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P R I S T I N E

Operational Value at Risk

- **Learning Outcome Statement**
- *The candidate should be able to:*
- Explain the Loss Model Approach
- Explain the Frequency Distribution
- Explain the Severity Distribution
- Demonstrate the Internal Measurement Approach
- Explain the Loss Distribution Approach
- Demonstrate Aggregating Operational Risk Capital (ORC)

Summary of Basel II approaches for operational risk capital calculation

Calculation of Capital Charge	Basic Indicator Approach	Standardized Approach	Advanced Measurement Approach (AMA)
Calculation of Capital charge	<ul style="list-style-type: none"> Average of gross income over three years as indicator of level of operational risk Capital charge equals 15% of that indicator 	<ul style="list-style-type: none"> Gross income per regulatory business line as indicator Depending on business line, 12%, 15%, or 18% of that indicator as capital charge Total capital charge equals sum of charge per business line 	<ul style="list-style-type: none"> Capital charge equals internally generated measure based on: <ul style="list-style-type: none"> Internal loss data External loss data Scenario analysis Business environment and internal control factors Recognition of risk mitigation (up to 20% possible)
Qualifying Criteria	<ul style="list-style-type: none"> No specific criteria Compliance with the Basel Committee's "Sound Practices for the Management and Supervision of Operational Risk" recommended 	<ul style="list-style-type: none"> Active involvement of board of directors & senior mgmt Existence of OR Management function Sound OR management system Systematic tracking of loss data 	<ul style="list-style-type: none"> Active involvement of board of directors and senior management Existence of OR Management function Sound OR management system Systematic tracking of loss data

AMA capital requirement

- Loss model Approach is becoming market standard for AMA
 - It is an Actuarial model
 - Bank collects its internal operational loss data. On basis of frequency and severity of internal (and external loss data), total loss distribution is generated. 99.9% of the resultant loss distribution is Operational Risk VaR.
 - Loss data (frequency and severity) is required for each risk type across each business line. Where data is not available, scenario analysis and Risk Self-Assessment (by a business line) maybe used.
- OR risks is analyzed in terms of:
 - Frequency: Number of losses during a time period
 - Severity: Impact of the event in terms of financial loss

AMA capital requirement (Cont...)

- On frequency, severity matrix:
 - Low frequency, high severity operational risks: Cannot be covered through capital because of high severity, but these risks are usually insurable
 - High frequency, low severity OR like credit card frauds: High EL but low UL (i.e. low chance of extreme large losses): can be covered through provisioning
 - Medium frequency, medium severity: Such events should be the main focus of operational risk capital calculation through AMA

Loss data approach

Loss Distribution Approach

- 1.) Internal loss data
- 2.) External loss data (to enrich internal data) and/or risk scenario data
- 3.) Qualitative assessment

Estimation of parameters based on time series of loss amounts (severity) and number of losses p.a. (frequency) for a given type of distribution function (e.g. Poisson/ Binomial)

Combining severity and frequency distr. (math: convolution) to get a loss distribution (prob. Of aggregated loss amount p.a.) by numerical methods - Monte-Carlo-Simulation

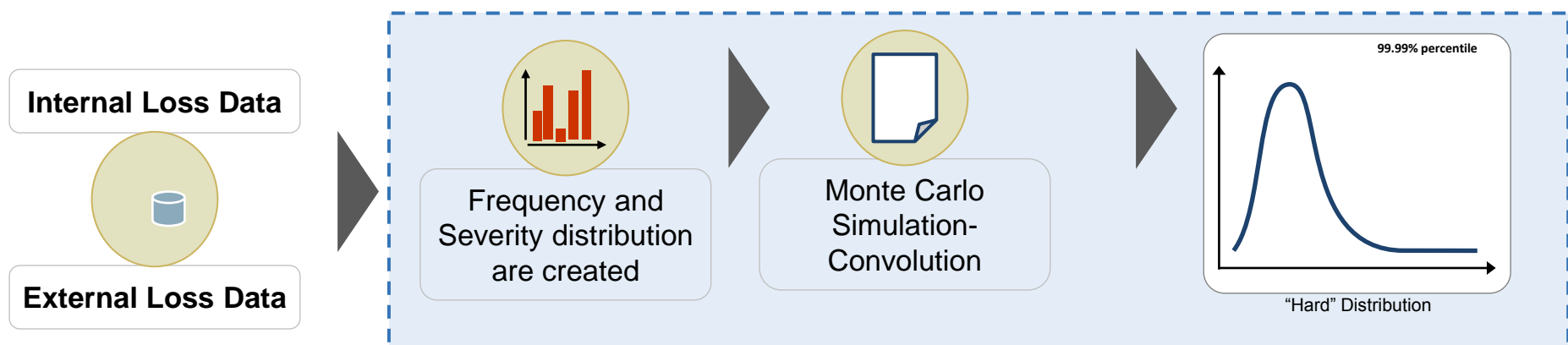
99.9-quantile is read from the loss distribution, the mean can be subtracted - under certain criteria. This is the VaR, which might be multiplied with a qualitative score factor. Expected loss is subtracted from VaR to arrive at capital requirement

Sometimes both internal and external loss data is insufficient to generate loss distribution (for a particular risk type, for a particular business line).

In such cases, qualitative assessment using RSA (Risk Self Assessment) methodology is used, where business line subjectively analyzes frequency and severity of that risk type in their business line

Total loss distribution

- Frequency distribution shows how frequently a loss is happening in a particular period
- Severity distribution shows when the loss happens what is its severity
- A Total loss distribution is obtained by combining (convolution of) both the severity and frequency distribution. This distribution directly shows what is the probability that a particular loss level would be observed during a particular period
 - Usually it is assumed that frequency and severity distributions are independent.
 - Monte Carlo Simulation or Numerical methods are used to combine frequency and severity distributions to obtain total loss distribution
 - Basel II guidelines require capital equal to 99.9 percentile of total loss distribution and one year horizon



Frequency distribution

- Modeling using binomial distribution
 - Requires two parameters
 - N: Total number of events. For instance, for trading activity, N could be target number of deals during next 12 months. For retail banking, N could be total number of credit cards issuance during the next 12 months
 - P: Probability of observing OR loss
 - Therefore, probability of observing 'r' losses is:

$$P(r) = {}^nC_r \times p^r \times q^{n-r}$$

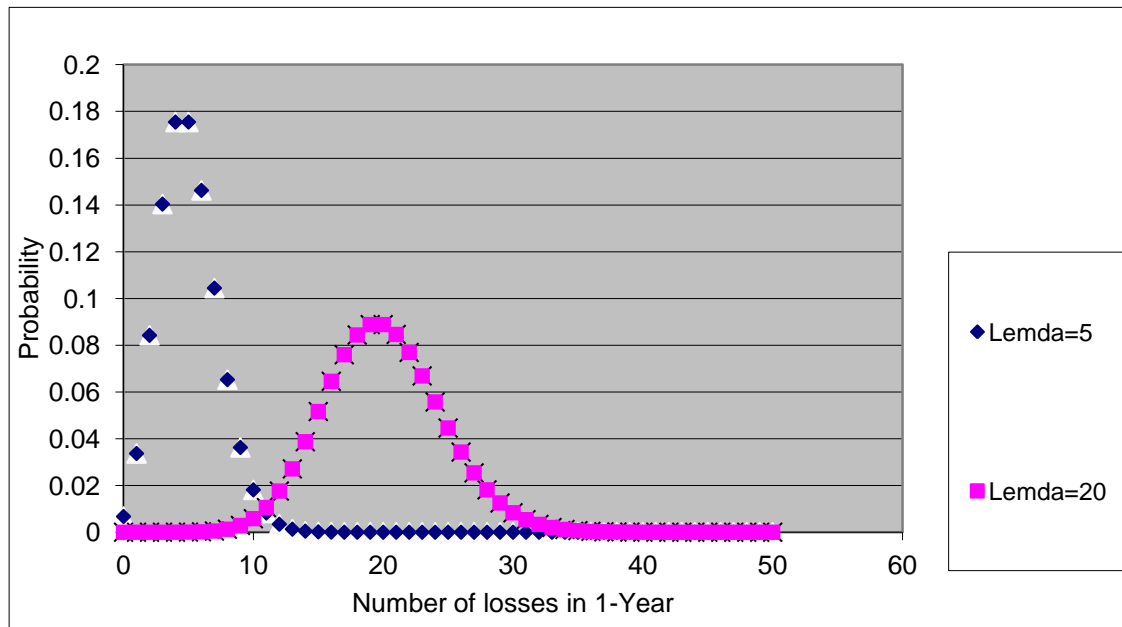
Frequency distribution (Cont...)

- Modeling using Poisson distribution
 - Only one parameter needs to be estimated: λ i.e. expected number of losses during a time horizon (expected loss frequency).
 - λ may be estimated directly using historical data
 - λ may also be estimated by multiplying total number of events (N) by probability (p) of observing that loss type. i.e. $\lambda = N \times p$
 - Another desirable feature of Poisson distribution is that both mean and variance are equal to λ

$$P(r) = \frac{\lambda^r \times \exp(-\lambda)}{r!}$$

Frequency distribution (Cont...)

- Modeling using negative binomial distribution
 - Two parameters Alpha and Beta are required to be estimated
- Choice of model should depend on
 - Type of data
 - Source of loss data: Internal, External or through risk self-assessments (RCSA)

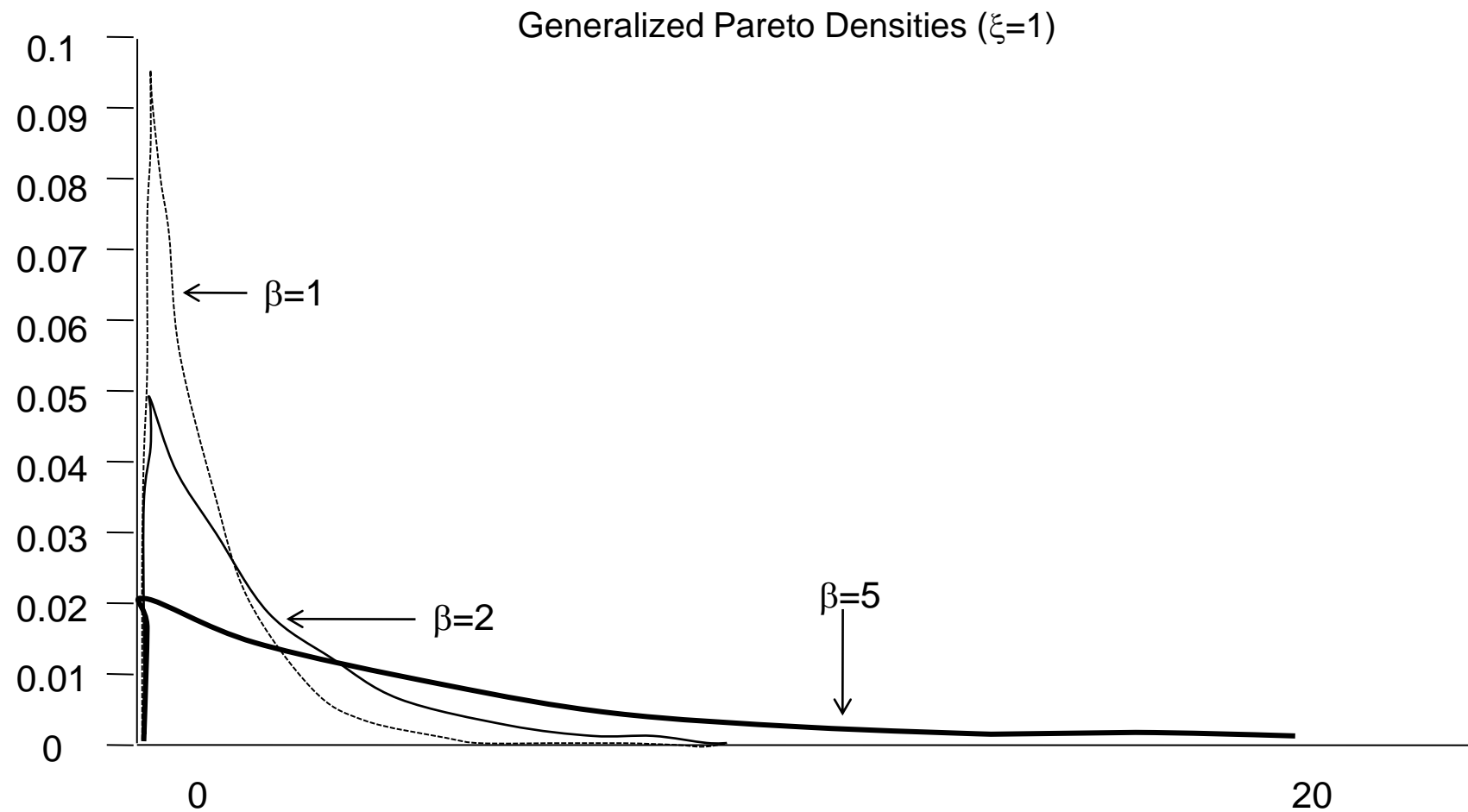


High frequency events would have high Lambda and vice-versa

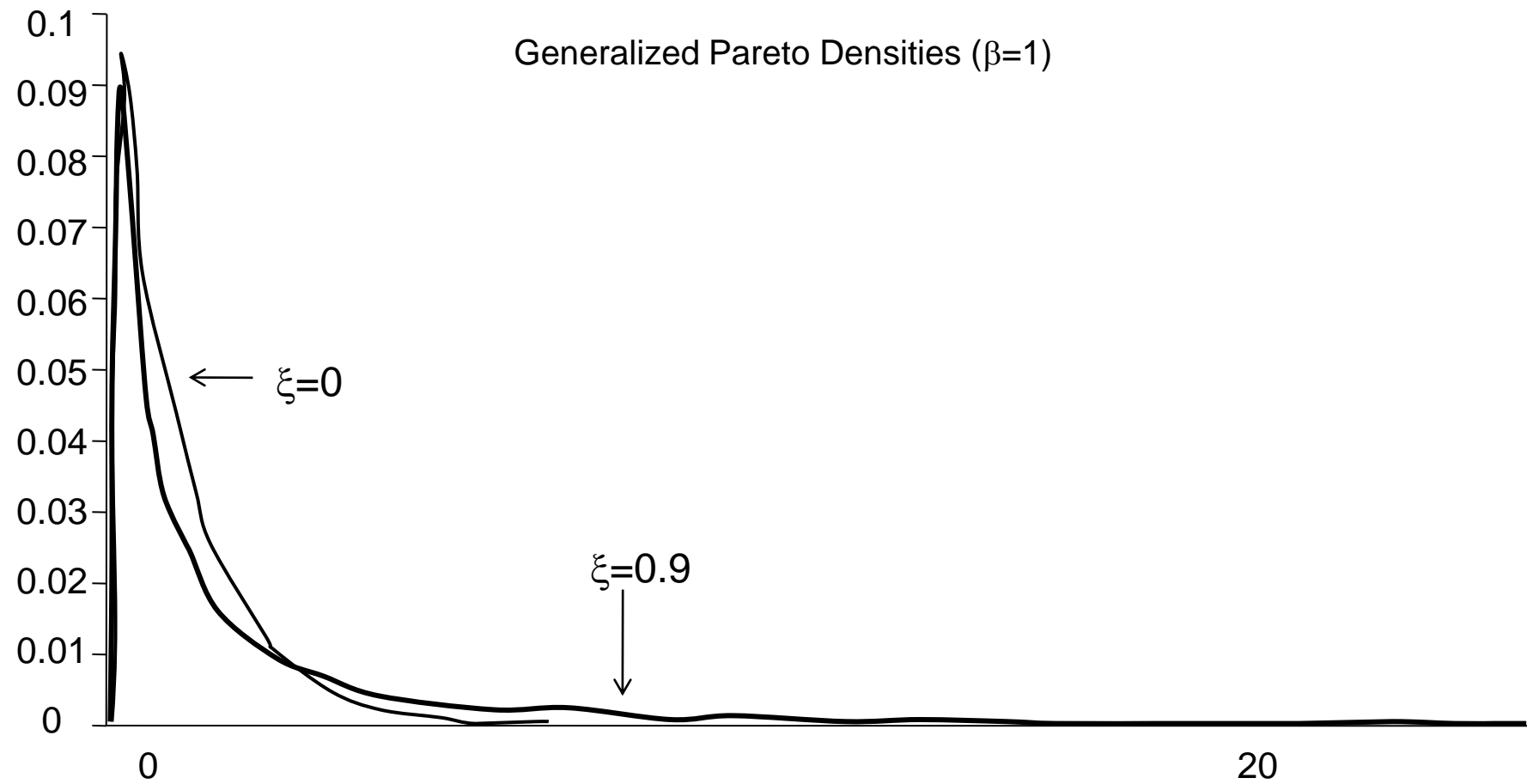
As can be seen from the chart, low frequency events (low Lambda) have skewed & leptokurtic frequency distribution. When combined with severity distribution, therefore, low frequency high severity events have highly skewed and leptokurtic loss distribution (indicating likelihood of extreme losses)

Severity distribution

- Modeling using lognormal distribution
 - Captures severity of high frequency events well
 - Lognormal distribution is not well-suited for low frequency high severity events, as high severity distributions are skewed and leptokurtic
- Modeling using Gamma distribution
 - Well-suited for even low frequency high severity events
- Applying Extreme Value Theory to severity distributions: EVT consists of distribution family known as Generalized Pareto Distribution (GPD). GPD is distribution of scaled excesses over a high threshold. In GPD, severity may be modeled using Peaks over Threshold (POT) model
 - POT is applicable when loss database records only losses that exceed a minimum threshold



Generalized Pareto distribution



The 'gamma' in the IMA (Poisson frequency)

$\lambda \rightarrow$	100	50	40	30	20	10
99.9%-ile	131.805	72.751	60.452	47.812	34.714	20.662
φ	3.18	3.218	3.234	3.252	3.290	3.372
γ	0.318	0.455	0.511	0.594	0.736	1.066
$\lambda \rightarrow$	8	6	5	4	3	2
99.9%-ile	17.63	14.449	12.771	10.956	9.127	7.113
φ	3.405	3.449	3.475	3.478	3.537	3.165
γ	1.204	1.408	1.554	1.739	2.042	2.556
$\lambda \rightarrow$	1	0.9	0.8	0.7	0.6	0.5
99.9%-ile	4.868	4.551	4.234	3.914	3.584	3.255
φ	3.868	3.848	3.839	3.841	3.853	3.896
γ	3.868	4.056	4.292	4.591	4.974	5.51
$\lambda \rightarrow$	0.4	0.3	0.2	0.1	0.05	0.01
99.9%-ile	2.908	2.49	2.072	1.421	1.065	0.904
φ	3.965	3.998	4.187	4.176	4.541	8.94
γ	6.269	7.300	9.362	13.205	20.306	89.401

Risk capital estimates with different correlation assumptions^{P R I S T I N E}

	= -0.5	=0	= 0.5
Expected Loss	22.3909	22.3951	22.3977
99.9 th Percentile	41.7658	48.7665	54.1660
Unexpected Loss	19.3749	26.3714	31.7683

Internal Measurement Approach

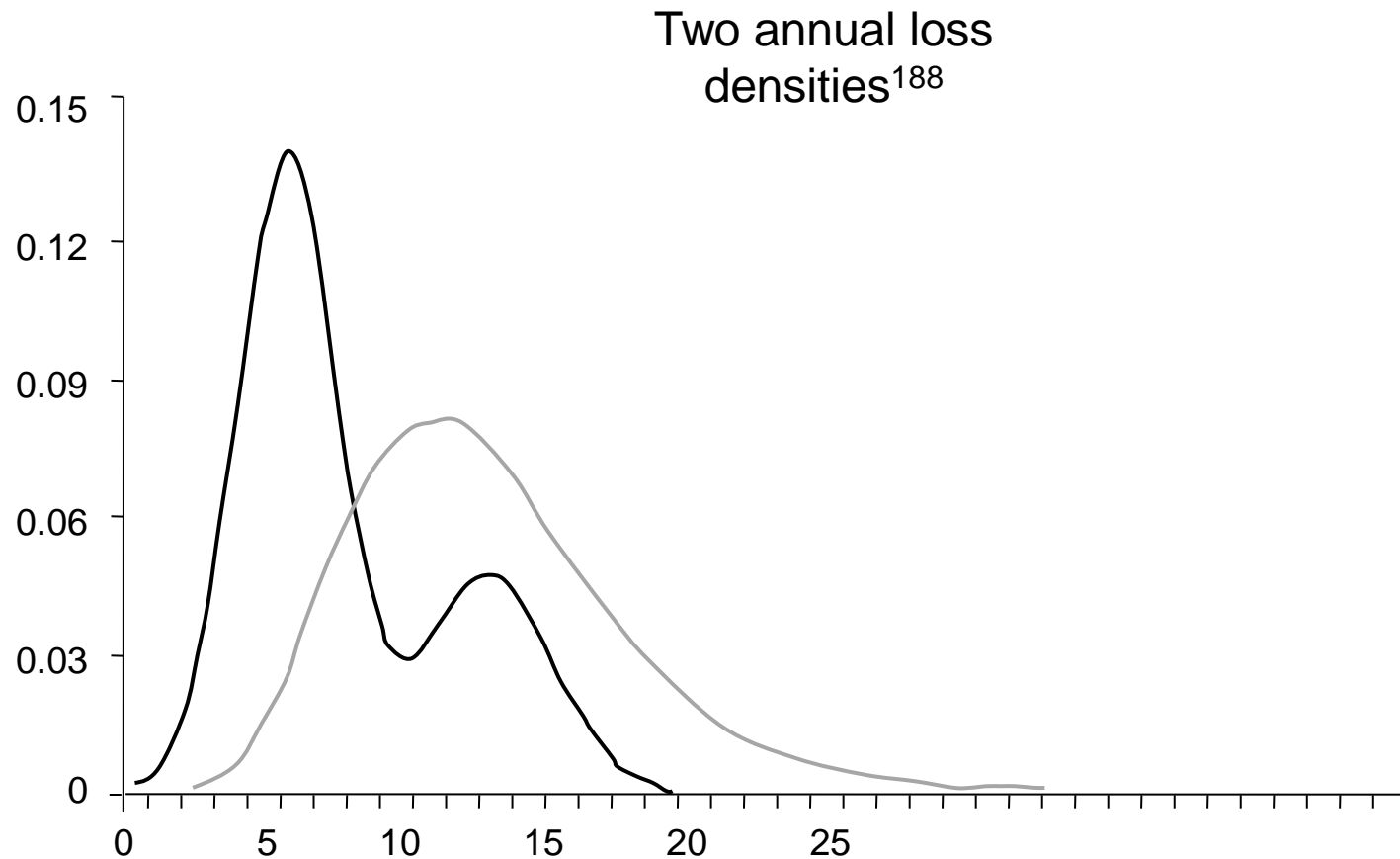
- Under certain assumptions (which are rather strong, but nevertheless appear to be admissible by regulators), there are simple analytic formulae for the expected loss and the unexpected loss in the annual loss distribution. These formulae are based on what the Basel Committee has called the 'internal measurement approach' (IMA). The basic formula for the IMA risk capital calculation given in the proposed Basel 2 Accord is given by:
 - $ORC = \text{Gamma} \times \text{Expected annual loss} = \gamma \times NpL$,where N is a volume indicator (a proxy for the number of operational events), p is the expected probability of a loss event, L is the loss given event, and 'gamma', is a multiplier that depends on the operational risk type.
- A very strong assumption of the IMA is that each time a loss is incurred, exactly the same amount is lost (within a given risk type). Introduction of severity uncertainty, as in the 'loss distribution approach' (LDA) described below, will always increase the ORC, often by a factor of 5 or more. Thus the IMA provides only a useful benchmark, a lower bound for the operational risk capital calculated using the full simulation method that we shall describe presently.

Aggregating Operational Risk Capital (ORC)

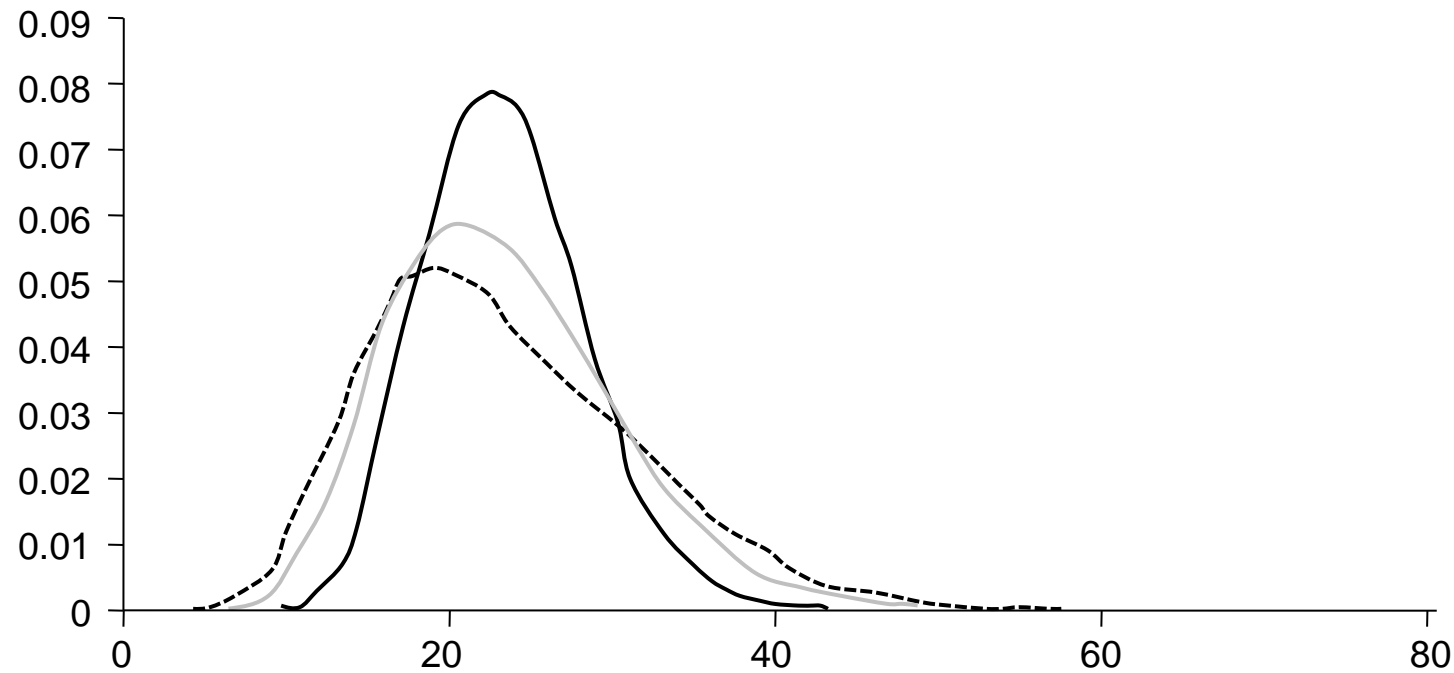
- It is very difficult to aggregate risks –
 - (a) when they are assessed using a VaR metric at an early stage
 - (b) because the ‘total’ we get for the risks is very much influenced by the assumptions we make about the dependencies between the risks
 - (c) because dependencies between risks are very difficult to assess. Thus risk aggregation is very difficult even within market and credit risks – it is a very thorny issue in operational risk!
- Dependencies between operational risks are common. Indeed, they occur whenever two operational risk types share a common key risk driver. For instance, risk drivers associated with ‘human’ risks – such as pay, training, management, workload – affect many types of operational risks, including employment practices, transactions processing, legal risks, and fraud.``

Aggregating Operational Risk Capital (ORC) contd...

- Often, when aggregating risks, particularly when the VaR metric is applied, banks will make just two simple assumptions:
 - Full dependency: This implies risks should simply be added to obtain the total risk; this is an approximate upper bound for the total risk.
 - No dependency: This is the assumption of 'independence'. It implies that the total risk is the square root of the sum of the squares of the component risks. For aggregating different types of operational risks, this will give an approximate lower bound for the total risk.



The total loss distribution under different assumptions for correlation



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End of Operational Value at Risk