



Office of the Superintendent of  
Financial Institutions Canada

Bureau du surintendant des  
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# **Scenario quantification for operational risk modeling**

**Fields-Mprime Industrial Problem Solving Workshop**

**August 11-15, 2014**

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# Disclaimer

All views expressed in this presentation are those of my own and do not represent the views of OSFI.

The problem put forth and the ensuing proposed solution does not signal that OSFI has adopted the preferred method.

Within the presentation, no confidential information of supervised financial institutions has been disclosed. Any information has been sourced from publically available sources (e.g. supplementary financial information) with references stated where applicable.

Any and all errors are that of my own.



# Agenda

1. Introduction of organization and banking regulation
2. Primer on regulatory capital and risk types
3. Focus on Operational Risk
4. Proposed problem: Scenario quantification for operational risk modeling
5. Recap and benefits of the workshop



# 1. Introduction of organization and banking regulation

## OSFI

- Independent agency of the Government of Canada, established in 1987 to contribute to the safety and soundness of the Canadian financial system.
- OSFI supervises and regulates federally registered banks and insurers, trust and loan companies, as well as private pension plans. Recently, CMHC has come under OSFI supervision.
- Offices in Vancouver, Ottawa, Toronto and Montreal.
- Employs approximately 660 people.



# 1. Introduction of organization and banking regulation

## Mandate

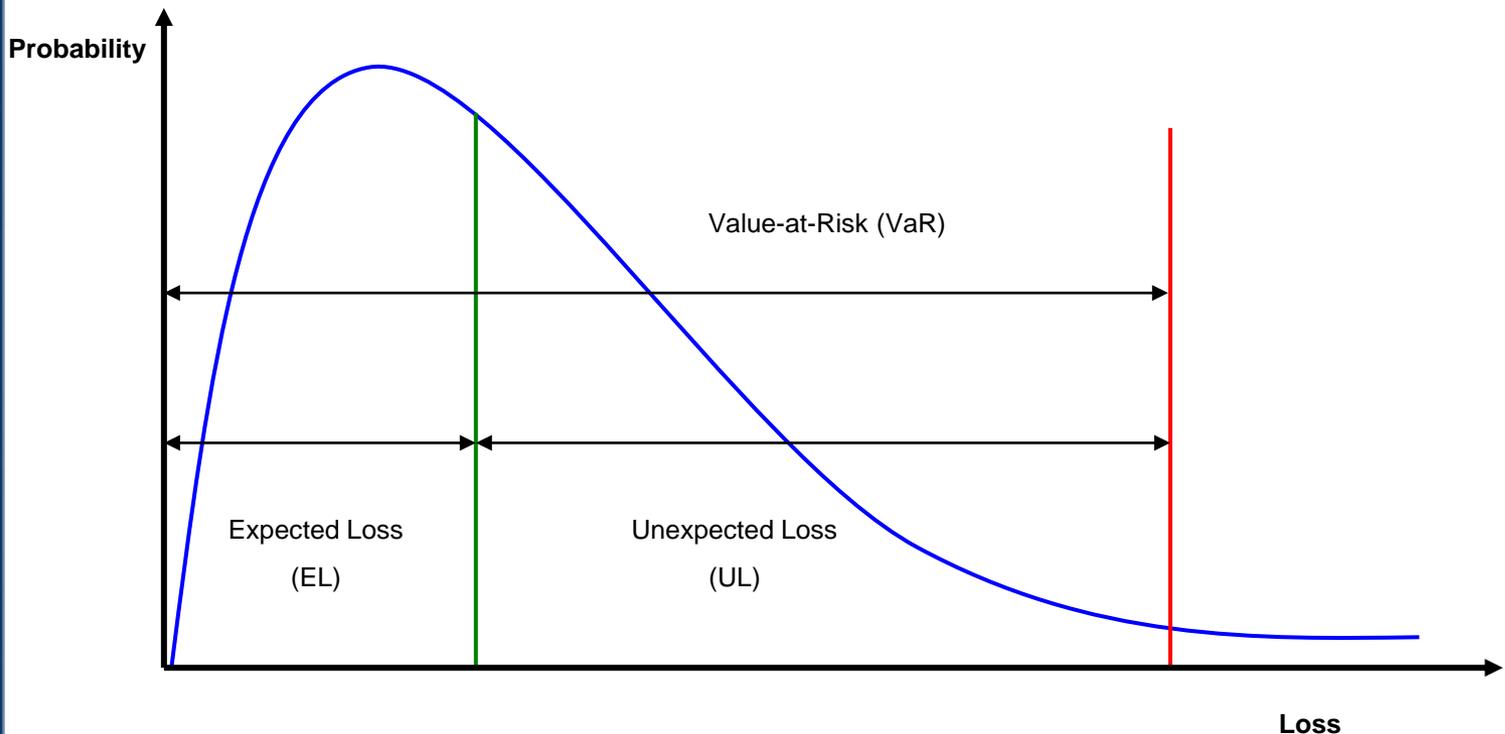
- Supervise federally regulated financial institutions and pension plans to determine whether they are in sound financial condition and meeting minimum plan funding requirements respectively, and are complying with their governing law and supervisory requirements.
- Promptly advise institutions and plans in the event there are material deficiencies and take or require management, boards or plan administrators to take necessary corrective measures expeditiously.
- Advance and administer a regulatory framework that promotes the adoption of policies and procedures designed to control and manage risk.
- Monitor and evaluate system-wide or sectoral issues that may impact institutions negatively.



## 2. Primer on regulatory capital and risk types

Regulatory capital: loss-absorbing elements that count as capital (valuable assets) that provides a buffer to protect depositors. Examples: common shares issued by bank, retained earnings, other compressive income etc.

Regulatory capital provides a buffer against unexpected loss.



## 2. Primer on regulatory capital and risk types

- Capital ratios are of broad interest to regulators and banks. They are computed as:

$$\text{capital ratio} = \text{capital} / \text{risk weighted assets}$$

- Capital: three main types; ordered by “quality”: common equity tier 1 is of higher quality than tier 1 which is of higher quality than total capital.
- Risk weighted assets (RWA): assets of banks weighted according to riskiness. Higher RWA attracts more risk and more capital.

Capital ratio type	2014 Minimum capital required	2014 Target capital target
CET1	4.0%	7.0%
Tier 1	5.5%	8.5%
Total capital	8.0%	10.5%



## 2. Primer on regulatory capital and risk types

- International convergence of capital measurement and capital standards was seen as a necessity and hence **Basel I** was created in 1988 from a group of central bankers around the work (the Basel Committee of Banking Supervision – BCBS). The group is one of many committee which fall under the Bank of International Settlements (BIS) in Basel, Switzerland.
- **Basel II** was published in 2004, a **2.5** version in 2009, and now **Basel III** in 2011. Each iteration has become more prescriptive incorporating lessons learned and advancement. There are already consultations on a new iteration...**3.5 or 4?**
- OSFI takes the Basel guidance, interprets or modifies the guidance and publishes its version called capital adequacy requirements (CAR) and uploads it on the OSFI public websites for institutions to reference.



## 2. Primer on regulatory capital and risk types

- Three types of broad risk types:
- Market risk: The risk of losses in on-and off-balance sheet positions arising from movements in market prices. The risks pertaining to this requirement (for instruments in the trading book): interest rate risk and equity position risk; (throughout the institution): foreign exchange risk and commodities risk.
- Credit risk: The risk that a bank borrower or counterparty will fail to meet its obligations in accordance with agreed terms (e.g. a loan).
- Operational risk: The risk of loss resulting from inadequate or failed
  - internal processes,
  - people,
  - systems or from,
  - external events.Includes legal risk, but excludes strategic and reputational risk.



## 2. Primer on regulatory capital and risk types

- Sense of scale:

\$Million	BMO	BNS	CIBC	RBC	TD	Average
CET1 capital (A)	22,340	28,499	13,347	32,998	27,803	-
Credit Risk RWA	198,803	253,196	118,548	253,799	263,971	81%
Market Risk RWA	14,494	16,714	4,170	44,055	13,177	7%
Operational Risk RWA	26,779	32,160	17,787	43,898	35,824	12%
Total RWA (B)	240,076	302,070	140,505	341,752	312,972	100%
CET1 ratio (A/B)	9.3	9.4	9.5	9.7	8.9	-

Source: Publicly disclosed on each bank's website - Q1 2014 Investor Relations -> Supplementary Financials



## 2. Primer on regulatory capital and risk types

- Choices for RWA: standardized method vs. advanced method.
- **Standardized = capital intensive, risk insensitive, “look up table”.**
- Market: based on rating, maturity bucket ->capital charge multiplier\* exposure.
- Credit: set risk weights based on loan type \*exposure.
- Operational: set multiplier\*gross income.



## 2. Primer on regulatory capital and risk types

- **Advanced = “maybe” hold less capital, risk sensitive, sophisticated.**
- **Market:**  $\max\{\text{VaR}_{t-1}; m_c * \text{VaR}_{\text{avg}}\}$   
+  $\max\{\text{stressed VaR}_{t-1}; m_s * \text{stressed VaR}_{\text{avg}}\}$ 
  - $m_c, m_s$  = multiplier floored at 3 (prescribed by regulator)
  - VaR = Value-at-Risk, 1-tailed, 99% c.l., 10 day holding period.
- **Credit:** Vasicek (1991) asymptotic single-risk factor (ASRF)
  - Modeled PD, LGD, EAD as inputs.
  - 99.9% c.l., exceed capital on average once in a thousand years.
- **Operational: advanced measurement approach (AMA)**
  - Based on loss distribution approach (LDA) from actuarial field with other modeling elements.
  - Value-at-Risk, 1-tailed, 99.9% c.l., exceed capital on average once in a thousand years.
- **RWA = capital\*12.5 (reciprocal of the minimum capital ratio of 8%; slight modification for credit risk RWA).**

aside



### 3. Focus on Operational Risk

Operational risk – why all the fuss?

- Impact on bank's bottom line,
- New complex financial products and strategies,
- Increased reliance on rapidly evolving technology,
- Globalization,
- Regulatory activism, growing litigation,
- **Growing area of research; need to advance field of study.**

- Motivation for later on...

The bank is now testing a variety of new models and methodologies to get a better handle on where the economy is headed, and updating its forecasts eight times a year.

“We are working hard to refine those models, but this experience is also leading us to put increase emphasis on anecdotal evidence – real conversations with real Canadians making economic decision.”

Source: Globe and Mail, March 28, 2014, Bank of Canada Governor Stepehn Poloz



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# 3. Focus on Operational Risk

## Notable Operational Risk Events (Global)

### (2013) JPMorgan Chase - **over \$8bn USD** - London Whale

*Aug 14 2013 - ['London whale' traders charged in US over \\$7bn loss](#)*

*Sep 19 2013 - [JP Morgan fined \\$920m over 'woefully deficient' London Whale controls](#)*

*Trader Bruno Iksil, nicknamed the London Whale, accumulated outsized CDS positions reportedly as part of the bank's hedging strategy. Strategy was "flawed, complex, poorly reviewed, poorly executed, and poorly monitored".*

### (2012) Busan Savings Bank internal fraud - **\$4.29bn USD**

*Jun 19 2012 - [Korean bank scandal prompt suicides](#)*

*Busan Savings Bank and its subsidiaries were making bad loans to more than 100 real estate and construction companies in South Korea. The bank's executives, including chairman Park, were detained for illegal loans and fraud. The Governor of the Financial Supervisory Service (FSS) were also found guilty for illegally holding a stake in the Bank.*

### (2011) UBS rogue trader- **\$2.3bn USD**

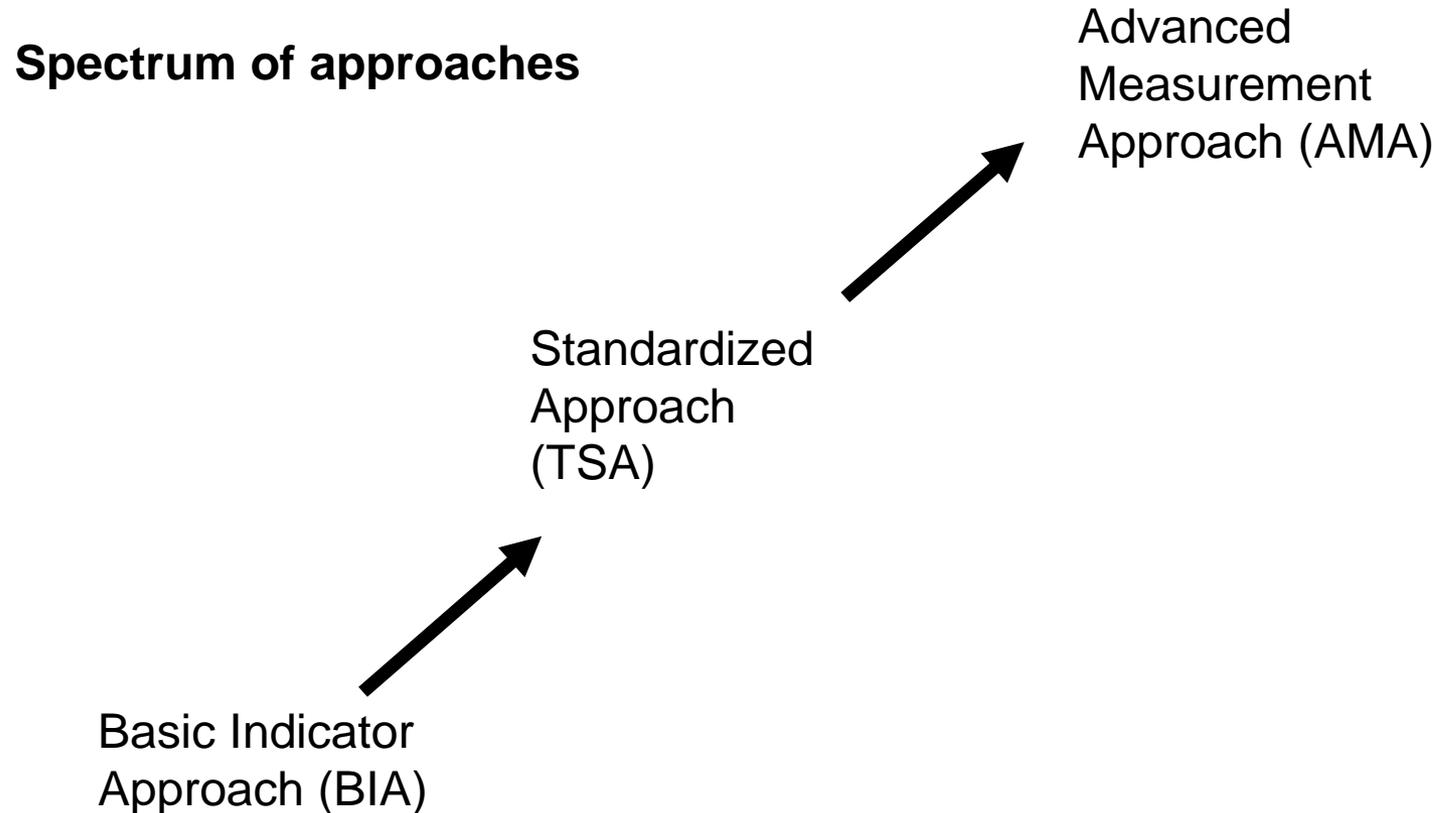
*The director of the bank's Global Synthetic Equities Trading team in London conducted a series of unauthorized trades, disguising the risk with fictitious, forward-settling, cash ETF positions.*

### (2011) 77 Bank tsunami loss - **\$378.24mn USD**

*The tsunami that hit Japan last year caused 77 Bank, a regional bank in Sendai, to suffer a great loss due to physical damages and unrecoverable loans.*



### 3. Focus on Operational Risk



### 3. Focus on Operational Risk

#### Basic Indicator Approach (BIA)

- Capital charge is based on the 3-year average of a fixed percentage ( $\alpha$ ) of positive gross income (GI).

$$\text{Capital charge} = [\sum_{i=1}^n (GI_i \times \alpha)]/n$$

- GI = net interest income + net non-interest income as defined by national supervisors and/or national accounting standards.
- Exclude years of negative gross income.
- $\alpha = 15\%$ .
- Generally used as a default op. risk capital charge.



# 3. Focus on Operational Risk

## Basic Indicator Approach (BIA)

- Exclude years with negative gross income.

	GI (\$B)	x 15% (\$B)
Year 1	80	12
Year 2	-20	
Year 3	120	18
Total		30
Average	Total / 2 =	\$15 B



### 3. Focus on Operational Risk

#### The Standardized Approach (TSA)

- Activities mapped to 8 Basel II business lines.
- Capital charge for each business line calculated by multiplying gross income by the factor ( $\beta$ ) for that business line ( $\beta$  factors are distributed around  $\alpha$ ).

$$\text{Capital charge} = \{\sum_{\text{years } 1-3} \max[\sum(GI_{1-8} \times \beta_{1-8}), 0]\}/3$$

- Total capital charge is the average of the simple summation of the capital charges across all business lines in each year of the preceding 3-year period.
- Unlike the BIA, the denominator must always be set to 3 (allows a bit of a break – granularity)..



### 3. Focus on Operational Risk

#### The Standardized Approach (TSA)

<b>Business Lines</b>	<b>Beta Value</b>
Corporate Finance	18%
Trading & Sales	18%
Retail Banking	12%
Commercial Banking	15%
Payment & Settlement	18%
Agency Services	15%
Retail Brokerage	12%
Asset Management	12%



# 3. Focus on Operational Risk

## The Standardized Approach (TSA)

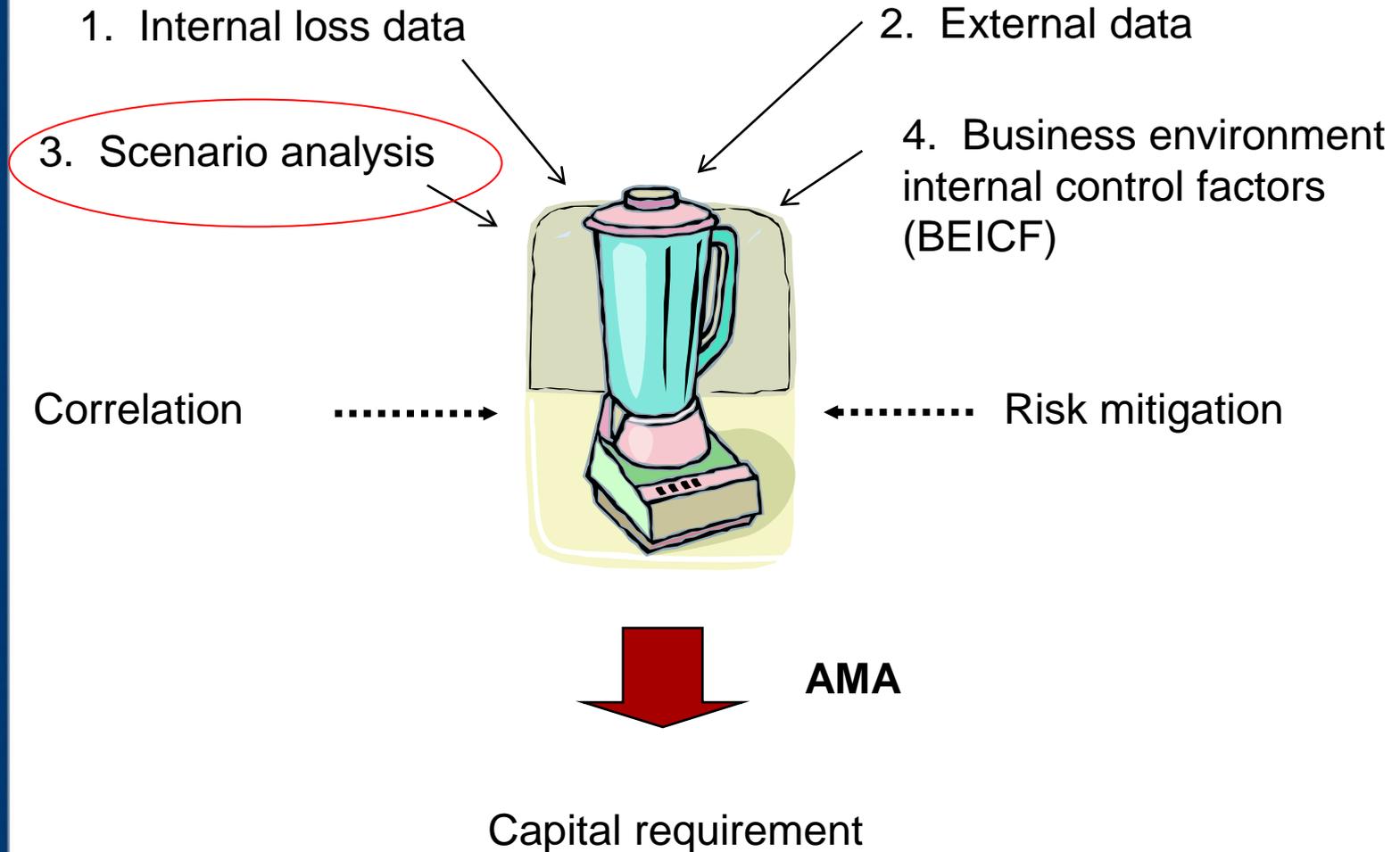
Year 1	Gross income (\$ B)	x Beta	Total (\$B)
Business Line A	60	12%	7.2
Business Line B	-10	15%	-1.5
Business Line C	30	18%	5.4
Total	80		11.1
Year 2	Gross income	x Beta	Total
Business Line A	30	12%	3.6
Business Line B	-40	15%	-6.0
Business Line C	-10	18%	-1.8
Total	-20		-4.2
Year 3	Gross income	x Beta	Total
Business Line A	80	12%	9.6
Business Line B	10	15%	1.5
Business Line C	30	18%	5.4
Total	120		16.5

Capital charge =

$$\frac{11.1 + 0 + 16.5}{3}$$

$$= \$9.2 \text{ B}$$

### 3. Focus on Operational Risk



### 3. Focus on Operational Risk

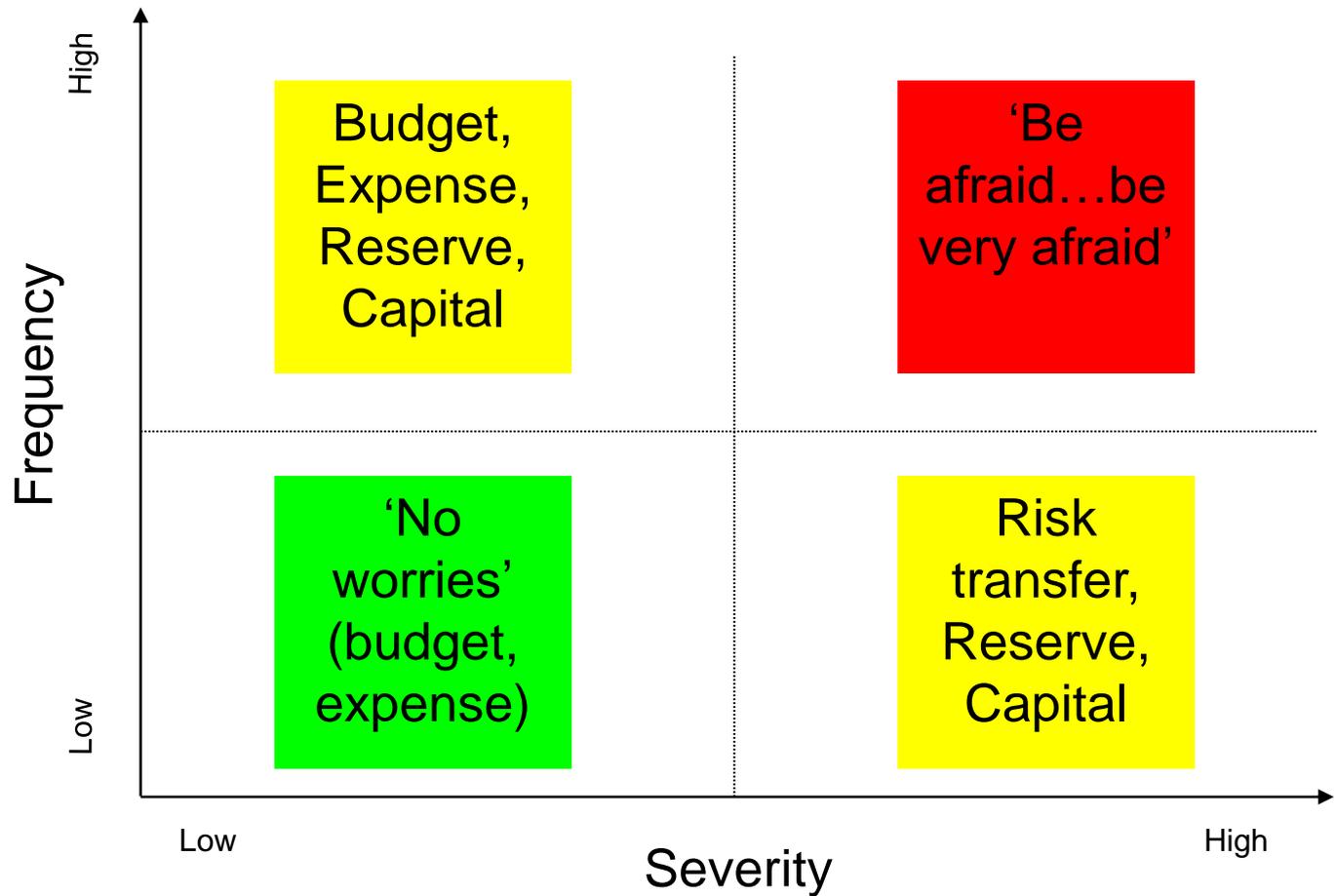
Data collection: 8 business lines, 7 event types = 56 units of measure

BL/ET	Internal Fraud	External Fraud	Employment Practices and Workplace Safety	Clients, Products & Business Practices	Damage to Physical Assets	Business Disruption and System Failures	Execution, Delivery & Process Management
Corporate Finance							
Trading & Sales							
Retail Banking							
Commercial Banking							
Payment and Settlement							
Agency Services							
Asset Management							
Retail Brokerage							



### 3. Focus on Operational Risk

#### Bank treatment of op. risk losses



### 3. Focus on Operational Risk

#### 1. Internal loss data

- Usually loss data collected for a minimum of 5 years.
- Losses collected above a threshold of \$10,000 USD.
- Losses booked into a central database by risk officers in each business line.
- Record date of occurrence, date of discovery, date of settlement, gross loss, recoveries, etc.
- Not all 56 units of measure will have sufficient data points to calibrate model (usually about 50-100 data points minimum).



# 3. Focus on Operational Risk

## 2. External loss data

- i. Vendor databases (e.g. SAS OpRisk and Algo OpRisk)
  - Compiled from public data and have a story-line approach to describing losses. Taken from newspapers, court records, journals etc.
  
- ii. Consortia databases (e.g.. ORX)
  - Give-and-take basis allowing banks to contribute operational loss data in order to receive in return anonymized loss data from peers groups.



# 3. Focus on Operational Risk

## 2. External loss data

Vendor; As of 2012	SAS OpRisk	Algo OpData
Total number of observations	22,000	12,000
Industries covered	21	20
Financial services covered	6,361	4,519
Loss threshold	\$ 100,000	\$1,000,000
First year of losses	1971	1972

Consortia; As of 2012	ORX
Total number of observations	160,000
Severity of losses	€55 billion
Member banks	54
First year of losses	2002
Loss threshold	€20,000

Source: [http://www.sas.com/en\\_us/software/risk-management/oprisk-management.html](http://www.sas.com/en_us/software/risk-management/oprisk-management.html)  
<http://www-03.ibm.com/software/products/en/algo-opdata/>  
<http://www.orx.org/Pages/HomePage.aspx>



### 3. Focus on Operational Risk

- Loss aggregation approaches
  - i) Analytic approach
    - The single loss approximation
  - ii) Numerical approach
    - The FFT approach
    - The Panjer recursion
  - iii) Simulation based approach
    - The Monte Carlo approach

**Most popularized method is the MC method**



### 3. Focus on Operational Risk

#### Monte Carlo Method

- Perform loss aggregate by modeling separately frequency and severity of losses.

$$S_k = \sum_{i=1}^{N_k} X_{k,i}$$

- $k=1 \dots m$ , where  $m = 56$  usually ( $S_1, S_2, \dots, S_{56}$ ).
- $N_k =$  frequency distribution (each cell may have different dist.).
- $X_{k,1}, \dots, X_{k,N_k} =$  random draws of the severity distribution  $X_k$  (each cell may have different dist.).

#### ALGORITHM

1. Draw from frequency distribution a number  $N$  which represents the number of occurrences a loss is to occur for a cell,
2. Draw  $N$  realizations from severity distribution,
3. Sum all the  $N$  losses to obtain an aggregate loss for the year,
4. Repeat steps 1 to 3 many times (ex. 1 million),
5. Pick up the 99.9% percentile as op risk capital.



### 3. Focus on Operational Risk

- Frequency - popular choices are: Poisson, Negative Binomial.
- Severity - popular choices are: Log-normal, Log-gamma, Log-logistic, Burr, Generalized Pareto, Weibull.

#### How to choose best severity distribution? – Goodness of fit tests

- Kolmogorov-Smirnov (KS) Test: Compares the empirical distribution function (EDF) with the cumulative distribution function (CDF) of the assumed distribution. The KS statistic is the maximum distance between the two curves.
- Anderson-Darling (AD) Test: Modified KS test to give more weight to the tail.
- Probability Plot: Graphical technique for assessing whether or not a sample follows a hypothesized distribution.
- Quantile-Quantile Plot: Similar to the PP plot, but determines whether two samples come from the same distribution.
- Etc..



## 3. Focus on Operational Risk

### 3. BEICF

- Firm-wide risk assessment methodology must capture key factors that are forward-looking and reflect quality of a bank's control and operating environment.
- Many options! May design a customized scorecard that assigns a point system to each factor across business lines or some level of granularity.
- **BE**: comment on products, strategy, business cycle, volumes, regulatory environment etc.
- **ICF**: comment on people, processes, systems, audit scores, etc.
- Tally points assigned above, depending on final score, assign capital adjustment of anywhere from -10%, 0, +10%.
- Usually applied on top of model incorporating loss data and scenarios.



### 3. Focus on Operational Risk

#### 4. Scenarios!

- “A bank must use scenario analysis of expert opinion in conjunction with external loss data to evaluate its exposure to high-severity events.”
- “...draws on the knowledge of business managers...to derive reasoned assessments of plausible severe losses”.
- “...could be expressed as parameters of an assumed statistical loss distribution”.
- Only one paragraph to go on!

Source: OSFI CAR Chapter 8, par 63



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# 3. Focus on Operational Risk

## 4. Scenarios!

- Used to provide a “forward looking view”.
- Used in places of data scarcity.

### Range of practice

- Some Australian and European banks (Italy, Germany) have scenario-based AMA models.
- US has less comfort with scenarios used directly in model (put into a benchmark model instead).
- Canada acknowledges best-practice with sufficient justification.



## 4. Proposed problem: Scenario quantification for operational risk modeling

Problem: How best should scenario workshops be conducted in order to elicit necessary and sufficient information to formulate scenarios for modeling?

How should questions be framed? What are realistic questions to ask on frequency and severity?

What sort of data should be referenced in order to guide scenario respondents?

How can scenarios be updated/refreshed over time to ensure their reasonableness?

Are scenarios a valuable element for AMA modeling?



## 4. Proposed problem: Scenario quantification for operational risk modeling

### Research

- Chaudhury (2010) discusses the key issues in operational risk capital modeling. Good coverage of the open problems with AMA modeling.
- Khaneman and Tversky (1979) introduce Prospect Theory which concerns decision making under conditions of risk.
- Empirically showed respondents underweight outcomes that were merely probable in comparison to outcomes that were obtained with certainty.
- Real-live workshops showed a preference for a sure gain over a larger gain that was merely probable.
- Rather than accept a smaller loss with certainty, participants preferred to take on risk and gamble on a loss what was merely probable but larger in loss magnitude.



## 4. Proposed problem: Scenario quantification for operational risk modeling

### Research

- Ergashev (2012) points to quantifying scenarios with an ordered pair: frequency estimate that represents a worst-in-a-M-year event and a severity estimate that represents a lower bound of loss amount. Does not go into detail how to arrive at 'M' or lower bound. Rather paper goes on to test if scenario moves the risk profile of the base LDA model by imposing a lower bound constraint on the severity distribution.
- Dutta and Babbel (2010) introduce Change of Measure approach to integrate scenarios. Starting from the point of a frequency estimate of 1 in N years and severity in a range [a,b], outlines methods to adjust baseline LDA model to incorporate scenarios. Does not suggest how to elicit N of [a,b]. However, does say to limit N to a 100 year event for methodology stability.
- **One possible method to incorporate scenario as raw estimate directly.**



## 4. Proposed problem: Scenario quantification for operational risk modeling

### Research

- Shevchenko and Wüthrich (2006) introduce method of combining loss data with expert opinions via Bayesian inference.
- Aside from main result of paper, points to ad hoc procedure to incorporate scenarios that are fitted to distribution:
$$w_1 F_{SA}(X) + w_2 F_I(X) + (1 - w_1 - w_2) F_E(X)$$
- Alternative method to simply integrate scenarios as a distribution
- Paul Embrechts and Eric Cope along with fellow collaborators are highly published and regarded in the operational risk community. Numerous papers of relevance.



## 4. Proposed problem: Scenario quantification for operational risk modeling

Issue:

- Banks unwilling to share operational loss data (confidential).
- Select publications that do exist mask identity of bank; also scale data.
- “It is ORX policy to work with industry and academic partners where appropriate and through an open selection process. If you are interested in a research partnership with ORX then please contact:

Dr. Luke Carrivick  
Head of Analytics and Research  
ORX  
Email: [luke.carrivick@orx.org](mailto:luke.carrivick@orx.org) “

- Other innovative methods? Simulated data?



## 4. Proposed problem: Scenario quantification for operational risk modeling

- Perhaps phrase the problem in terms of weather?
- <http://climate.weather.gc.ca/>. Data readily available on rainfall, snowfall.
- Extension to catastrophic events such as tornadoes, hurricanes (low frequency/high severity)? Occurs with somewhat random frequency and varying severities. Tail events.
- Develop baseline LDA model; reference data of neighbouring cities; develop scenarios.
- If results seems tractable, reach out to data consortium/banks, publish results?



## 5. Recap and benefits of the workshop

- Introduced banking regulation and the numerous areas where mathematical and statistical models are needed and used.
- Narrowed the focus to operational risk in order to spur research and seek answers to open questions.
- For the AMA model, looking to apply a structured mathematical process to elicit scenarios and also calibrate and integrate scenarios.
- Value-add through publication and/or guidance to the industry in terms of potential new regulatory policy.
- OSFI continually hires mathematical/statistical candidates (MSc, MA, PhD, CFA, FRM etc.). Two potential positions opening up in 2015 in RMAAS group – look for it!



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# Questions?

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