ORM programs are producing no value. But their operational risk managers refuse to admit there is a better approach.
- Some auditors are “validating” these flawed methodologies. These “approved” methodologies are fast becoming the standard for industry best practices.
- Most banks have established ORM programs only to meet Basel II compliance; currently they see no need to make improvements.
- A paradigm shift is necessary for banks to evolve towards modern ORM, but the industry is not moving in this direction. This will only happen if the regulators lead the way.
- If the regulators don’t take action soon, ORM under Basel II will fail. The window of opportunity is about to close for good!
- Many Asian banks are leap-frogging their Western counterparts by developing programs based on Modern ORM principles. Some Western banks may fail to comply with Basel II in Asia.

Some recommendations

- Provide the industry with a clear definition of the term "*risk*." Require that this definition be used in every aspect of the bank's ORM framework (not just the VaR models). Make clear that the product of likelihood and impact is not risk, nor even the expected loss.
- Educate the industry on the uses and misuses of historical loss data. Require that any use of external data be based on the objective application of data sets not the subjective manipulation of individual data points.
- As part of the Pillar III requirements, ask banks to disclose the confidence intervals around their model results, i.e., the range of expected loss and unexpected loss estimates that could be calculated by varying any weights and assumptions based on "expert judgment."

Biographical Information – Ali Samad-Khan

Ali Samad-Khan is *President of OpRisk Advisory LLC*. He has over nine years experience in operational risk measurement and management and more than twenty years experience in financial services. His areas of expertise include: establishing an integrated operational risk measurement and management framework, developing policies and procedures, internal loss event database design and implementation; data quality assessment, data sufficiency analysis, risk indicator identification, risk and control self assessment, disciplined scenario analysis, causal/predictive modeling, advanced VaR measurement techniques and economic capital allocation.

Ali has advised dozens of the world's leading banks on operational risk measurement and management issues. His significant practical experience in this field comes from managing the implementation of more than ten major operational risk consulting engagements at leading institutions in North America, Europe and Australia. Key elements of the ORA framework and methodology have been adopted by dozens of leading financial institutions worldwide and have also been incorporated into the Basel II regulations.

Ali has frequently advised the major bank regulatory authorities, including the Risk Management Group of Basel Committee on Banking Supervision, the Board of Governors of the Federal Reserve System, the Federal Reserve Bank of New York, the Financial Services Authority (UK) and the Australian Prudential Regulation Authority. He also holds seminars and workshops in North America, Europe and Asia for the national and international regulators.

Prior to founding OpRisk Advisory, Ali was founder and President of OpRisk Analytics LLC, which was acquired by SAS in 2003. (From June 2003 to September 2004 Ali provided transitional support for the acquisition of OpRisk Analytics, serving as SAS' Head of Global Operational Risk Strategy.) He has also worked at PricewaterhouseCoopers (PwC) in New York, where from 1998-2001 he headed the Operational Risk Group within the Financial Risk Management Practice, in the Operational Risk Management Department at Bankers Trust as well as the Federal Reserve Bank of New York and the World Bank.

Ali holds a B.A. in Quantitative Economics from Stanford University and an M.B.A. in Finance from Yale University.

Articles include:" Fundamental Issue in OpRisk Management," with Armin Rheinbay and Stephane Le Blevec, *OpRisk and Compliance Magazine*, February 2006; "Why COSO is Flawed," *Operational Risk Magazine*, January 2005; "Is the Size of an Operational Loss Related to Firm Size," with Jimmy Shih and Pat Medapa, *Operational Risk Magazine*, January 2000; "Measuring Operational Risk," with David Gittleson, *Global Trading*, Fourth Quarter, 1998.
Working papers include: *"How to Categorize Operational Losses – Applying Principals as Opposed to Rules"* March 2002 and *"Categorization Analysis"* January 2003.