### Quantifying operational risk Appendix

CAS: seminar on reinsurance

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### ERNST & YOUNG

Quality In Everything We Do

### Insurance operational risk taxonomy: Solvency II/ Basel II Level 1, Basel II Level 2, ORIC Level 3

Event-type category (Level 1)	Definition	Categories (Level 2)	Activity (Level 3)	Insurance activity examples
Internal fraud	Losses due to acts of a type intended to defraud, misappropriate property or circumvent regulations, the law or company policy, excluding diversity/ discrimination events, which involves at least one internal party.	Unauthorized activity	<ul> <li>Unauthorized use of computer systems to defraud firm or customer</li> <li>Unauthorized transactions</li> <li>Unreported transactions</li> <li>Over-reporting of transactions</li> <li>Falsifying personal details</li> </ul>	<ul> <li>Inappropriate use of a system username and password to circumvent application controls</li> <li>Inappropriately authorized payment</li> <li>Nondisclosure of investment losses</li> <li>Intentionally circumventing claims payment limits</li> <li>Use of false personal details in order to make a claim</li> </ul>
		Theft and fraud (also see external fraud >> theft and fraud)	<ul> <li>Theft of assets</li> <li>Destruction of assets</li> <li>Forgery, impersonation</li> <li>Disclosure of confidential information</li> <li>Accounting irregularities</li> <li>Misappropriation of assets</li> </ul>	<ul> <li>Office burglaries, with internal collusion</li> <li>Deliberate sabotage of a firm's property with internal collusion</li> <li>An employee impersonating a client, in order to perpetrate a fraudulent claim</li> <li>An employee colluding with an individual making a fraudulent claim</li> <li>Deliberately following an incorrect accounting procedure for fraudulent gain</li> </ul>
External fraud	Losses due to acts of a type intended to defraud, misappropriate property or circumvent the law, by a third party.	Theft and fraud	<ul> <li>Theft of assets</li> <li>Forgery, impersonation</li> <li>Fraudulent billing by suppliers</li> <li>Fraudulent claims</li> </ul>	<ul> <li>An office burglary</li> <li>A policyholder knowingly supplies incorrect policy data to obtain cover.</li> <li>A supplier deliberately overcharging for their services</li> <li>Fraudulent surrenders e.g., commission fraud</li> </ul>
		Systems security (see also business disruption and systems failure >> systems >> external interference)	<ul> <li>Hacking</li> <li>Theft of information</li> <li>Viruses</li> </ul>	



### Insurance operational risk taxonomy: Basel II/ Solvency II Level 1, Basel II Level 2, ORIC Level 3

Event-type category (Level 1)	Definition	Categories (Level 2)	Activity (Level 3)	Insurance activity examples
Employment practices and workspace safety	Losses arising from acts inconsistent with employment, health or safety laws or agreements, from payment of personal injury claims or from diversity/discrimination events.	Employee relations	<ul> <li>Harassment</li> <li>Terminations, including tribunals</li> <li>Industry activity</li> <li>Management</li> <li>Loss of key personnel</li> </ul>	<ul> <li>Fines due to workspace harassment</li> <li>An individual wins a case for constructive dismissal</li> <li>Downtime costs associated with general strike by staff</li> <li>Lack of succession planning</li> <li>Key man dependency</li> </ul>
		Safe environment	<ul> <li>Health and safety</li> <li>Public liability</li> <li>Employee liability</li> </ul>	<ul> <li>Fines by health and safety executive</li> <li>Public compensation claims due to negligence or personal injury</li> <li>Employee compensation claims due to negligence or personal injury</li> </ul>
		Diversity and discrimination	<ul> <li>Equal opportunities</li> <li>Human rights</li> </ul>	<ul> <li>Discrimination — religious, sex, age, ethnicity and so on</li> <li>Fines due to breaches of human rights</li> </ul>
Damage to physical assets	Losses arising from loss or damage to physical assets from natural disaster or other events.	Disasters and other events	<ul> <li>Natural disaster losses</li> <li>Losses from external sources (terrorism, vandalism)</li> <li>Physical asset failure (not systems)</li> </ul>	<ul> <li>Claims to replace or repair assets and buildings</li> <li>Human cost</li> </ul>
Business disruption and system failures	Losses arising from disruption of business or system failures.	Systems	<ul> <li>Hardware</li> <li>Software</li> <li>IT network</li> <li>Telecommunications</li> <li>Utility outage/disruptions</li> <li>External interference (excluding fraudulent activity) see also systems security</li> </ul>	<ul> <li>IT system and telecommunications failure and downtime</li> <li>Software failure</li> <li>Viruses and security breaches</li> <li>Telephone systems failure</li> <li>Power outage</li> <li>Hacking</li> </ul>



### Insurance operational risk taxonomy: Basel II/ Solvency II Level 1, Basel II Level 2, ORIC Level 3

Event-type category (Level 1)	Definition	Categories (Level 2)	Activity (Level 3)	Insurance activity examples
Clients, products and business practices	Losses arising from an unintentional or negligent failure to meet a professional obligation to specific clients (including fiduciary and suitability requirements), or from the nature or design of a product.	ligent     disclosure and fiduciary       ion to <ul> <li>Data Protection Act</li> <li>disclosure and fiduciary</li> <li>Begulatory compliance of</li> </ul>	<ul> <li>Contractual policyholder breaches. e.g., advice given around cost of rebuild for home insurance, or guarantees about cover, not honored in the future</li> <li>Fines under the data protection rules because the firm sells a database of customer's details to another insurance firm</li> <li>Fines due to a regulatory breach by a financial advisor</li> <li>Fines due to failure to ensure that a customer had sufficient information during the claims handling process</li> </ul>	
		Improper business or market practices	<ul> <li>Money laundering</li> <li>Other improper market practices</li> <li>Insider dealing</li> <li>Tax evasion</li> <li>Antitrust</li> </ul>	<ul> <li>Regulator imposed fines as a consequence of non-qualified individual selling or giving advice after January 2005. e.g., breach of privacy</li> <li>Fines due to other regulatory or tax breaches</li> <li>Fines incurred due to anticompetitive market practices such as price fixing</li> </ul>
		Product flaws	<ul> <li>Product defects (unauthorized)</li> <li>Product literature defects</li> <li>Product design</li> <li>Unintentional guarantees</li> </ul>	<ul> <li>Product related complaints</li> <li>Misleading wording in policy</li> <li>Costs associated with an under researched product going to market, requiring further unplanned development</li> <li>Customer discounts being incorrectly applied on policies</li> </ul>
		Selection, sponsorship and exposure (investigate original Level 2 description)	<ul> <li>Client fact-finding</li> <li>Client exposure</li> </ul>	<ul> <li>Cost associated with contractual breaches from partnerships and third parties</li> </ul>
		Advisory activities	<ul> <li>Miss-selling due to mortgage endowment</li> <li>Miss-selling (other)</li> </ul>	



### Insurance operational risk taxonomy: Basel II/ Solvency II Level 1, Basel II Level 2, ORIC Level 3

Event-type category (Level 1)	Definition	Categories (Level 2)	Activity (Level 3)	Insurance activity examples
Execution, delivery and process management	Losses from failed transaction processing or process management, from relations with trade counterparties and vendors.	Transaction capture, execution and maintenance	<ul> <li>Customer service failure</li> <li>Data entry error</li> <li>Transaction system error</li> <li>Management information error</li> <li>Accounting error</li> <li>Incorrect application of charges</li> <li>Incorrect unit pricing/allocation</li> <li>Management failure</li> <li>Inadequate process documentation</li> <li>Training and compliance</li> </ul>	<ul> <li>Service related complaints</li> <li>Incorrect entry input</li> <li>Systems corruption</li> <li>Incorrect management information</li> <li>Reconciliation errors</li> <li>Pricing errors or backdating adjustments</li> <li>Projects initiated, then cancelled</li> <li>Failure of staff to follow required procedure</li> </ul>
		Monitoring and reporting	<ul> <li>Failed mandatory reporting</li> <li>Inaccurate external reporting</li> </ul>	
		Customer intake and documentation	<ul> <li>Incomplete/incorrect application documents</li> <li>Contract documents incorrect</li> <li>Inappropriate underwriting</li> <li>Inappropriate reinsurance</li> <li>Missing documentation</li> </ul>	<ul> <li>Redrafting of mislaid or incorrect legal documentation</li> <li>Ineffective documents</li> <li>Exceeding underwriting limits (unintentional)</li> <li>Missing policy document</li> </ul>
		Customer/client account management	<ul> <li>Incorrect customer records</li> <li>Payment to incorrect customer/client</li> <li>Incorrect payment to customer/client</li> </ul>	
		Trade counterparties	<ul> <li>Third-party actions</li> <li>Ethical and environmental failures</li> </ul>	<ul> <li>Reinsurers, brokers advertising agencies</li> </ul>
		Vendors and suppliers	<ul><li>Vendor delivery failure</li><li>Vendor disputes</li></ul>	<ul> <li>Legal expenses for financial recoveries</li> </ul>



## **Causal categories: (ORIC)**

Level 1	Level 2	Level 3 – cascading from level 1 only	
People	<ul> <li>Training</li> <li>Competence</li> <li>Knowledge</li> <li>Culture/behavior</li> <li>Inadequate resources</li> <li>Other</li> </ul>	<ul> <li>Caliber of recruits</li> <li>Human error</li> <li>Misinterpretation</li> <li>Poor relationship management</li> <li>Lack of communication</li> <li>Not meeting customers reasonable expectations</li> <li>Senior management awareness</li> <li>Key person/knowledge dependency</li> <li>Unaware of change</li> <li>Senior management knowledge</li> <li>Product too complex</li> <li>Inappropriate customer/product fit</li> <li>Regional/international differences</li> <li>Succession planning</li> </ul>	
Process	<ul> <li>Inadequate operational procedures</li> <li>Inadequate policies</li> <li>Product design</li> <li>Inadequate monitoring/reporting</li> <li>Process change/implementation</li> <li>Other</li> </ul>	<ul> <li>Dealing with change</li> <li>Spreadsheet workarounds</li> <li>Lack of documentation</li> <li>Lack of due diligence</li> <li>Poor contract/service level agreement</li> <li>Management decision/change not implemented</li> <li>Management decision/change not</li> </ul>	
System (IT)	<ul> <li>Coding</li> <li>Testing</li> <li>IT strategy</li> <li>Complexity of interfaces</li> <li>Maintenance</li> <li>Investment</li> <li>Data integrity</li> <li>Resilience</li> <li>Other</li> </ul>	<ul> <li>Software design</li> <li>Virus</li> <li>Hardware failure</li> <li>Security</li> <li>Poor user acceptance testing/regression testing</li> <li>Legacy systems</li> </ul>	
External event	<ul> <li>Trade counterparty</li> <li>Customer</li> <li>Regulatory/political</li> <li>Infrastructure failure</li> <li>Service provider</li> <li>Other</li> </ul>	<ul> <li>Lack of understanding of third-party data</li> <li>Third-party situation beyond firm control (power/telephony/water/services)</li> <li>Reliance on third-party data</li> <li>Lack of understanding of implications of change to third-party systems</li> <li>Lack of understanding of implications of change to third-party systems</li> <li>Increase in transaction volume</li> <li>Unrealistic customer expectation</li> <li>Disgruntled employee</li> </ul>	



## **ORIC** data

The Operational Risk Insurance Consortium (ORIC):

- The Association of British Insurers (ABI) founded ORIC together with 16 core insurers to provide thought leadership and enhance quantitative and qualitative understanding of operational risk. ORIC is constantly growing both in the UK and internationally, adding new members every year. It remains a not-for-profit organization, and its current members are drawn from both life and nonlife types of business.
- The database currently stores more than 2,500 loss events collected from 23 member firms over the last four years, with total gross operational risk losses more than £1bn.
- The ORIC has set a standard for the industry in terms of risk event categorization. The Level 1 and 2 categories are consistent with the Basel II Accord. ORIC and its members have developed a further Level 3 categorization system to increase the granularity of the database.



## ORIC data (cont'd)

The "Loss" database maintained by ORIC provides in-depth narratives of the events leading to losses. It also captures the causes that lead risks to materialize and turn into loss events. The database design suits the international expansion of ORIC as it captures the geography of losses and allows firms to submit data in various currencies. The database infrastructure supports data relating to actual monetary losses as well as near misses. In addition, when it is not possible to accurately quantify near miss losses in monetary terms, they can be stored in the ORIC database as "unquantifiable near misses".



## **ORX** data

The Operational Riskdata eXchange Association (ORX)

- ORX is dedicated to advancing the measurement and management of operational risk in the global financial services industry.
- ORX was founded in 2002 with the primary objective of creating a platform for the secure and anonymized exchange of high-quality operational risk loss data. Today ORX operates the world's leading operational risk loss data consortium for the financial services industry. The ORX Global Loss Database contains approximately 158,000 operational risk loss events, each event more than €20,000 in value, to a total value of €47 billion.
- ORX is owned and controlled, on an equal basis, by its 54 member firms:



## **ORX** data

The membership of ORX is growing rapidly. Originally, ORX was founded by 12 member banks; membership has now grown to 54 leading banks from 18 different countries. The current membership is as follows:

- ABN AMRO
- Banc Sabadell
- Banco Bilbao Vizcaya Argentaria
- Banco Bradesco
- Banco Pastor
- Banco Português de Negócios
- Bank Austria Member of UniCredit Group
- Bank of America
- Bank of Ireland Group
- Barclays Bank
- BMO Financial Group
- BNP Paribas Fortis
- Caixa Catalunya

- Caixanova
- Caja Laboral
- Cajamar
- Capital One
- Commerzbank AG
- Commonwealth Bank of Australia
- Credit Agricole
- Danske Bank A/S
- Deutsche Bank AG
- Deutsche Postbank AG
- ► Erste Group Bank AG
- Euroclear Bank
- FirstRand
- Fortis NL
- Grupo Banco Popular

- Grupo Banesto
- Grupo Santander
- HSBC
- ► ING
- Intesa San Paolo IMI
- JPMorganChase
- Lloyds TSB Bank plc
- Morgan Stanley
- National Australia Bank
- Northern Trust
- ► PNC
- Rabobank
- ► RBC Financial Group
- Royal Bank of Scotland
- RZB Group

- Skandinaviska Enskilda Banken AB
- Societe Generale
- Standard Chartered
- State Street Corporation
- TD Bank Financial Group
- The Bank of New York Mellon
- The Bank of Nova Scotia
- US Bancorp
- Wells Fargo & Co
- WestLB
- Westpac Banking Corporation



### Scenario approach – parameter estimation

- The model for quantification of operational risk is based on the separate modeling of two attributes of each loss type – frequency and severity. In the first step, the frequency distribution and severity distribution are modeled separately.
- For frequency modeling of losses, a Poisson distribution is widely used. The Poisson distribution makes the assumption that the losses occur independently. The estimated average frequency of loss for each scenario is taken to be the mean of the distribution. In case that the frequency (expressed as events per year) is lower than one, a Bernoulli distribution is used instead, as the Poisson distribution is not an appropriate statistical tool in this case.



### Scenario approach – parameter estimation

- Severities are modeled using fat-tailed and medium-tailed distributions. It is recommended that a gamma distribution be used in a situation where the data is good enough (two data points of severity distribution function are available) to meaningfully determine the two (α, λ) gamma distribution parameters.
- If, however, only one point on the severity distribution function can be estimated, a distribution function with one free parameter has to be used. In this case, an exponential distribution function with  $\lambda$  parameter will be used. The exponential distribution is a special case of the gamma distribution with  $\alpha = 1$ .
- It can happen that not all input data are available for certain scenarios; in such a situation following modeling, approaches are used based on the data availability.



### Scenario approach – distributions

Input data				Modeling approach	
Most likely event (ML)		Worst case scenario (WCS)		Frequency modeling	Severity modeling
Freq. AF	Severity AS	Freq. WF	Severity WS	approach	approach
Х	Х	х	х	<i>Poisson</i> : if AF>1 <i>Bernoulli</i> : if AF<1	Gamma
	x (ignored)	х	х	<i>Bernoulli</i> for extreme losses: p= WF	Gamma for extreme losses
х		х	х	<i>Poisson</i> : if AF>1 <i>Bernoulli</i> : if AF<1	Exponential ( $\lambda$ derived from the known (1–W <i>F/AF</i> )*100th percentile <i>WS</i> )
		х	х	<i>Bernoulli</i> for extreme losses: p= WF	Gamma for extreme losses
х	х			<i>Poisson</i> : if AF>1 <i>Bernoulli</i> : if AF<1	Exponential

Note: x – data available.

The estimated parameters define the distribution functions for frequency and severity.

Then separate distribution functions for frequency and severity are aggregated into the loss distribution.



# Developing the loss distribution for each cell

Consider again the collective risk process for each cell:

 $Z = S_1 + S_2 + \dots + S_N$  where:

- Z is the total loss;
- ► S<sub>i</sub> is the size of the i<sup>th</sup> loss, i.e., the i<sup>th</sup> severity; and
- N is the number of losses in a year and N is a random variable.

The distribution of the total loss is required to calculate expected and unexpected loss. The techniques used to derive distributions for N and for S are considered above. The aggregation of frequency and severity, assuming that their distributions are independent to each other, is obtained by combining (or convoluting) the potential number of losses in a year and the potential size of those losses. I.e., the probability distribution of Z is:

$$f_{Z}(z) = \sum_{n=0}^{\infty} P\{N=n\} f_{S}^{*n}(z)$$

where  $f_s(s)$  is the common probability distribution of the  $S_i s$  and  $f_s^{*n}$  is its the n<sup>th</sup> convolution.

A direct evaluation of the expression of the aggregate loss distribution is usually very complicated and time consuming. To accelerate the process we use:

- 1. <u>The matching-mean method</u> to construct a discrete severity distribution from the severity distribution that was estimated. The distribution is evaluated on multiples of a convenient monetary unit *h* for each cell and the probability weight assigned to each bucket is chosen in a way to keep the expected value of the distribution unchanged.
- 2. <u>The Fast Fourier Transformation (FFT)</u> to combine the discrete severity distribution with the frequency distribution and compute the aggregate loss distribution for each cell.



# Discretizing the severity distribution using matching mean method

#### The matching-mean method

For a severity distribution with cumulative distribution function  $F_s$ , we first evaluate the limited expected values at multiples of *h*:

$$E[S; j \cdot h] = \int_0^{j \cdot h} [1 - F_s(u)] du, \qquad for \qquad j = 1, 2, \dots$$

The probability vector is calculated by:

$$f_{0} = P\{S = 0 \cdot h\} = 1 - \frac{E[S;h]}{h},$$
  

$$f_{j} = P\{S = j \cdot h\} = \frac{2E[X; j \cdot h] - E[S;(j-1) \cdot h] - E[S;(j+1) \cdot h]}{h}, \qquad j = 1, 2, ...$$

The advantage of this approach is to preserve the mean severity of the continuous distribution for every bin of the discrete distribution.

In the above method, a discrete vector of limited expected values was obtained first; by taking the second-order finite difference, a discrete probability function was determined.



# Creating a loss distribution using a fast fourier transform

Assume a combination of a loss frequency *N* (number of events in a given year that can cause loss) and a discrete loss severity *X*. The random sum

$$Z = X_1 + X_2 + \ldots + X_N ,$$

where  $X_j$  are independent and identically distributed (i.i.d.) and have the following probability distribution:

$$f_Z(x) = \Pr(Z = x) = \sum_{n=0}^{\infty} \Pr(N = n) \Pr(Z = x \mid N = n) = \sum_{n=0}^{\infty} \Pr(N = n) f_X^{*_n}(x),$$

where

$$f_X(x) = \Pr(X = x)$$

is the common probability distribution of the  $X_{j}$ . A direct evaluation of the above equation (convolution) is very complicated. Instead the Fast Fourier Transform (FFT) technique is introduced for computing the aggregate loss distribution.

In the aggregate loss model, there is in terms of characteristic function:

$$\phi_{Z}(t) = E[e^{it(Z)}] = E_{N}[E[e^{it(X_{1}+X_{2}+\ldots+X_{N})} | N]] = E_{N}[\phi_{X}(t)^{N}] = P_{N}(\phi_{X}(t)),$$

where  $P_N$  is the probability generating function of *N*. This relation in terms of characteristic function suggests that the computation of the compound loss distributions,  $f_z(x)$ , for each scenario can be done using the FFT.

The FFT has been chosen over other algorithms (eg. Heckman-Meyers) due to its speed. The algorithm can be summarized as follows:

1. Choose  $n = 2^m$  for some integer *m*; *n* is the number of points desired in  $f_z(x)$ . In other words, the aggregate loss distribution has negligible probability outside the range [0,*n*].



# Creating a loss distribution using a fast fourier transform

2. Transform the severity probability distribution from a continuous to a discrete one. The span depends on the probability range of severity distribution.

Let  $(f_0, f_1, ..., f_{m-1})$  represent the discrete severity distribution. Zeros are added to the severity probability vector so that it is of length *n*. The padded discrete severity distribution is noted by

$$\mathbf{f}_{X} = [f_{X}(0), f_{X}(1), ..., f_{X}(n-1)].$$

3. Apply FFT to the severity probability vector:

$$\mathbf{f}_{X} = FFT(\mathbf{f}_{X}).$$

4. Apply the probability generating function of the Poisson frequency distribution

 $P_N(t) = E[t^N] = e^{\lambda(t-1)} ,$ 

element by element, to the FFT of the severity vector:

$$\tilde{\mathbf{f}}_{Z}=P_{N}(\tilde{\mathbf{f}}_{X}).$$

5. Apply the Inverse Fourier Transform (IFFT) to recover the aggregate loss distribution

 $\tilde{\mathbf{f}}_{Z} = \mathrm{IFFT}(\tilde{\mathbf{f}}_{Z}).$ 



## Mitigation via insurance (Basel II limitations)

This section will consider the treatment of insurance as a risk mitigant which has not been addressed in other components of the methodology.

- Basel II limits the capital reduction for insurance to 20% of the gross capital assessment subject to the following criteria:
- The insurance provider has a minimum claims paying ability rating of A.
- The insurance policy must have an initial term of no less than one year. Lower periods of cover require the credit of risk mitigation to be reduced up to no allowance for cover with a residual term of 90 days or less.
- The insurance policy has a minimum notice period of 90 days.
- The insurance policy has no exclusions of limitations based upon regulatory action for the receiver or liquidator of a failed bank.
- The risk mitigation calculations must reflect the bank's insurance coverage in a manner that is transparent in its relationship to, and consistent with, the actual likelihood and impact of loss used in the bank's overall determination of its operational risk capital.



# Mitigation via insurance (Basel II limitations) (cont'd)

- The insurance is provided by a third party entity. This holds true for captives as well.
- The framework for recognizing insurance is well reasoned and documented.
- The bank discloses the reduction of the operational risk capital charge due to insurance.

The methodology for recognizing insurance shall capture the following elements through discount or haircuts in the amount of insurance recognition:

- The residual term of an insurance policy, where less than one year;
- A policy's cancellation terms, where less than one year, and
- The uncertainty of payment as well as mismatches in coverage of insurance policies



# Solvency II standard calculation for operational risk

Solvency II – uses VaR of the basic own funds of an insurance or reinsurance undertaking subject to a confidence level of 99.5% over a one-year period.

BSCR = Basic Solvency Capital Requirement

 $SCR_{op}$  = The Capital Charge for Operational Risk

= min(.30 \* BSCR; Op<sub>Inul</sub>) + .25\*Exp<sub>ul</sub>

 $Op_{ln \, ul} = Basic Operational risk charge for all business (not including unit linked business [e.g. ,equity index life contracts])$  $= max [.02*Earn_{nl} + .02Tp_{nl} + .003*(Earn_{life}-Earn_{life}-Ip_{life}-Tp_{life}-Tp_{life}-Ip$ 

SCR = Overall standard capital charge

= BSCR + SCR<sub>op</sub> – Adj



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