The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

External Loss Data

Topic 43

Exam Focus

This topic examines the motivations for using external operational loss data and compares characteristics of loss data from different sources. For the exam, understand why firms are motivated to use external data in their internal operational risk framework development and the types of data that are available. Also, understand the differences in construction methodologies between the ORX and FIRST databases and be able to cite examples of how these differences manifest themselves in the data. Finally, be able to describe the Société Générale operational loss event.

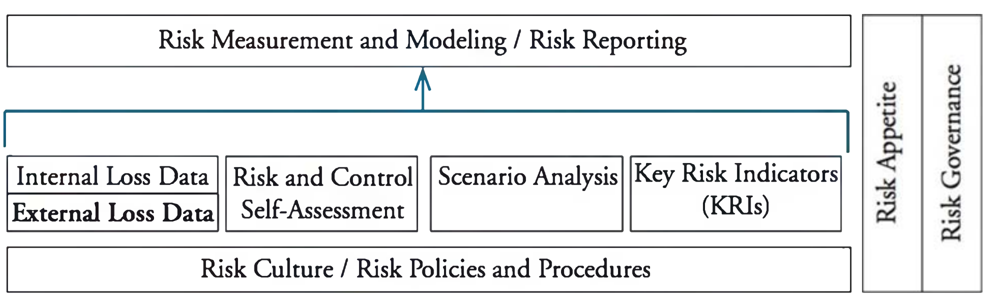
Collecting External Loss Data

LO 43.1: Explain the motivations for using external operational loss data and common sources of external data.

One reason operational risk departments look at events outside the firm is to gain valuable insights and inputs into operational risk capital calculations. Furthermore, external data is a required element in the advanced measurement approach (AMA) capital calculation under Basel II.

External events can be useful in many areas of the firm's operational risk framework, as these events provide information for risk self-assessment activities. They are key inputs in scenario analysis and can help in developing key risk indicators for monitoring the business environment.

Figure 1: External Loss Data in the Operational Risk Framework



Senior management should take an interest in external events because news headlines can provide useful information on operational risk. Examining events among industry peers and competitors helps management understand the importance of effective operational risk management and mitigation procedures. This is why external data is the key to developing a strong culture of operational risk awareness.

An example of a huge risk event that impacted industry discipline is the €4.9 billion trading scandal at Société Générale in 2006. This internal loss for Société Générale demonstrated to the financial services industry how operational risk can lead to large losses. In spite of the lessons learned from this experience, the financial industry saw another huge trading loss event at UBS in 2011, which led firms to reassess how they respond to external events and to ensure any lessons learned do not go unheeded.

Sources of External Loss Data

There are many sources of operational risk event data in the form of news articles, journals, and email services. Operational risk system vendors offer access to their database of events, and there are consortiums of operational risk losses as well. External events are a valuable source of information on individual events and also serve as a benchmarking tool for comparing internal loss patterns to external loss patterns. This process provides insight into whether firm losses are reflective of the industry.

Subscription Databases

Subscription databases include descriptions and analyses of operational risk events derived from legal and regulatory sources and news articles. This information allows firms to map events to the appropriate business lines, risk categories, and causes. The primary goal of external databases is to collect information on tail losses and examples of large risk events. An excerpt showing the total operational risk loss percentages to date by risk category in the IBM Algo FIRST database is shown in Figure 2.

Figure 2: Operational Risk Losses Recorded in IBM Algo FIRST (Q4 2012)

Event Type	*% of Losses*	*% of Events*
Business Disruption and System Failures	0.41%	1.54%
Clients, Products, and Business Practices	48.25%	46.11%
Damage to Physical Assets	19.22%	3.18%
Employment Practices and Workplace Safety	0.88%	5.97%
Execution, Delivery, and Process Management	6.68%	7.28%
External Fraud	3.94%	9.71%
Internal Fraud	20.63%	26.20%
Total	**100%**	**100%**

Through these statistics, we can see some patterns in operational risk events. For example, 46% of all records fall into the category of Clients, Products, and Business Practices, accounting for 48% of dollar value losses. Internal Fraud is another large area of risk events, with 26% of records and 21% of losses. Damage to Physical Assets is the next most expensive category with 19% of losses but only 3% of events.

Figure 2 shows us that within an internal database such IBM Algo FIRST (FIRST), operational risk losses from Internal Fraud, Damage to Physical Assets, and Client, Products, and Business Practices are more significant than those from other categories. However, keep in mind that the FIRST database includes business lines that are not part of the Basel-specified business lines. This results in relatively high Damage to Physical Assets losses, as insurance company losses are included in that category.

In Figure 3, we see subsets of losses from the FIRST database. (Note that any losses not attributed to one of the Basel business lines have been removed.)

Figure 3: FIRST Losses by Business Line (Q4 2012)

Business Line	*% of Losses*	*% of Events*
Agency Services	0.35%	2.22%
Asset Management	14.40%	16.37%
Commercial Banking	23.42%	17.70%
Corporate Finance	17.56%	9.00%
Payment and Settlement	2.72%	5.90%
Retail Banking	23.67%	20.79%
Retail Brokerage	1.30%	10.33%
Trading and Sales	16.58%	17.70%
Total	**100%**	**100%**

Figure 3 shows about 10% of events occur in the Retail Brokerage business line, but these retail brokerage events account for only 1% of losses because average losses in this business line are relatively small. Conversely, we see that Corporate Finance generated 9% of events but accounted for 18% of losses. Clearly, average losses in Corporate Finance tend to be more expensive.

We should keep in mind that this analysis is based on publicly available data for operational risk events, which is subject to reporting bias. The FIRST database is useful for financial services firms to compare their risk profiles to the industry by category and business line. FIRST provides insights into events that may not have occurred at a particular firm in the risk modeling process.

Consortium Data

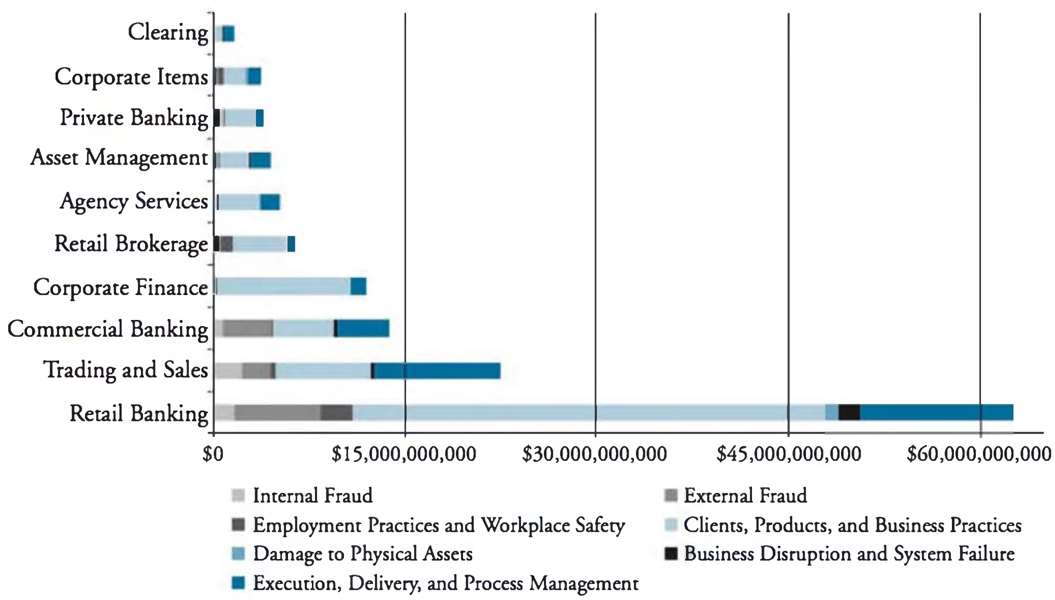
Besides the FIRST approach to collecting data, there are also consortium-based risk event services that provide a central data repository. **Operational Riskdata eXchange Association** (ORX) is a provider of this data, which is gathered from members to provide benchmarking. ORX applies quality assurance standards to keep all receipt and delivery of data anonymous and to provide consistency in definitions of events.

Unlike subscription services, ORX data does not suffer from the availability bias that skews the FIRST data (which relies on public sources of information). With ORX, all events are entered anonymously into the database; however, the data relates only to a small subset of firms that are members of the consortium. ORX also uses different business lines than FIRST. For example, it splits retail banking into two groups: Retail Banking and Private

Banking. It also renames Payment and Settlement to "Clearing." The ORX database has gathered nearly 30,000 events costing its members over €100 billion, which helps highlight the potential costs of operational risk.

ORX publishes reports that summarize the number and amount of losses for each business line and risk category. Regarding the reported contributions, the Retail Banking business area generates 58% of events; most of them in the External Fraud category. Trading and Sales and Commercial Banking follow with about 10% of total events each. Retail Banking has the biggest share of total costs at 46% of total losses. Execution, Delivery, and Process Management produce the largest number of events (36%), with 25% of total costs. Also, Clients, Products, and Business Practices accounts for about 17% of events but more than 50% of losses, which demonstrates that for members of ORX, these events tend to be large. Many firms use information from this category to conduct scenario analysis for potential "fat tail" events. Data representing dollar value losses of operational risk for each business line is shown in Figure 4.

Figure 4: Dollar Value Losses by Risk Category and Business Line



Subscription vs. Consortium Databases

LO 43.2: Explain ways in which data from different external sources may differ.

Differences in the collection methods between the ORX and the FIRST databases have an interesting impact on the relative distribution of the loss data.

Size and Frequency of Losses by Risk Category

When comparing the size of losses by risk category in the ORX and FIRST databases, we see that the FIRST database has a significantly higher percentage of losses for Internal Fraud than ORX does. In contrast, ORX has a significantly higher percent of Execution, Delivery, and Process Management losses than does FIRST. This could be because not all Execution, Delivery, and Process Management losses are reported by the press, implying that the FIRST database is missing many events and has an unavoidable collection bias.

The primary difference between these two databases with respect to Execution, Delivery, and Process Management events is that ORX data is supplied directly from member banks, which does not include all banks, implying that ORX also suffers from collection bias. This is in contrast to the FIRST database that collects data on all firms, including a significant number of firms outside of Basel II compliance.

Regarding the frequency of losses by risk category, Execution, Delivery, and Process Management events are missing from FIRST data, presumably because they rarely get press coverage. ORX has a larger frequency of External Fraud than FIRST, which suggests that such events are often kept from the press. ORX data also shows a large amount of External Fraud due to the participation of retail banks in the consortium. This is because Retail Banking includes credit card services, which causes this category to be driven by numerous small instances of fraud in retail banking and credit cards. The threshold for reporting loss data to ORX is €20,000.

Size and Frequency of Losses by Business Line

When comparing the size of losses by business lines in the ORX and FIRST databases, ORX losses are heavily weighted toward Retail Banking. Also, Commercial Banking accounts for a smaller percentage of losses for ORX than for FIRST, which may be due to recent commercial banking events making it into the press and, therefore, into the FIRST database (but not the ORX database).

Regarding the frequency of losses by business line, ORX data is driven by Retail Banking events, whereas FIRST events are more evenly distributed among the various business lines. Also, the majority of events for ORX and FIRST occur in Retail Banking but by a slimmer margin for the FIRST database.

Challenges with Using External Data

LO 43.3: Describe the challenges that can arise through the use of external data.

Many firms' operational risk systems not only include ORX and FIRST data but are also supplemented with information from the firm's own research and relevant industry news and journals. However, as we noted previously about the various differences between ORX and FIRST, the databases must be viewed with caution, as there are several challenges with using external data.

For example, external data derived from the media is subject to reporting bias. This is because it is up to the press to decide which events to cover, and the preference is for illegal and dramatic acts. For instance, consider that a large internal trading fraud might get press coverage, while a systems outage might get none. We should also consider that a major gain is less likely to be reported by the media than a major loss. Another barrier to determining whether an event is relevant is that some external events may be ignored because they are perceived as types of events that "could not happen here." Finally, the use of benchmark data may be a concern because there is a chance that comparisons may not be accurate due to different interpretations of the underlying database definitions.

One of the best ways to use external data is not to spot exact events to be avoided but rather to determine the types of errors and control failings that could cause similar losses. External data may have direct relevance despite differences in the details. For example, the Société Générale event led many firms to overhaul their fraud controls.

External data can serve a valuable role in operational risk management if its limitations are acknowledged. Databases can provide valuable lessons about risk management and highlight trends in the industry. While internal and external databases only tell us about what has already gone wrong, the data can be used to implement controls to mitigate the chances of similar events repeating, and they provide valuable inputs into the operational risk framework. Loss data is also useful for self-assessment, scenario analysis, and key risk indicators (KRIs) that indicate loss trends and weaknesses in controls.

Société Générale Operational Loss Event

LO 43.4: Describe the Société Générale operational loss event and explain the lessons learned from the event.

In January 2008, it was discovered that one of Société Générale's junior traders, Jérôme Kerviel, was involved in rogue trading activities, which ultimately resulted in losses of €4.9 billion. The multinational bank was fined €4 million, and Mr. Kerviel was sentenced to three years in prison. The incident damaged the reputation of Société Générale and required the bank to raise additional funds to meet capital needs.

Between July 2005 and January 2008, Kerviel established large, unauthorized positions in futures contracts and equity securities. To hide the size and riskiness of these unauthorized positions, he created fake transactions that offset the price movements of the actual positions. Kerviel created fake transactions with forward start dates and then used his knowledge of control personnel confirmation timing to cancel these trades right before any confirmations took place. Given the need to continuously replace fake trades with new ones, Kerviel created close to 1,000 fictitious trades before the fraud was finally discovered.

The operational risk world was galvanized by this event as it demonstrated the dangers of unmitigated operational risk. In 2008, many firms were developing operational risk frameworks and often focused on the delivery of new reporting, loss data tools, and adaptions to their scenario analysis programs. However, even though firms were developing internal risk systems, the amount of new regulatory requirements rapidly overcame their ability to keep up in practice. With the news of Mr. Kerviel's activities, many heads of operational risk found themselves asking the question "Could that happen here?"

IBM Algo FIRST provided an analysis based on press reviews. The highlights of alleged contributing factors to this operational loss event are summarized as follows:

1. Mr. Kerviel was involved in extensive unauthorized trading activities.

2. Mr. Kerviel was not sufficiently supervised.

3. Mr. Kerviel used his knowledge of middle and back office controls to ensure his fraud went undetected.

4. Mr. Kerviel achieved password access to systems allowing him to manipulate trade data.

A number of reasons were cited that explained how Kerviel's unauthorized trading activity went undetected, including the incorrect handling of trade cancellations, the lack of proper supervision, and the inability of the bank's trading system to consider gross positions.

Regarding trade cancellations, the bank's system was not equipped to review trading information that was entered and later canceled. In addition, the system was not set up to flag any unusual levels of trade cancellations. Regarding the lack of supervision, oversight of Kerviel's trading activity was weak, especially after his manager resigned in early 2007. Under the new manager, Kerviel's unauthorized trading activity increased significantly. Regarding the size of Kerviel's positions, the bank's system was only set up to evaluate net positions instead of both net and gross positions. Thus, the abnormally large size of his trading positions went undetected. Had the system properly monitored gross positions, it is likely that the large positions would have issued a warning sign given the level of riskiness associated with those notional amounts. Also, the large amount of trading commissions should have raised a red flag to management.

Additional reasons that contributed to the unauthorized positions going undetected included the inaction of Kerviel's trading assistant to report fraudulent activity, the violation of the bank's vacation policy, the weak reporting system for collateral and cash accounts, and the lack of investigation into unexpected reported trading gains.

Kerviel's trading assistant had immediate access to Kerviel's trading activities. Because the fictitious trades and the manipulation of the bank's trading system went unreported, it was believed that the trading assistant was acting in collusion with Kerviel. Regarding the bank's vacation policy, the rule that forced traders to take two weeks of vacation in a row was ignored. Had this policy been enforced, another trader would have been responsible for Kerviel's positions and likely would have uncovered the fraudulent activity of rolling fake transactions forward. Regarding collateral and cash reports, the fake transactions did not warrant any collateral or cash movements, so nothing balanced the collateral and cash needs of the actual trades that were being offset. If Société Générale's collateral and cash reports had been more robust, it would have detected unauthorized movements in the levels of these accounts for each individual trader. Regarding reported trading gains, Kerviel inflated trading gains above levels that could be reasonably accounted for given his actual authorized trades. This action should have prompted management to investigate the source of the reported trading gains.

Ultimately, the unauthorized trading positions were discovered by chance after one of Kerviel's fake trades was detected by control personnel during a routine monitoring of positions. Kerviel's inability to explain the fictitious transaction led to a rigorous investigation, revealing the depth of his fraudulent activities.

Lessons to be learned specific to this operational loss event include the following:

- Traders who perform a large amount of trade cancellations should be flagged and, as a result, have a sample of their cancellations reviewed by validating details with trading counterparties to ensure cancellations are associated with real trades.
- Tighter controls should be applied to situations that involve a new or temporary manager.
- Banks must check for abnormally high gross-to-net-position ratios. High ratios suggest a greater probability of unauthorized trading activities and/or basis risk measurement issues.
- Control personnel should not assume the independence of a trading assistant's actions. Trading assistants often work under extreme pressure and, thus, are susceptible to bullying tactics given that job performance depends on them following direction from traders.
- Mandatory vacation rules should be enforced.
- Requirements for collateral and cash reports must be monitored for individual traders.
- Profit and loss activity that is outside reasonable expectations must be investigated by control personnel and management. Reported losses or gains can be compared to previous periods, forecasted values, or peer performance.

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Key Concepts

LO 43.1

Operational risk departments look at events outside the firm to gain valuable insights and inputs into operational risk capital calculations. External events can also be useful in many areas of a firm's operational risk framework, as they provide information useful for risk self-assessment activities. These events are key inputs in scenario analysis and can help in developing key risk indicators for monitoring the business environment. Additionally, external data is a required element in the advanced measurement approach (AMA) capital calculation.

Subscription databases include descriptions and analyses of operational risk events, which are derived from legal and regulatory sources and news articles. In addition to database systems, there are also consortium-based risk event services that provide a central data repository to member firms and can offer benchmarking services as well. ORX is a provider of this type of data.

LO 43.2

When comparing data in the FIRST and ORX databases, we see significant differences between them. The FIRST database has a significantly higher percentage of losses for Internal Fraud than does ORX. In contrast, ORX has a significantly higher percent of Execution, Delivery, and Process Management losses. This could be because not all Execution, Delivery, and Process Management events are reported by the press, implying the FIRST database is missing many events and has an unavoidable collection bias.

Another difference between the two databases with respect to Execution, Delivery, and Process Management events is that ORX data is supplied directly from member banks. However, not all banks are ORX members, implying that ORX likely also suffers from collection bias. This is in contrast to the FIRST database that collects data on all firms, including a significant number of firms outside of Basel II compliance.

LO 43.3

ORX and FIRST databases must be viewed with caution, as there are several challenges with using external data. For example, external data derived from the media is subject to reporting bias because the press is far more likely to cover illegal and dramatic events. The use of benchmark data is also a concern, as there is a chance that comparisons are not accurate because of different interpretations of the underlying database definitions.

One of the best ways to use external data is not to spot exact events to be avoided but rather to determine the types of errors and control failings necessary to avoid similar losses. External data can still have a valuable role in operational risk management if staff acknowledges any limitations. Databases can provide valuable lessons about risk management and highlight trends in the industry.

LO 43.4

Jérôme Kerviel, a junior trader at Société Générale, participated in unauthorized trading activity and concealed this activity with fictitious offsetting transactions. The fraud resulted in €4.9 billion in losses and severely damaged the reputation of Société Générale.

Concept Checkers

1. Which of the following reasons is least likely to be a motivation for firms to use external data?
   A. To provide inputs into operational risk calculations.
   B. To engage in risk self-assessment activities.
   C. To ignore any operational loss events outside of external loss databases.
   D. To use in the advanced measurement approach (AMA) capital calculation.

2. In the IBM Algo FIRST database, which event type accounts for the most risk events?
   A. Business Disruptions and Systems Failures.
   B. Execution, Delivery, and Process Management.
   C. Clients, Products, and Business Practices.
   D. Internal Fraud.

3. Which database is likely to suffer from selection bias for Execution, Delivery, and Process Management losses because not all events are reported in the press?
   I. IBM Algo FIRST
   II. Operational Riskdata eXchange Association (ORX)
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

4. Which of the following statements is least likely to be a limitation of using external databases? External databases:
   A. must be viewed with caution.
   B. suffer from collection biases.
   C. do not report all events.
   D. cannot be used in internal calculations.

5. Which of the following statements was not a contributing factor to Jérôme Kerviel's activities at Société Générale? Mr. Kerviel:
   A. engaged in extensive unauthorized activities.
   B. engaged in rogue trading despite being sufficiently supervised.
   C. had knowledge of controls to ensure his activities were not detected.
   D. gained password access to back office systems to manipulate data.

Concept Checker Answers

1. **C** Operational risk departments look at events outside the firm to gain valuable insights and inputs into operational risk capital calculations. Firms should understand that external loss databases only include a sample of potential operational loss events.

2. **C** Forty six percent of all records in the FIRST database fall into the category of Clients, Products, and Business Practices, more than any other category.

3. **A** Because not all Execution, Delivery, and Process Management events are reported by the press, it is likely that the FIRST database is missing many events and, thus, has an unavoidable collection bias.

4. **D** The use of external databases is critical to firms' operational risk management calculations, an example of which is observing fat tail events at other firms.

5. **B** Mr. Kerviel was insufficiently supervised according to IBM Algo FIRST.

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Capital Modeling

Topic 44

Exam Focus

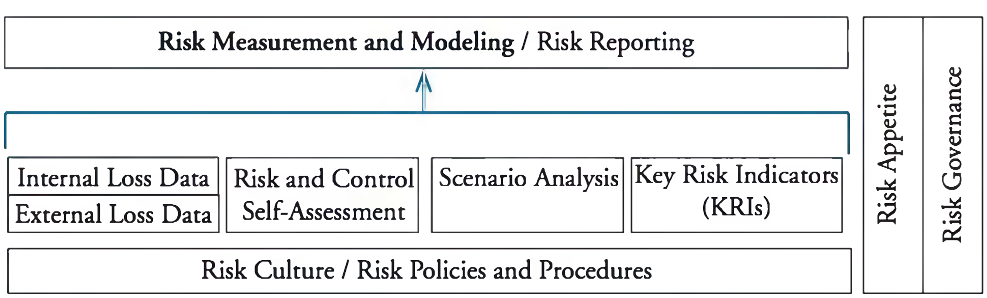
This topic discusses approaches for modeling operational risk capital requirements. Collecting data for loss frequency and loss severity distributions is an important component of allocating operational risk capital among various bank business lines. The loss distribution approach (LDA) models losses with respect to both frequency and severity with the goal of determining the appropriate level of capital. For the exam, be able to compare the approaches for calculating operational risk capital charges and be able to describe the LDA for modeling capital. Approaches for calculating operational risk capital requirements will be covered again in Topics 45 and 59.

Operational Risk Capital Requirements

LO 44.1: Compare the basic indicator approach, the standardized approach, and the alternative standardized approach for calculating the operational risk capital charge, and calculate the Basel operational risk charge using each approach.

Basel II proposed three approaches for determining the operational risk capital requirement (i.e., the amount of capital needed to protect against the possibility of operational risk losses). The **basic indicator approach** (BIA) and the **standardized approach** (TSA) determine capital requirements as a multiple of gross income at either the business line or institutional level. The **advanced measurement approach** (AMA) offers institutions the possibility to lower capital requirements in exchange for investing in risk assessment and management technologies. If a firm chooses to use the AMA, calculations will draw on the underlying elements illustrated in Figure 1.

Figure 1: Role of Capital Modeling in the Operational Risk Framework



Basel II encourages banks to develop more sophisticated operational risk management tools and expects international banks to use either the standardized approach or advanced measurement approach. In fact, many nations require large financial institutions to calculate operational risk with the AMA in order to be approved for Basel II.

Basic Indicator Approach

With the BIA, operational risk capital is based on 15% of the bank's annual gross income (GI) over a three-year period. Gross income in this case includes both net interest income and noninterest income. The capital requirement, K_{BIA}, under this approach is computed as follows:

$$K_{BIA} = \frac{\left(\sum_{i=1}^{n} GI_i \times \alpha\right)}{n}$$

where:
GI = annual (positive) gross income over the previous three years
n = number of years in which gross income was positive
α = 15% (set by Basel Committee)

Firms using this approach are still encouraged to adopt the risk management elements outlined in the Basel Committee on Banking Supervision, Risk Management Group, "Sound Practices for the Management and Supervision of Operational Risk." When a firm uses the BIA, it does not need loss data, risk and control self-assessment, scenario analysis, and business environment internal control factors (BEICF) for capital calculations. However, these data elements are needed as part of an operational risk framework to ensure risks are adequately identified, assessed, monitored, and mitigated.

Example 1: Calculating BIA capital charge

Assume Omega Bank has the following revenue results from the past three years:

	Year 1	*Year 2*	*Year 3*
Annual Gross Revenue (in $100 millions)	25	30	35

Calculate the operational risk capital requirement under the BIA.

Answer:

$$K_{BIA} = \frac{[(25+30+35)\times 0.15]}{3} = 4.5$$

Thus, Omega Bank must hold $450 million in operational risk capital under Basel II using the basic indicator approach.

Example 2: Calculating BIA capital charge

Assume Theta Bank has the following revenue results from the past three years:

	Year 1	*Year 2*	*Year 3*
Annual Gross Revenue (in $100 millions)	10	–5	15

Calculate the operational risk capital requirement under the BIA.

Answer:

Because Year 2 is negative, it will not count toward the sum of gross income over the past three years. This will also reduce the value of *n* to two.

$$K_{BIA} = \frac{[(10+15)\times 0.15]}{2} = 1.875$$

Thus, Theta Bank must hold $187.5 million in operational risk capital under Basel II using the basic indicator approach.

The BIA for risk capital is simple to adopt, but it is an unreliable indication of the true capital needs of a firm because it uses only revenue as a driver. For example, if two firms had the same annual revenue over the last three years, but widely different risk controls, their capital requirements would be the same. Note also that operational risk capital requirements can be greatly affected by a single year's extraordinary revenue when risk at the firm has not materially changed.

The Standardized Approach

For the standardized approach (TSA), the bank uses eight business lines with different **beta factors** to calculate the capital charge. With this approach, the beta factor of each business line is multiplied by the annual gross income amount over a three-year period. The results are then summed to arrive at the total operational risk capital charge under the standardized approach. The beta factors used in this approach are shown as follows:

- Investment banking (corporate finance): 18%.
- Investment banking (trading and sales): 18%.
- Retail banking: 12%.
- Commercial banking: 15%.
- Settlement and payment services: 18%.
- Agency and custody services: 15%.
- Asset management: 12%.
- Retail brokerage: 12%.

The standardized approach attempts to capture operational risk factors not covered by the BIA by assuming that different business activities carry different levels of operational risk.

Any negative capital charges from business lines can be offset up to a maximum of zero capital. The capital requirement, K_{TSA}, under this approach is computed as follows:

$$K_{TSA} = \frac{\left\{ \sum_{3 \text{ Years}} \max\left[\sum (GI_{1-8} \times \beta_{1-8}), 0\right] \right\}}{3}$$

where:
$GI_{1\text{-}8}$ = annual gross income in a given year for each of the eight business lines
$\beta_{1\text{-}8}$ = beta factors (fixed percentages for each business line)

In the following examples, Gamma Bank has only three lines of business and uses the standardized approach for its operational risk capital calculation.

Example 1: Calculating TSA capital charge

Assume Gamma Bank has the following revenue (in $100 millions) for the past three years for its three lines of business: trading and sales, commercial banking, and asset management.

Business Line	*Year 1*	*Year 2*	*Year 3*
Trading and Sales	10	15	20
Commercial Banking	5	10	15
Asset Management	10	10	10

Calculate the operational risk capital requirement under TSA.

Answer:

To calculate TSA capital charge, we first incorporate the relevant beta factors as follows:

Business Line	*Year 1*	*Year 2*	*Year 3*
Trading and Sales	10 × 18% = 1.8	15 × 18% = 2.7	20 × 18% = 3.6
Commercial Banking	5 × 15% = 0.75	10 × 15% = 1.5	15 × 15% = 2.25
Asset Management	10 × 12% = 1.2	10 × 12% = 1.2	10 × 12% = 1.2
Total	3.75	5.4	7.05

Next, enter these totals into the capital charge calculation as follows:

$$K_{TSA} = \frac{(3.75 + 5.4 + 7.05)}{3} = 5.4$$

Thus, Gamma Bank must hold $540 million in operational risk capital under Basel II using the standardized approach.

Example 2: Calculating TSA capital charge

If Delta Bank has negative revenue in any business line, it can offset capital charges that year up to a maximum benefit of zero capital. Beta Bank has had the following revenue (in $100 millions) for the past three years for its two lines of business: corporate finance and retail banking.

Business Line	*Year 1*	*Year 2*	*Year 3*
Corporate Finance	5	10	15
Retail Banking	5	–25	5

Calculate the operational risk capital requirement under TSA.

Answer:

Business Line	*Year 1*	*Year 2*	*Year 3*
Corporate Finance	5 × 18% = 0.90	10 × 18% = 1.80	15 × 18% = 2.7
Retail Banking	5 × 12% = 0.60	–25 × 12% = –3.0	5 × 12% = 0.60
Total	1.5	–1.2	3.3

Because a negative number cannot be used in the numerator, we replace –1.2 in Year 2 with zero. However, unlike the BIA, the number of years remains at three. Entering these totals into the capital charge calculation yields:

$$K_{TSA} = \frac{(1.5 + 0 + 3.3)}{3} = 1.6$$

Thus, Delta Bank would hold $160 million operational risk capital under Basel II using the standardized approach.

Alternative Standardized Approach

Under Basel II, a bank can be permitted to use the alternative standardized approach (ASA) provided it can demonstrate an ability to minimize double counting of certain risks. The ASA is identical to the standardized approach except for the calculation methodologies in the retail and commercial banking business lines. For these business lines, gross income is replaced with loans and advances times a multiplier, which is set equal to 0.035. Under the ASA, the beta factor for both retail and commercial banking is set to 15%. The capital requirement for the retail banking business line, K_{RB}, (which is the same for commercial banking) is computed as follows:

$$K_{RB} = \beta_{RB} \times LA_{RB} \times m$$

where:
β_{RB} = beta factor for retail banking business line (15%)
LA_{RB} = average total outstanding retail loans and advances over the past three years
m = multiplier (0.035)

Unanticipated Results from Negative Gross Income

The BIA and TSA capital charge methodologies can produce inappropriate results when accounting for negative gross income. For example, consider the following gross income amounts multiplied by the corresponding beta factors (in $100 millions):

Business Line	*Year 1*	*Year 2*	*Year 3*
Corporate Finance	5 × 18% = 0.9	10 × 18% = 1.8	–15 × 18% = –2.7
Retail Banking	5 × 12% = 0.6	–25 × 12% = –3	5 × 12% = 0.6
Total	1.5	–1.2	–2.1

Under this scenario, the standardized approach will compute a capital charge of $50 million as follows:

$$K_{TSA} = \frac{(1.5+0+0)}{3} = 0.5$$

However, recall that the BIA applies a fixed 15% of gross income and reduces the value of *n* when negative gross income is present. Thus, under the same scenario, the BIA will compute a capital charge of $150 million as follows:

$$K_{BIA} = \frac{[(5+5)\times 0.15]}{1} = 1.5$$

Therefore, this bank would hold only $50 million in operational risk capital using TSA but $150 million under the BIA. The Basel Committee has recognized that capital under Pillar 1 (minimum capital requirements) may be distorted and, therefore, recommends that additional capital should be added under Pillar 2 (supervisory review) if negative gross income leads to unanticipated results.

Advanced Measurement Approach

LO 44.2: Describe the modeling requirements for a bank to use the Advanced Measurement Approach (AMA).

The advanced measurement approach (AMA) allows banks to construct their own models for calculating operational risk capital. Although the Basel Committee allows significant flexibility in the use of the AMA, there are three main requirements. A bank must:

- Demonstrate an ability to capture potentially severe "fat-tail" losses (banks must use 99.9th percentile events with a one-year time horizon).
- Include internal loss data, external loss data, scenario analysis, and business environment internal control factors (i.e., the four data elements).
- Allocate capital in a way that incentivizes good behavior (i.e., create incentives to improve business line operational risk management).

Under the AMA, capital requirements should be made for all seven risk categories specified by Basel II. Some firms calculate operational risk capital at the firm level and then allocate down to the business lines, while others calculate capital at the business line level. Capital calculations are typically performed by constructing a business line/event type matrix, where capital is allocated based on loss data for each matrix cell.

Additional quantitative requirements under the AMA include:

- The approach must capture all expected and unexpected losses and may only exclude expected losses under certain criteria as stated in Basel II.
- The approach must provide sufficient detail to ensure that fat-tail events are captured.
- The bank must sum all calculated cells in the business line/event type matrix and be able to defend any correlation assumptions made in its AMA model.
- All four data elements must be included in the model, including the use of internal and external data, scenario analysis, and business environment factors.
- The bank must use appropriate weights for the four data elements when determining operational risk capital.

While the four data elements must be considered in the capital calculations, many banks use some of these elements only to allocate capital or perform stress tests, and then adjust their models, rather than using them as direct inputs into capital calculations. Regulators have accepted many different types of AMA models, such as the loss distribution approach, given the rapid development of modeling operational risk capital.

Loss Distribution Approach

LO 44.3: Describe the loss distribution approach to modeling operational risk capital.

The **loss distribution approach** (LDA) relies on internal losses as the basis of its design. A simple LDA model uses internal losses as direct inputs with the remaining three data elements being used for stressing or allocation purposes. However, according to Basel II, a bank must have at least five years of internal loss data regardless of its model design but can use three years of data when it first moves to the AMA.

The advantage of the LDA is that it is based on historical data relevant to the firm. The disadvantage is that the data collection period is likely to be relatively short and may not capture fat-tail events. For example, no firm can produce 1,000 years of data, but the model is supposed to provide a 99.9% confidence level. Also, some firms find that they have insufficient loss data to build a model, even if they have more than five years of data. Additionally, banks need to keep in mind that historical data is not necessarily reflective of the future because firms change products, processes, and controls over time.

LO 44.4: Explain how frequency and severity distributions of operational losses are obtained, including commonly used distributions and suitability guidelines for probability distributions.

Modeling Frequency

When developing a model of expected operational risk losses, the first step is to determine the likely frequency of events on an annual basis. The most common distribution for

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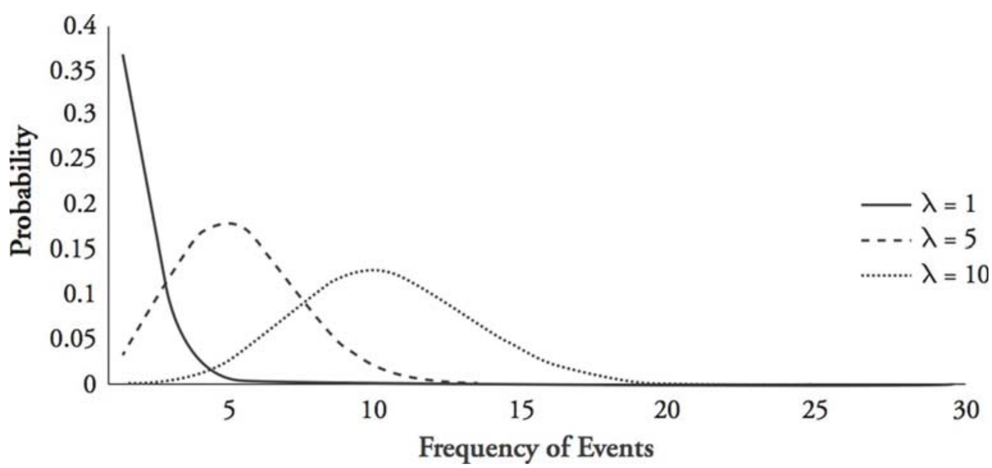
modeling frequency is the **Poisson distribution**. This distribution uses only one parameter, λ, which represents the average number of events in a given year, as well as the distribution's mean and variance. In an LDA model, λ can be obtained by observing the historical number of internal loss events per year and then calculating the average.

The Poisson distribution represents the probability of a certain number of events occurring in a single year. As shown in Figure 2, lower values of λ produce more skewed and leptokurtic annual loss distributions than higher values of λ.

Figure 2: Comparing Poisson Distributions

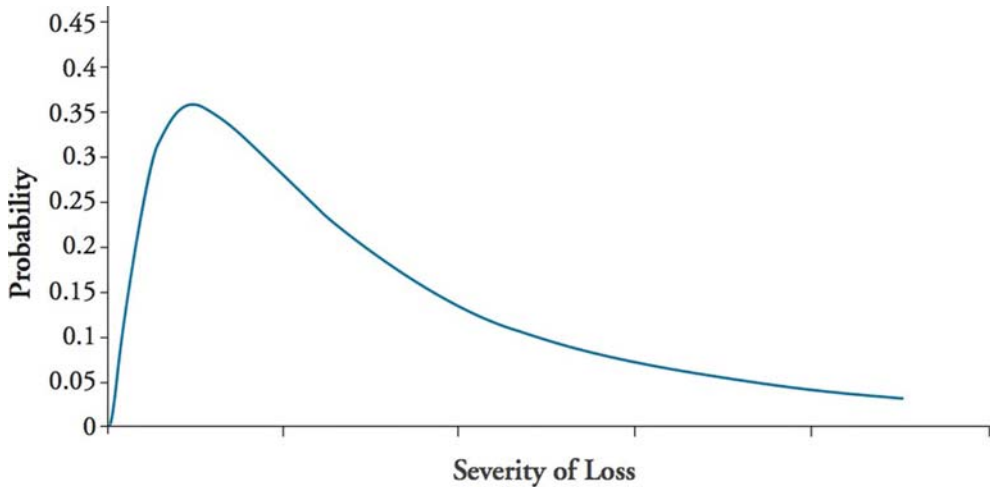


Modeling Severity

The next step in modeling expected operational risk losses is to determine the likely size (i.e., severity) of an event. The most common and least complex approach is to use a **lognormal distribution**. However, low frequency losses may be a better fit to distributions such as Generalized Gamma, Transformed Beta, Generalized Pareto, or Weibull. Regulators are interested in the selected distribution's "goodness of fit."

Regardless of the distribution selected, the probability density function must exhibit fat tails. Events that are more than three standard deviations from the mean are more likely to occur than in a normal distribution; thus, the distribution will be skewed as seen in Figure 3.

Figure 3: Example Severity Probability Distribution



Monte Carlo Simulation

LO 44.5: Explain how Monte Carlo simulation can be used to generate additional data points to estimate the 99.9th percentile of an operational loss distribution.

Once the frequency and severity distributions have been established, the next step is to combine them to generate data points that better estimate the capital required. This is done to ensure that likely losses for the next year will be covered at the 99.9% confidence level. **Monte Carlo simulation** can be used to combine frequency and severity distributions (a process known as **convolution**) in order to produce additional data points with the same characteristics as the observed data points.

With this process, we make random draws from the loss frequency data and then draw those events from the loss severity data. Each combination of frequency and severity becomes a potential loss event in our loss distribution. This process is continued several thousand times to create the potential loss distribution. To find the 99.9% confidence level, with a million observations for example, we would select the 1,000th item in an ordered list (from largest to smallest loss) to represent the maximum loss that will be experienced in a single year with 99.9% certainty.

Scenario Analysis

LO 44.6: Explain the use of scenario analysis and the hybrid approach in modeling operational risk capital.

Scenario analysis data is designed to identify fat-tail events, which is useful when calculating the appropriate amount of operational risk capital. The advantage of using scenario analysis is that data reflects the future through a process designed to consider "what if" scenarios, in contrast to the LDA which only considers the past. The major disadvantage of scenario analysis is that the data is highly subjective, and it only produces a few data points. As a result, complex techniques must be applied to model the full loss distribution, as the lack of data output in scenario analysis can make the fitting of distributions difficult. In addition, small changes in assumptions can lead to widely different results.

There are many different approaches to scenario analysis, but whichever method is used, a scarcity of data points is likely. This makes pure scenario analysis a difficult approach to defend in estimating risk capital. Also, the more reliance there is on scenario analysis, the more robust the program must be because sometimes there is little or no loss data available and a model may need to rely purely on scenario analysis for a particular risk category. Consequently, it is acceptable to have different modeling techniques for various risk categories as long as the differences are justified. While some scenario-based models have been approved in Europe, U.S. regulators generally do not accept them.

In the **hybrid approach**, loss data and scenario analysis output are both used to calculate operational risk capital. Some firms combine the LDA and scenario analysis by stitching together two distributions. For example, the LDA may be used to model expected losses, and scenario analysis may be used to model unexpected losses. Another approach combines scenario analysis data points with actual loss data when developing frequency and severity distributions.

Insurance

Banks have the option to insure against the occurrence of operational risks. The important considerations are how much insurance to buy and which operational risks to insure. Insurance companies offer polices on everything from losses related to fire to losses related to a rogue trader. A bank using the AMA for calculating operational risk capital requirements can use insurance to reduce its capital charge. However, the recognition of insurance mitigation is limited to 20% of the total operational risk capital required.

The LDA allows for a risk profiling of an institution, which can include the risk reducing effect of insurance, which then alters the aggregate loss distribution. Typically this is done by reducing the severity of the losses that exceed a given deductible in the insurance policy. In other words, insurance typically lowers the severity but not the frequency.

Operational risk capital may need to be billions of dollars, so it can be worthwhile to pursue insurance as a means to reduce the amount of capital needed. Insurance companies are attempting to accommodate industry needs through new insurance products that meet Basel requirements.

Key Concepts

LO 44.1

The three methods for calculating operational risk capital requirements are (1) the basic indicator approach (BIA), (2) the standardized approach (TSA), and (3) the advanced measurement approach (AMA). Large banks are encouraged to move from TSA to the AMA in an effort to reduce capital requirements.

LO 44.2

The first requirement to use the AMA is that the model must hold sufficient capital to cover all operational risk losses for one year with a certainty of 99.9%. The second requirement is that internal loss data, external loss data, scenario analysis, and business environment internal control factors must be included in the model. The third requirement is that there must be a method for allocating capital that incentivizes good behavior.

LO 44.3

The loss distribution approach (LDA) relies on internal losses as the basis of its design. It uses internal losses as direct inputs, with the remaining data elements being used for stressing or allocation purposes. However, regardless of its model design, a bank must have at least three years of loss data. The advantage of the LDA model is that it is based on historical data relevant to the firm. The disadvantage is that the data collection period is likely to be relatively short and may not capture all fat-tail events.

LO 44.4

When developing a model of expected operational risk losses, the first step is to determine the likely frequency of events on an annual basis. The most popular distribution for modeling frequency is the Poisson distribution. In a Poisson distribution, there is only one parameter, λ, which represents the average number of events in a given year. The next step in modeling expected operational risk losses is to determine the severity of an event. The most common and least complex distribution is to use a lognormal distribution.

LO 44.5

Once the frequency and severity distributions have been established, the next step is to use them to generate data points to better estimate the capital required at a 99.9% confidence level. Monte Carlo simulation is a method for combining frequency and severity distributions to produce additional data points that have the same characteristics as observed data points.

LO 44.6

Scenario analysis data is designed to identify fat-tail events and is useful in calculating the appropriate amount of operational risk capital. In the hybrid approach, loss data and scenario analysis output are both used to calculate operational risk capital.

Concept Checkers

1. Under the basic indicator approach (BIA), what is Alpha Bank's capital charge if it has revenues of $100 million, $150 million, and $200 million in the first three years?
   A. $22.0 million.
   B. $22.5 million.
   C. $23.0 million.
   D. $23.5 million.

2. Which of the following statements is not a requirement to apply the advanced measurement approach (AMA)?
   A. The model must hold capital to cover all operational risk losses for one year with a certainty of 99.9%.
   B. Internal loss data, external loss data, scenario analysis, and business environment internal control factors must be included in the model.
   C. Capital must be allocated to minimize risk.
   D. There must be a method for allocating capital that incentivizes good behavior.

3. Which of the following reasons is not a disadvantage of the loss distribution approach (LDA) to modeling operational risk capital requirements?
   A. The LDA is based on historical data.
   B. Most firms have limited historical data.
   C. Fat-tail events may not be captured by modeling.
   D. Historical data is not reflective of the future.

4. When modeling risk frequency, it is common to:
   A. use a Poisson distribution.
   B. assume that risks are highly correlated.
   C. assume risk frequency and severity are the same.
   D. use a straight-line projection from the most recent loss data.

5. Extreme losses in the tail of the operational risk loss distribution most likely follow which type of process/distribution?
   A. Generalized Pareto distribution.
   B. Historical simulation method.
   C. Poisson distribution.
   D. Extreme value theory.

Concept Checker Answers

1. **B** The BIA is based on 15% of the bank's annual gross income over a three-year period and is computed as follows:

$$K_{BIA} = \frac{[(100 + 150 + 200) \times 0.15]}{3} = \$22.5 \text{ million}$$

2. **C** There is no specific requirement under the AMA to minimize risk.

3. **A** An advantage of the LDA model is that it is based on historical data relevant to the firm.

4. **A** It is common to use a Poisson distribution to model loss frequency. A Poisson distribution has a single parameter, λ, which can be varied to accurately describe loss data.

5. **A** The most common and least complex approach for modeling extreme losses is to use a lognormal distribution. However, low frequency losses may be a better fit to distributions such as Generalized Gamma, Transformed Beta, Generalized Pareto, or Weibull.

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Standardized Measurement Approach for Operational Risk

Topic 45

Exam Focus

The focus of this topic is on the calculation of the standardized measurement approach (SMA). In particular, candidates should understand how the business indicator (BI) is derived and how buckets are used to group banks by size such that the BI will have a different impact on the SMA given a bank's bucket. Candidates should also know how to calculate the internal loss multiplier and the loss component, along with understanding how this component impacts the SMA given a bank's bucket classification. The SMA has evolved over time from earlier approaches that were more model-based and allowed too much flexibility. Candidates should also be familiar with the Basel Committee's outline of general and specific criteria applicable to operational loss data.

The Standardized Measurement Approach

LO 45.1: Explain the elements of the proposed Standardized Measurement Approach (SMA), including the business indicator, internal loss multiplier and loss component, and calculate the operational risk capital requirement for a bank using the SMA.

The **standardized measurement approach** (SMA) represents the combination of a financial statement operational risk exposure proxy (termed the business indicator, or BI) and operational loss data specific for an individual bank. Because using only a financial statement proxy such as the BI would not fully account for the often significant differences in risk profiles between medium to large banks, the historical loss component was added to the SMA to account for future operational risk loss exposure. As such, the loss component serves to both enhance the SMA's sensitivity to risk and to offer an incentive for a bank to improve on its operational risk management practices. A bank will be required to hold less in operational risk regulatory capital with fewer operational risk losses and a more effective risk management system.

The Business Indicator

The **business indicator** (BI) incorporates most of the same income statement components that are found in the calculation of gross income (GI). A few differences include:

- Positive values are used in the BI (versus some components incorporating negative values into the GI).
- The BI includes some items that tie to operational risk but are netted or omitted from the GI calculation.

The SMA calculation has evolved over time, as there were several issues with the first calculation that were since remedied with the latest version. These items include:

- Modifying the service component to equal max(fee income, fee expense) + max(other operating income, other operating expense). This change still allowed banks with large service business volumes to be treated differently from banks with small service businesses, while also reducing the inherent penalty applied to banks with both high fee income and high fee expenses.
- Including dividend income in the interest component, which alleviated the differing treatment among institutions as to where dividend income is accounted for on their income statements.
- Adjusting the interest component by the ratio of the net interest margin (NIM) cap (set at 3.5%) to the actual NIM. Before this adjustment, banks with high NIMs (calculated as net interest income divided by interest-earning assets) were penalized with high regulatory capital requirements relative to their true operational risk levels.
- For banks with high fee components (those with shares of fees in excess of 50% of the unadjusted BI), modifying the BI such that only 10% of the fees in excess of the unadjusted BI are counted.
- Netting and incorporating all financial and operating lease income and expenses into the interest component as an absolute value to alleviate inconsistent treatment of leases.

Business Indicator Calculation

The BI is calculated as the most recent three-year average for each of the following three components:

$$BI = ILDC_{avg} + SC_{avg} + FC_{avg}$$

where:
ILDC = interest, lease, dividend component
SC = services component
FC = financial component

The three individual components are calculated as follows, using three years of average data:

interest, lease, dividend component (ILDC) =

$$\min[\text{abs}(II_{avg} - IE_{avg}), 0.035 \times IEA_{avg}] + \text{abs}(LI_{avg} - LE_{avg}) + DI_{avg}$$

where:
abs = absolute value
II = interest income (excluding operating and finance leases)
IE = interest expenses (excluding operating and finance leases)
IEA = interest-earning assets
LI = lease income
LE = lease expenses
DI = dividend income

services component (SC) =

$$\max(OOI_{avg}, OOE_{avg}) + \max\{abs(FI_{avg} - FE_{avg}), \min[\max(FI_{avg}, FE_{avg}), 0.5 \times uBI + 0.1 \times (\max(FI_{avg}, FE_{avg}) - 0.5 \times uBI)]\}$$

where:

OOI = other operating income
OOE = other operating expenses
FI = fee income
FE = fee expenses
uBI = unadjusted business indicator =

$$ILDC_{avg} + \max(OOI_{avg}, OOE_{avg}) + \max(FI_{avg}, FE_{avg}) + FC_{avg}$$

financial component (FC) =

$$abs(\text{net } P\&LTB_{avg}) + abs(\text{net } P\&LBB_{avg})$$

where:

P&L = profit & loss statement line item
TB = trading book
BB = banking book

For the purposes of calculating the SMA, banks (based on their size for the BI component) are divided into five buckets as shown in Figure 1.

Figure 1: BI Buckets

Bucket	*BI Range*	*BI Component*
1	€0 billion–€1 billion	0.11 × BI
2	€1 billion–€3 billion	€110 million + 0.15(BI – €1 billion)
3	€3 billion–€10 billion	€410 million + 0.19(BI – €3 billion)
4	€10 billion–€30 billion	€1.74 billion + 0.23(BI – €10 billion)
5	€30 billion – +∞	€6.34 billion + 0.29(BI – €30 billion)

While a bank's internal losses are not factored in for the bucket 1 group, internal losses are factored in for banks in buckets 2–5 to the extent that they allow for differentiation among banks with different risk profiles. As is evident from Figure 1, there is both a linear increase in the BI component within a given bucket and an increase in the marginal impact (i.e., 0.11 for bucket 1, 0.15 for bucket 2, etc.) of the BI for banks in higher versus lower buckets.

The BI component calculation should exclude all of the following P&L items: administrative expenses, recovery of administrative expenses, impairments and impairment reversals, provisions and reversals of provisions (unless they relate to operational loss events), fixed asset and premises expenses (unless they relate to operational loss events), depreciation and amortization of assets (unless it relates to operating lease assets), expenses tied to share capital repayable on demand, income/expenses from insurance or reinsurance businesses, premiums paid and reimbursements/payments received from insurance or reinsurance policies, goodwill changes, and corporate income tax.

Internal Loss Multiplier Calculation

Through the addition of a loss component, the SMA becomes more sensitive to risk than it would be with just the BI component alone. As highlighted above, internal losses become a relevant factor for banks in buckets 2–5. Internal losses are factored into the SMA calculation via the **internal loss multiplier**, which is calculated as follows:

$$\text{internal loss multiplier} = \ln\left(e^1 - 1 + \frac{\text{loss component}}{\text{BI component}}\right)$$

where:
loss component =
7 × average total annual loss
+ 7 × average total annual loss only including loss events above €10 million
+ 5 × average total annual loss only including loss events above €100 million

The **loss component** serves to reflect the operational loss exposure based on a bank's internal loss experiences. To differentiate between banks with similar average loss totals but differing loss distributions, the loss component distinguishes between smaller loss events versus those above €10 million and €100 million. The logarithmic function contained within the internal loss multiplier suggests that it increases at a decreasing rate (with the loss component) and has a lower bound equal to: [$\ln(e^1 - 1) = 0.541$].

Ideally, a bank will have 10 years of quality data to calculate the averages that go into the loss component calculation. If 10 years are not available, then during the transition to the SMA calculation, banks may use 5 years and add more years as time progresses until they reach the 10-year requirement. If a bank does not have 5 years of data, then the BI component becomes the only component of the SMA calculation.

A bank whose exposure is considered average relative to its industry will have a loss component equivalent to its BI component; this implies an internal loss multiplier equal to one and an SMA capital requirement equal to its BI component. If a bank's loss experience is greater (less) than the industry average, its loss component will be above (below) the BI component and its SMA capital will be above (below) the BI component.

SMA Capital Requirement Calculation

The SMA is used to determine the operational risk capital requirement and is calculated as follows:

For BI bucket 1 banks:

SMA capital = BI component

For BI bucket 2–5 banks:

SMA capital = 110M + (BI component – 110M) × internal loss multiplier

The amounts used in the BI component, which are bucket-dependent, will follow the equations shown in the BI component column of Figure 1. The internal loss multiplier is calculated per the previous section.

For banks that are part of a consolidated entity, the SMA calculations will incorporate fully consolidated BI amounts (netting all intragroup income and expenses). At a subconsolidated level, the SMA uses BI amounts for the banks that are consolidated at that particular level. At the subsidiary level, the SMA calculations will use the BI amounts from the specific subsidiary. If the BI amounts for a subsidiary or subconsolidated level reach the bucket 2 level, the banks must incorporate their own loss experiences (not those of other members of the group). If a subsidiary of a bank in buckets 2–5 does not meet the qualitative standards associated with using the loss component, the SMA capital requirement is calculated using 100% of the BI component.

It is possible that the Committee will consider an alternative to the calculation of the internal loss multiplier shown earlier, which would replace the logarithmic function with a maximum multiple for the loss component. The formula for the internal loss multiplier would then be updated as:

$$\left(\frac{m \times LC + (m-1) \times BIC}{LC + (2m-2) \times BIC}\right)$$

where:
m = factor to be calibrated
LC = loss component
BIC = business indicator component

Example: Computing the SMA Capital Requirement

PS Bank Inc., has a BI of €18.48 million for the current fiscal year. **Calculate** PS Bank's capital requirement with the standardized measurement approach.

Answer:

PS Bank is a bucket 1 bank because its BI falls within the range of €0 billion–€1 billion. For bucket 1 banks, the only component of the SMA calculation is the BI component and the calculation is: 0.11 × €18.48 million, or €2.03 million.

SMA vs. Earlier Operational Risk Capital Approaches

LO 45.2: Compare the SMA to earlier methods of calculating operational risk capital, including the Alternative Measurement Approaches (AMA), and explain the rationale for the proposal to replace them.

Before the development of the SMA, banks were using either the advanced measurement approach (AMA), the standardized approach (TSA), or its variation, the alternative standardized approach (ASA), to assess operational risk. The advanced measurement approach, which was introduced as part of the Basel II framework in 2006, allowed for the estimation of regulatory capital based on a range of internal modeling practices. This approach was a principles-based framework allowing for significant flexibility. Although the hope of the Basel Committee was for best practices to emerge as flexibility declined, this never happened and challenges associated with comparability among banks (due to a wide range of modeling practices) and overly complex calculations remained.

Given these challenges, the Basel Committee set a goal of creating a new measure to allow for greater comparability and less complexity relative to prior methods. The SMA was created as this measure, with the intent of providing a means of assessing operational risk that would include both a standardized measure of operational risk and bank-specific loss data. Unlike AMA, the SMA is a single, non-model-based method used to estimate operational risk capital that combines financial statement information with the internal loss experience of a specific bank. The SMA is to be applied to internationally active banks on a consolidated basis, whereas it is optional for non-internationally active institutions. Although it is a relatively new measure, the SMA combines key elements of the standardized approach along with an internal loss experience component that was central to older approaches.

Identification, Collection, and Treatment of Operational Loss Data

LO 45.3: Describe general and specific criteria recommended by the Basel Committee for the identification, collection, and treatment of operational loss data.

Banks that incorporate the loss component into the SMA calculation must follow the following general criteria:

- Documented processes and procedures must be in place for the identification, collection, and treatment of internal loss data.
- A bank must maintain information on each operational risk event, including gross loss amounts, the date of occurrence (when the event first began or happened), the date of discovery (when the bank became aware of the event), the date of accounting (when the reserve, loss, or loss provision was first recognized in the bank's income statement, any gross loss amount recoveries, and what the drivers were of the loss event itself).
- Specific criteria must exist for loss data assignments stemming from centralized function events and related events over time (considered grouped losses).
- For the purposes of calculating minimum regulatory capital per the SMA framework, operational risk losses tied to credit risk will be excluded from the calculation. Operational risk losses tied to market risk will be included in the SMA calculation.
- A bank has to be able to document any criteria used to allocate losses to specific event types. In addition, a bank must be able to categorize historical internal loss data into the appropriate Level 1 supervisory categories per the Basel II Accord (Annex 9) and be prepared to provide this to supervisors when requested.
- An observation period of 10 years must be used as a basis for internally generated loss data calculations. On an exception basis and as long as good-quality data is not available for more than a five-year period, a bank first moving to the SMA can use a five-year observation period.
- Internal loss data must be comprehensive in nature and capture all material exposures and activities across all geographic locations and subsystems. When a bank first moves to the SMA, a €20,000 de minimis gross loss threshold is acceptable. Afterward, this threshold is lowered to €10,000.

In addition to the general criteria noted previously, specific criteria must also be followed as described as follows:

- A policy must exist for each bank that sets the criteria for when an operational risk event or loss (which is recorded in the internal loss event database) is included in the loss data set for calculating the SMA regulatory capital amount (i.e., the SMA loss data set).
- For all operational loss events, banks must be able to specifically identify gross loss amounts, insurance recoveries, and non-insurance recoveries. A gross loss is a loss before any recoveries, while a net loss takes into account the impact of recoveries. The SMA loss data cannot include losses net of insurance recoveries.
- In calculating the **gross loss** for the SMA loss data set, the following components must be *included*:
    - External expenses (legal fees, advisor fees, vendor costs, etc.) directly tied to the operational risk event itself and any repair/replacement costs needed to restore the bank to the position it was in before the event occurring.
    - Settlements, impairments, write-downs, and any other direct charges to the bank's income statement as a result of the operational risk event.
    - Any reserves or provisions tied to the potential operational loss impact and booked to the income statement.
    - Losses (tied to operational risk events) that are definitive in terms of financial impact but remain as pending losses because they are in transition or suspense accounts not reflected on the income statement. Materiality will dictate whether the loss is included in the data set.
    - Timing losses booked in the current financial accounting period that are material in nature and are due to events that give rise to legal risk and cross more than one financial accounting period.
- In calculating the gross loss for the SMA loss data set, the following components must be *excluded*:
    - The total cost of improvements, upgrades, and risk assessment enhancements and initiatives that are incurred after the risk event occurs.
    - Insurance premiums.
    - The costs associated with general maintenance contracts on property, plant, and equipment (PP&E).
- For every reporting year of the SMA regulatory capital, the gross losses included in the loss data set must incorporate any financial adjustments (additional losses, settlements, provision changes) made within the year for risk events with reference dates up to 10 years before that reporting year. The operational loss amount after adjustments must then be identified and compared to the €10 million and €100 million threshold.
- The only two dates a bank can use to build its SMA loss data set are the date of discovery or the date of accounting. For any legal loss events, the date of accounting (which is when the legal reserve representing the probable estimated loss) is the latest date that can be used for the loss data set.
- Any losses that are related to a common operational risk event or are related by operational risk events over time are considered grouped losses and must be entered as a single loss into the SMA loss data set.
- The circumstances, data types, and methodology for grouping data should be defined with criteria found in the individual bank's internal loss data policy. In instances where individual judgment is needed to apply the criteria, this must be clarified and documented.

Key Concepts

LO 45.1

The standardized measurement approach (SMA) includes both a business indicator (BI) component accounting for operational risk exposure and an internal loss multiplier and loss component accounting for operational losses unique to an individual bank. While the BI component is factored into the SMA for banks of all sizes, the impact it has on the SMA calculation will vary depending on where the bank is classified from buckets 1–5. The loss component is factored in for all banks classified in buckets 2–5.

LO 45.2

The older advanced measurement approach (AMA) allowed banks to use a vast range of models that were inherently more flexible for individual banks but prevented valuable comparisons among banks. From this, the SMA was created as a non-model-based approach used to assess operational risk using both financial statement measures and loss data unique to individual banks.

LO 45.3

For identifying, collecting, and accounting for operational loss data, the Basel Committee has outlined several general and specific criteria that should be used. Key general criteria include processes and procedures, documentation needed, thresholds for capturing losses, and appropriate periods. Specific criteria include how to calculate gross losses (what is included versus what is excluded), key dates used to capture the losses, how to quantify grouped losses, and policies needed.

Concept Checkers

1. The business indicator (BI) component in the standardized measurement approach (SMA) calculation for a bank with a BI of €13 billion will be closest to:
   A. €1.43 billion.
   B. €1.91 billion.
   C. €2.43 billion.
   D. €13.00 billion.

2. Which of the following items from the profit & loss (P&L) statement should be included in the BI component calculation?
   A. Administrative expenses.
   B. Insurance premiums paid.
   C. Depreciation related to capitalized equipment.
   D. Provision reversals related to operational loss events.

3. Which of the following components within the BI calculation takes into account a bank's trading and banking book P&L results?
   A. Loss component.
   B. Services component.
   C. Financial component.
   D. Interest, lease, dividend component.

4. Which of the following statements best describes a difference between the SMA and the older operational risk capital approaches?
   A. The standardized approach (TSA) and the alternative standardized approach (ASA) were variations of the SMA.
   B. The advanced measurement approach (AMA) was more flexible in its application than the SMA.
   C. The SMA accounts for internal loss experiences that were not factored into the AMA.
   D. The SMA uses a model-based methodology, while the AMA was more flexible and principles-based.

5. In deriving the SMA loss data set for an individual bank, each of the following items will most likely be included in the gross loss calculation except:
   A. legal fees of €900,000 associated with an unusual risk event.
   B. a €2 million settlement tied to a recent operational risk event.
   C. a €1.4 million reserve booked to the income statement to cover a potential operational loss.
   D. €1.75 million spent on maintenance contracts tied to the bank's property, plant, and equipment (PP&E).

Concept Checker Answers

1. **C** A bank with a BI of €13 million will fall into bucket 4, which covers a BI range of €10 billion to €30 billion. With the BI component formula of €1.74 billion + 0.23(BI – €10 billion) for bucket 4 banks, the BI component for this bank will be equal to €1.74 billion + 0.23(€13 billion – €10 billion) = €2.43 billion.

2. **D** A provision reversal would normally be excluded except when it relates to operational loss events. Each of the other three choices represents a P&L item that should be excluded from the BI component calculation.

3. **C** The formula for the financial component of the BI calculation is equal to:

   $$\text{abs}(\text{net P\&LTB}_{\text{avg}}) + \text{abs}(\text{net P\&LBB}_{\text{avg}})$$

   with TB representing the trading book and BB representing the banking book.

4. **B** Because banks were able to use a wide range of models for calculating the AMA, there was more flexibility to these approaches than under the new SMA. TSA and ASA were older approaches rather than variations of the SMA. AMA did account for internal losses. The SMA is non-model-based, whereas the AMA did incorporate bank-specific models.

5. **D** The costs associated with maintenance contracts for PP&E are outlined in the specific criteria for collecting operational loss data as *excluded* for the purposes of calculating the gross loss for the SMA loss data set.

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Parametric Approaches (II): Extreme Value

Topic 46

Exam Focus

Extreme values are important for risk management because they are associated with catastrophic events such as the failure of large institutions and market crashes. Since they are rare, modeling such events is a challenging task. In this topic, we will address the generalized extreme value (GEV) distribution, and the peaks-over-threshold approach, as well as discuss how peaks-over-threshold converges to the generalized Pareto distribution.

Managing Extreme Values

LO 46.1: Explain the importance and challenges of extreme values in risk management.

The occurrence of extreme events is rare; however, it is crucial to identify these extreme events for risk management since they can prove to be very costly. Extreme values are the result of large market declines or crashes, the failure of major institutions, the outbreak of financial or political crises, or natural catastrophes. The challenge of analyzing and modeling extreme values is that there are only a few observations for which to build a model, and there are ranges of extreme values that have yet to occur.

To meet the challenge, researchers must assume a certain distribution. The assumed distribution will probably not be identical to the true distribution; therefore, some degree of error will be present. Researchers usually choose distributions based on measures of central tendency, which misses the issue of trying to incorporate extreme values. Researchers need approaches that specifically deal with extreme value estimation. Incidentally, researchers in many fields other than finance face similar problems. In flood control, for example, analysts have to model the highest possible flood line when building a dam, and this estimation would most likely require a height above observed levels of flooding to date.

Extreme Value Theory

LO 46.2: Describe extreme value theory (EVT) and its use in risk management.

Extreme value theory (EVT) is a branch of applied statistics that has been developed to address problems associated with extreme outcomes. EVT focuses on the unique aspects of extreme values and is different from "central tendency" statistics, in which the central-limit theorem plays an important role. Extreme value theorems provide a template for estimating the parameters used to describe extreme movements.

One approach for estimating parameters is the Fisher–Tippett theorem (1928). According to this theorem, as the sample size *n* gets large, the distribution of extremes, denoted M_n, converges to the following distribution known as the **generalized extreme value (GEV) distribution:**

$$F(X \mid \xi,\mu,\sigma) = \exp\left[-\left(1+\xi \times \frac{x-\mu}{\sigma}\right)^{-1/\xi}\right] \text{ if } \xi \neq 0$$

$$F(X \mid \xi,\mu,\sigma) = \exp\left[-\exp\left(\frac{x-\mu}{\sigma}\right)\right] \text{ if } \xi = 0$$

For these formulas, the following restriction holds for random variable *X*:

$$\left(1+\xi \times \frac{x-\mu}{\sigma}\right) > 0$$

The parameters μ and σ are the location parameter and scale parameter, respectively, of the limiting distribution. Although related to the mean and variance, they are not the same. The symbol ξ is the tail index and indicates the shape (or heaviness) of the tail of the limiting distribution. There are three general cases of the GEV distribution:

1. $\xi > 0$, the GEV becomes a Frechet distribution, and the tails are "heavy" as is the case for the *t*-distribution and Pareto distributions.

2. $\xi = 0$, the GEV becomes the Gumbel distribution, and the tails are "light" as is the case for the normal and log-normal distributions.

3. $\xi < 0$, the GEV becomes the Weibull distribution, and the tails are "lighter" than a normal distribution.

Distributions where $\xi < 0$ do not often appear in financial models; therefore, financial risk management analysis can essentially focus on the first two cases: $\xi > 0$ and $\xi = 0$. Therefore, one practical consideration the researcher faces is whether to assume either $\xi > 0$ or $\xi = 0$ and apply the respective Frechet or Gumbel distributions and their corresponding estimation procedures. There are three basic ways of making this choice.

1. The researcher is confident of the parent distribution. If the researcher is confident it is a *t*-distribution, for example, then the researcher should assume $\xi > 0$.

2. The researcher applies a statistical test and cannot reject the hypothesis $\xi = 0$. In this case, the researcher uses the assumption $\xi = 0$.

3. The researcher may wish to be conservative and assume $\xi > 0$ to avoid model risk.

Peaks-Over-Threshold

LO 46.3: Describe the peaks-over-threshold (POT) approach.

The peaks-over-threshold (POT) approach is an application of extreme value theory to the distribution of excess losses over a high threshold. The POT approach generally requires fewer parameters than approaches based on extreme value theorems. The POT approach provides the natural way to model values that are greater than a high threshold, and in this way, it corresponds to the GEV theory by modeling the maxima or minima of a large sample.

The POT approach begins by defining a random variable *X* to be the loss. We define *u* as the threshold value for positive values of *x*, and the distribution of excess losses over our threshold *u* as:

$$F_u(x) = P\{X - u \leq x \mid X > u\} = \frac{F(x+u) - F(u)}{1 - F(u)}$$

This is the conditional distribution for *X* given that the threshold is exceeded by no more than *x*. The parent distribution of *X* can be normal or lognormal, however, it will usually be unknown.

Generalized Pareto Distribution

LO 46.5: Evaluate the tradeoffs involved in setting the threshold level when applying the GP distribution.

The Gnedenko-Pickands-Balkema-deHaan (GPBdH) theorem says that as *u* gets large, the distribution $F_u(x)$ converges to a **generalized Pareto distribution** (GPD), such that:

$$1 - \left[1 + \frac{\xi x}{\beta}\right]^{-1/\xi} \text{ if } \xi \neq 0$$

$$1 - \exp\left[-\frac{x}{\beta}\right] \text{ if } \xi = 0$$

The distribution is defined for the following regions:

$$x \geq 0 \text{ for } \xi \geq 0 \text{ and } 0 \leq x \leq -\beta/\xi \text{ for } \xi < 0$$

The tail (or shape) index parameter, ξ, is the same as it is in GEV theory. It can be positive, zero, or negative, but we are mainly interested in the cases when it is zero or positive. Here, the beta symbol, β, represents the scale parameter.

The GPD exhibits a curve that dips below the normal distribution prior to the tail. It then moves above the normal distribution until it reaches the extreme tail. The GPD then provides a linear approximation of the tail, which more closely matches empirical data.

Since all distributions of excess losses converge to the GPD, it is the natural model for excess losses. It requires a selection of *u*, which determines the number of observations, N_u, in excess of the threshold value. Choosing the threshold involves a tradeoff. It needs to be high enough so the GPBdH theory can apply, but it must be low enough so that there will be enough observations to apply estimation techniques to the parameters.

VaR and Expected Shortfall

One of the goals of using the POT approach is to ultimately compute the **value at risk** (VaR). From estimates of VaR, we can derive the **expected shortfall** (a.k.a. **conditional VaR**). Expected shortfall is viewed as an average or expected value of all losses greater than the VaR. An expression for this is: $E[L_P \mid L_P > VaR]$. Because it gives an insight into the distribution of the size of losses greater than the VaR, it has become a popular measure to report along with VaR.

The expression for VaR using POT parameters is given as follows:

$$VaR = u + \frac{\beta}{\xi}\left[\left[\frac{n}{N_u}(1 - \text{confidence level})\right]^{-\xi} - 1\right]$$

where:
u = threshold (in percentage terms)
n = number of observations
N_u = number of observations that exceed threshold

The expected shortfall can then be defined as:

$$ES = \frac{VaR}{1-\xi} + \frac{\beta - \xi u}{1-\xi}$$

Example: Compute VaR and expected shortfall given POT estimates

Assume the following observed parameter values:

- β = 0.75.
- ξ = 0.25.
- u = 1%.
- N_u/n = 5%.

Compute the 1% VaR in percentage terms and the corresponding expected shortfall measure.

Answer:

$$VaR = 1 + \frac{0.75}{0.25}\left[\left[\frac{1}{0.05}(1 - 0.99)\right]^{-0.25} - 1\right] = 2.486\%$$

$$ES = \frac{2.486}{1 - 0.25} + \frac{0.75 - 0.25 \times 1}{1 - 0.25} = 3.981\%$$

Generalized Extreme Value and Peaks-Over-Threshold

LO 46.4: Compare and contrast generalized extreme value and POT.

Extreme value theory is the source of both the GEV and POT approaches. These approaches are similar in that they both have a tail parameter denoted ξ. There is a subtle difference in that GEV theory focuses on the distributions of extremes, whereas POT focuses on the distribution of values that exceed a certain threshold. Although very similar in concept, there are cases where a researcher might choose one over the other. Here are three considerations.

1. GEV requires the estimation of one more parameter than POT. The most popular approaches of the GEV can lead to loss of useful data relative to the POT.

2. The POT approach requires a choice of a threshold, which can introduce additional uncertainty.

3. The nature of the data may make one preferable to the other.

Multivariate EVT

LO 46.6: Explain the importance of multivariate EVT for risk management.

Multivariate EVT is important because we can easily see how extreme values can be dependent on each other. A terrorist attack on oil fields will produce losses for oil companies, but it is likely that the value of most financial assets will also be affected. We can imagine similar relationships between the occurrence of a natural disaster and a decline in financial markets as well as markets for real goods and services.

Multivariate EVT has the same goal as univariate EVT in that the objective is to move from the familiar central-value distributions to methods that estimate extreme events. The added feature is to apply the EVT to more than one random variable at the same time. This introduces the concept of tail dependence, which is the central focus of multivariate EVT. Assumptions of an elliptical distribution and the use of a covariance matrix are of limited use for multivariate EVT.

Modeling multivariate extremes requires the use of copulas. Multivariate EVT says that the limiting distribution of multivariate extreme values will be a member of the family of EV copulas, and we can model multivariate EV dependence by assuming one of these EV copulas. The copulas can also have as many dimensions as appropriate and congruous with the number of random variables under consideration. However, the increase in the dimensions will present problems. If a researcher has two independent variables and classifies univariate extreme events as those that occur one time in a 100, this means that the researcher should expect to see one multivariate extreme event (i.e., both variables taking extreme values) only one time in 100 × 100 = 10,000 observations. For a trinomial distribution, that number increases to 1,000,000. This reduces drastically the number of multivariate extreme observations to work with, and increases the number of parameters to estimate.

Key Concepts

LO 46.1

Estimating extreme values is important since they can be very costly. The challenge is that since they are rare, many have not even been observed. Thus, it is difficult to model them.

LO 46.2

Extreme value theory (EVT) can be used to model extreme events in financial markets and to compute VaR, as well as expected shortfall.

LO 46.3

The peaks-over-threshold (POT) approach is an application of extreme value theory. It models the values that occur over a given threshold. It assumes that observations beyond the threshold follow a generalized Pareto distribution whose parameters can be estimated.

LO 46.4

The GEV and POT approach have the same goal and are built on the same general principles of extreme value theory. They even share the same shape parameter: ξ.

LO 46.5

The parameters of a generalized Pareto distribution (GPD) are the scale parameter β and the shape parameter ξ. Both of these can be estimated using maximum-likelihood technique

When applying the generalized Pareto distribution, the researcher must choose a threshold. There is a tradeoff because the threshold must be high enough so that the GPD applies, but it must be low enough so that there are sufficient observations above the threshold to estimate the parameters.

LO 46.6

Multivariate EVT is important because many extreme values are dependent on each other, and elliptical distribution analysis and correlations are not useful in the modeling of extreme values for multivariate distributions. Modeling multivariate extremes requires the use of copulas. Given that more than one random variable is involved, modeling these extremes can be even more challenging because of the rarity of multiple extreme values occurring at the same time.

Concept Checkers

1. According to the Fisher-Tippett theorem, as the sample size *n* gets large, the distribution of extremes converges to:
   A. a normal distribution.
   B. a uniform distribution.
   C. a generalized Pareto distribution.
   D. a generalized extreme value distribution.

2. The peaks-over-threshold approach generally requires:
   A. more estimated parameters than the GEV approach and shares one parameter with the GEV.
   B. fewer estimated parameters than the GEV approach and shares one parameter with the GEV.
   C. more estimated parameters than the GEV approach and does not share any parameters with the GEV approach.
   D. fewer estimated parameters than the GEV approach and does not share any parameters with the GEV approach.

3. In setting the threshold in the POT approach, which of the following statements is the most accurate? Setting the threshold relatively high makes the model:
   A. more applicable but decreases the number of observations in the modeling procedure.
   B. less applicable and decreases the number of observations in the modeling procedure.
   C. more applicable but increases the number of observations in the modeling procedure.
   D. less applicable but increases the number of observations in the modeling procedure.

4. A researcher using the POT approach observes the following parameter values: $\beta = 0.9$, $\xi = 0.15$, $u = 2\%$ and $N_u/n = 4\%$. The 5% VaR in percentage terms is:
   A. 1.034.
   B. 1.802.
   C. 2.204.
   D. 16.559.

5. Given a VaR equal to 2.56, a threshold of 1%, a shape parameter equal to 0.2, and a scale parameter equal to 0.3, what is the expected shortfall?
   A. 3.325.
   B. 3.526.
   C. 3.777.
   D. 4.086.

Concept Checker Answers

1. D The Fisher-Tippett theorem says that as the sample size *n* gets large, the distribution of extremes, denoted M_n, converges to a generalized extreme value (GEV) distribution.

2. B The POT approach generally has fewer parameters, but both POT and GEV approaches share the tail parameter ξ.

3. A There is a trade-off in setting the threshold. It must be high enough for the appropriate theorems to hold, but if set too high, there will not be enough observations to estimate the parameters.

4. B $\text{VaR} = 2 + \frac{0.9}{0.15}\left[\left[\frac{1}{0.04}(1-0.95)\right]^{-0.15} - 1\right]$

   VaR = 1.802

5. A $\text{ES} = \frac{\text{VaR}}{1-\xi} + \frac{\beta - \xi u}{1-\xi} = \frac{2.560}{1-0.2} + \frac{0.3 - 0.2 \times 1}{1-0.2} = 3.325$

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Validating Rating Models

Topic 47

Exam Focus

This is a specialized and rather detailed topic that deals with rating system validation. There is broad coverage of both qualitative and quantitative validation concepts with greater importance being assigned to qualitative validation. For the exam, focus on best practices as well as the specific elements of qualitative and quantitative validation. Within the realm of quantitative validation, focus specifically on the concepts of calibration and discriminatory power. Note that this material is an extension of the Rating Assignment Methodologies topic from Book 2 (Topic 20).

Model Validation

LO 47.1: Explain the process of model validation and describe best practices for the roles of internal organizational units in the validation process.

According to the Basel Committee (2004)[1], a rating system (or a rating model) "comprises all of the methods, processes, controls, and data collection and IT systems that support the assessment of credit risk, the assignment of internal risk ratings, and the quantification of default and loss estimates."

To validate a rating model, a financial institution must confirm the reliability of the results produced by the model and that the model still meets the financial institution's operating needs and any regulatory requirements. The tools and approaches to validation are regularly reassessed and revised to stay current with the changing market and operating environment. The breadth and depth of validation should be consistent with the type of credit portfolios analyzed, the complexity of the financial institution, and the level of market volatility.

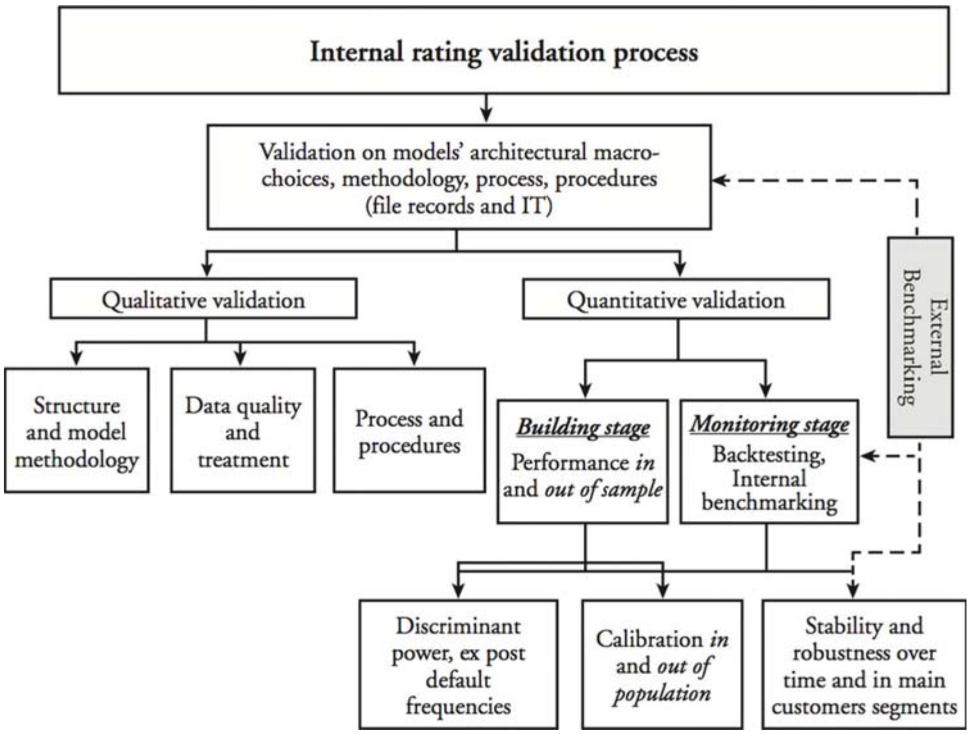
The rating model validation process includes a series of formal activities and tools to determine the accuracy of the estimates for the key risk components as well as the model's predictive power. The overall validation process can be divided between quantitative and qualitative validation. **Quantitative validation** includes comparing ex post results of risk measures to ex ante estimates, parameter calibrations, benchmarking, and stress tests. **Qualitative validation** focuses on non-numerical issues pertaining to model development such as logic, methodology, controls, documentation, and information technology.

The rating model validation process requires confirmation and method of use within the financial institution. Results must be sufficiently detailed in terms of weaknesses and limitations, in the form of reports that are forwarded regularly to the internal control group

1. Basel Committee on Banking Supervision (2004 and 2006), "International Convergence of Capital Measurement and Capital Standards," A Revised Framework, Basel, Switzerland.

and to regulatory agencies. At the same time, there must be a review of any anticipated remedies should the model prove to be weak. A summary of the overall process of model validation is provided in Figure 1.

Figure 1: Model Validation Process



Source: Figure 5.1. *Fundamental steps in rating systems validation process*. Reprinted from "Developing, Validating and Using Internal Ratings," by Giacomo De Laurentis, Renato Maino, Luca Molteni, (Hoboken, New Jersey: John Wiley & Sons, 2010), p 239.

Best Practices

The Basel Committee (2004) outlined the following two key requirements regarding corporate governance and oversight:

"All material aspects of the rating and estimation processes must be approved by the bank's board of directors or a designated committee thereof and senior management. Those parties must possess a general understanding of the bank's risk rating system and detailed comprehension of its associated management reports. Senior management must provide notice to the board of directors or a designed committee thereof of material changes or exceptions from established policies that will materially impact the operations of the bank's rating system."

"Senior management must also have a good understanding of the rating system's design and operation, and must approve material differences between established procedure and actual practice. Management must also ensure, on an ongoing basis, that the rating system is operating properly. Management and staff in the credit control function must meet regularly to discuss the performance of the rating process, areas needing improvement, and the status of efforts to improve previously identified deficiencies."

In response to these two requirements, best practices for the roles of internal organizational units in the validation process include:

1. Senior management needs to examine the recommendations that arise from the validation process together with analyzing the reports that are prepared by the internal audit group.

2. Smaller financial institutions require, at a minimum, a manager who is appointed to direct and oversee the validation process.

3. The validation group must be independent from the groups that are developing and maintaining validation models and the group(s) dealing with credit risk. The validation group should also be independent of the lending group and the rating assignment group. Ultimately, the validation group should not report to any of those groups.

4. Should it not be feasible for the validation group to be independent from designing and developing rating systems, then the internal audit group should be involved to ensure that the validation group is executing its duties with independence. In such a case, the validation group must be independent of the internal audit group.

5. In general, all staff involved in the validation process must have sufficient training to perform their duties properly.

6. Internal ratings must be discussed when management reports to or meets with the credit control group.

7. The internal audit group must examine the independence of the validation group and ensure that the validation group staff is sufficiently qualified.

8. Given that validation is mainly done using documentation received by groups dealing with model development and implementation, the quality of the documentation is important. Controls must be in place to ensure that there is sufficient breadth, transparency, and depth in the documentation provided.

A summary of the validation and control processes involving various internal organizational units is provided in Figure 2.

Figure 2: Validation and Control Processes

	Models	*Procedures*	*Tools*	*Management decision*
Basic controls	**Task:** model development and backtesting **Owner:** credit risk models development unit	**Task:** credit risk procedures maintenance **Owner:** lending units/internal control units	**Task:** operations maintenance **Owner:** lending units/IT/ internal audit	**Task:** lending policy applications **Owner:** central and decentralized units/internal control units
Second controls layer	**Task:** continuous test of models/ processes/tools performance **Owner:** lending unit/internal audit		**Task:** lending policy suitability **Owner:** validation unit/internal audit	
Third controls layer	Risk management/ CRO	Organization/ COO	Lending unit/ CLO/COO	Lending unit/ CLO/CRO
Accountability for supervisory purposes	Top management/Surveillance Board/Board of Directors			

Source: Table 5.1. *Processes and roles of validation and control of internal rating system.* Reprinted from "Developing, Validating and Using Internal Ratings," by Giacomo De Laurentis, Renato Maino, Luca Molteni, (Hoboken, New Jersey: John Wiley & Sons, 2010), p. 241.

Comparison of Qualitative and Quantitative Validation Processes

LO 47.2: Compare qualitative and quantitative processes to validate internal ratings, and describe elements of each process.

The goal of qualitative validation is to correctly apply quantitative procedures and to correctly use ratings. Qualitative and quantitative validation are complements although a greater emphasis is placed on qualitative validation given its holistic nature. In other words, neither a positive nor negative conclusion on quantitative validation is sufficient to make an overall conclusion.

Elements of Qualitative Validation

Rating systems design involves the selection of the correct model structure in context of the market segments where the model will be used. There are five key areas regarding rating systems that are analyzed during the qualitative validation process: (1) obtaining probabilities of default, (2) completeness, (3) objectivity, (4) acceptance, and (5) consistency.

Obtaining probabilities of default (PD). Using statistical models created from actual historical data allows for the determination of the PD for separate rating classes through the calibration of results with the historical data. A direct PD calculation is possible with logistic regression, whereas other methods (e.g., linear discriminant analysis) require an adjustment. An ex post validation of the calibration of the model can be done with data obtained during the use of the model. The data would allow continuous monitoring and validation of the default parameter to ensure PDs that are consistent with true economic conditions.

Completeness of rating system. All relevant information should be considered when determining creditworthiness and the resulting rating. Given that most default risk models include only a few borrower characteristics to determine creditworthiness, the validation process needs to provide assurance over the completeness of factors used for credit granting purposes. Statistical-based models allow for many borrower characteristics to be used, so there needs to be validation of the process of adding variables to the model to have greater coverage of appropriate risk factors.

Objectivity of rating system. Objectivity is achieved when the rating system can clearly define creditworthiness factors with the least amount of interpretation required. A judgment-based rating model would likely be fraught with biases (with low discriminatory power of ratings); therefore, it requires features such as strict (but reasonable) guidelines, proper staff training, and continual benchmarking. A statistical-based ratings model analyzes borrower characteristics based on actual data, so it is a much more objective model.

Acceptance of rating system. Acceptance by users (e.g., lenders and analysts) is crucial, so the validation process must provide assurance that the models are easily understood and shared by the users. In that regard, the output from the models should be fairly close to what is expected by the users. In addition, users should be educated as to the key aspects of models, especially statistical-based ones, so that they understand them and can make informed judgments regarding acceptance. Heuristic models (i.e., expert systems) are more easily accepted since they mirror past experience and the credit assessments tend to be consistent with cultural norms. In contrast, fuzzy logic models and artificial neural networks are less easily accepted given the high technical knowledge demands to understand them and the high complexity that creates challenges when interpreting the output.

Consistency of rating system. The validation process must ensure that the models make sense and are appropriate for their intended use. For example, statistical models may produce relationships between variables that are nonsensical, so the process of eliminating such variables increases consistency. The validation process would test such consistency. In contrast, heuristic models do not suffer from the same shortcoming since they are based on "real life" experiences. Statistical models used in isolation may still result in rating errors due to the mechanical nature of information processing. As a result, even though such models can remain the primary source of assigning ratings, they must be supplemented with a human element to promote the inclusion of all relevant and important information (usually qualitative and beyond the confines of the model) when making credit decisions.

Additionally, the validation process must deal with the continuity of validation processes, which includes periodic analysis of model performance and stability, analysis of model relationships, and comparisons of model outputs versus actual outcomes. In addition, the validation of statistical models must evaluate the completeness of documentation with focus on documenting the statistical foundations. Finally, validation must consider external benchmarks such as how rating systems are used by competitors.

Elements of Quantitative Validation

Quantitative validation comprises the following areas: (1) sample representativeness, (2) discriminatory power, (3) dynamic properties, and (4) calibration.

Sample representativeness. Sample representativeness is demonstrated when a sample from a population is taken and its characteristics match those of the total population. A key problem is that some loan portfolios (in certain niche areas or industries) have very low default rates, which frequently results in an overly low sample size for defaulting entities. The validation process would use bootstrap procedures that randomly create samples through an iterative process that combines items from a default group and items from a non-default group. The rating model is reassessed using the new samples; after analyzing a group of statistically created models, should the end result be stable and common among the models, then the reliability of the result is satisfied. If not, instability risk would still persist and further in-depth analysis would be required. Using more homogeneous subsets in the form of cluster analysis, for example, could provide a more stable result. Alternatively, the model could focus on key factors within the subsets or consider alternative calibrations.

Discriminatory power. Discriminatory power is the relative ability of a rating model to accurately differentiate between defaulting and non-defaulting entities for a given forecast period. The forecast period is usually 12 months for PD estimation purposes but is longer for rating validation purposes. It also involves classifying borrowers by risk level on an overall basis or by specific attributes such as industry sector, size, or geographical location.

Dynamic properties. Dynamic properties include rating systems stability and attributes of migration matrices. In fact, the use of migration matrices assists in determining ratings stability. Migration matrices are introduced after a minimum two-year operational period for the rating model. Ideal attributes of annual migration matrices include (1) ascending order of transition rates to default as rating classes deteriorate, (2) stable ratings over time (e.g., high values being on the diagonal and low values being off-diagonal), and (3) gradual rating movements as opposed to abrupt and large movements (e.g., migration rates of +/– one class are higher than those of +/– two classes). Should the validation process determine the migration matrices to be stable, then the conclusion is that ratings move slowly given their relative insensitivity to credit cycles and other temporary events.

Calibration. Calibration looks at the relative ability to estimate PD. Validating calibration occurs at a very early stage, and because of the limited usefulness in using statistical tools to validate calibration, benchmarking could be used as a supplement to validate estimates of probability of default (PD), loss given default (LGD), and exposure at default (EAD). The benchmarking process compares a financial institution's ratings and estimates to those of other comparable sources; there is flexibility permitted in choosing the most suitable benchmark.

Data Quality

LO 47.3: Describe challenges related to data quality and explain steps that can be taken to validate a model's data quality.

Challenges to Data Quality

Strong data quality is crucial when performing quantitative validation. General challenges involved with data quality include (1) completeness, (2) availability, (3) sample representativeness, (4) consistency and integrity, and (5) data cleansing procedures.

Defaults are the key constraint in terms of creating sufficiently large data sets for model development, rating quantification, and validation purposes. As a result, reliability and completeness are important issues. In addition, the definition of default needs to be consistent between the potentially wide variety of data collection sources and the Basel II definition of default.

Sample size and sample homogeneity present challenges as well. Practically speaking, it is difficult to create samples from a population over a long period using the same lending technology. **Lending technology** refers to the information, rules, and regulations used in credit origination and monitoring. In practice, it is almost impossible to have credit rules and regulations remain stable for even five years of a credit cycle. Changes occur because of technological breakthroughs that allow for more efficient handling of the credit function, market changes and new segments that require significant changes to credit policies, and merger and acquisition activity. Unfortunately, the changes result in less consistency between the data used to create the rating model and the population to which the model is applied.

The time horizon of the data may be problematic because the data should be created from a full credit cycle. If it is less than a full cycle, the estimates will be biased by the favorable or unfavorable stages during the selected period within the cycle.

Other data management issues such as outliers, missing values, and unrepresentative data may create challenges with validation.

Note that data quality involves the use of samples in the model building process. It is not easy to make inferences about the population merely from the samples used in the model. To do so, it is necessary to calibrate appropriately and do out-of-sample testing. Out-of-sample testing refers to observations created from the same lending technology but not included in the development sample.

Validating a Model's Data Quality

Validating data quality focuses on the stability of the lending technology and the degree of calibration required to infer sample results to the population. For example, if the observed in-sample default rate differs from that of the population, then the validation process should confirm that the calibration takes into account the difference. Or, if the lending technology changes due to a merger or acquisition, then the validation process must confirm the corresponding recalibration. The same confirmation of recalibration is required if there are material differences between borrowers' profiles in the sample versus the population.

An incorrect long-term average annual default rate results in an incorrect default probability, so validation must ensure that the long-term default rate is reasonably correct. Statistical central tendency is the average value to which population characteristics converge after many iterations of a given task. In applying central tendency to defaults, given relatively few defaults (i.e., few iterations) in any year during normal periods, it is not usually possible for the validation group to properly validate central tendency for at least 18 months. The time period is dependent on the markets, the nature of the lending facilities, and the characteristics of the customer segments. Validating central tendency in the long term is conducted through backtesting and stress testing.

The validation group should also watch market prices, consider information from the marketing department, and analyze significant transactions to determine appropriate benchmarks in which to compare the financial institution with its direct competitors.

LO 47.4: Explain how to validate the calibration and the discriminatory power of a rating model.

Validating Calibration

The validation process looks at the variances from the expected PDs and the actual default rates.

The Basel Committee (2005a)[2] suggests the following tests for calibration:

- Binomial test.
- Chi-square test (or Hosmer-Lemeshow).
- Normal test.
- Traffic lights approach.

The **binomial test** looks at a single rating category at a time, while the **chi-square test** looks at multiple rating categories at a time. The **normal test** looks at a single rating category for more than one period, based on a normal distribution of the time-averaged default rates. Two key assumptions include (1) mean default rate has minimal variance over time and (2) independence of default events. The **traffic lights approach** involves backtesting in a single rating category for multiple periods. Because each of the tests has some shortcomings, the overall conclusion is that no truly strong calibration tests exist at this time.

Validating Discriminatory Power

The validation process is performed ex post using backtesting of defaulting and non-defaulting items. Therefore, the concept of a longer forecast period requires that the forecast period begin further away from t = 0 and from the time the data is collected.

Validating discriminatory power can be done using the following four methods as outlined by the Basel Committee (2005a):

- Statistical tests (e.g., Fisher's r^2, Wilks' λ, and Hosmer-Lemeshow).
- Migration matrices.
- Accuracy indices (e.g., Lorentz's concentration curves and Gini ratios).
- Classification tests (e.g., binomial test, Type I and II errors, chi-squared test, and normality test).

The frequency distribution of errors is key to assessing the model's forecasting reliability. With regard to error rates, validation requires an assessment of error tolerance, its calibration, and its financial impact (e.g., a false positive or Type I error increases losses, and a false negative or Type II error increases opportunity costs).

2. Basel Committee on Banking Supervision (2005a), "Studies on Validation of Internal Rating Systems," Working Papers 14, Basel, Switzerland.

Key Concepts

LO 47.1

To validate a rating model, a financial institution must confirm the reliability of the results produced by the model and that the model still meets the financial institution's operating needs and any regulatory requirements. The tools and approaches to validation are regularly reassessed and revised to stay current with the changing market and operating environment.

Best practices for the roles of internal organizational units in the validation process include active involvement of senior management and the internal audit group. In general, all staff involved in the validation process must have sufficient training to perform their duties properly.

With regard to independence, the validation group must be independent from the groups that are developing and maintaining validation models and the group(s) dealing with credit risk. The validation group should also be independent of the lending group and the rating assignment group. Ultimately, the validation group should not report to any of those groups. Given that validation is mainly done using documentation received by groups dealing with model development and implementation, the quality of the documentation is important. Controls must be in place to ensure that there is sufficient breadth, transparency, and depth in the documentation provided.

LO 47.2

There are five key areas regarding rating systems that are analyzed during the qualitative validation process: (1) obtaining probabilities of default, (2) completeness, (3) objectivity, (4) acceptance, and (5) consistency.

Quantitative validation comprises the following areas: (1) sample representativeness, (2) discriminatory power, (3) dynamic properties, and (4) calibration.

LO 47.3

Defaults are the key constraint in terms of creating sufficiently large data sets for model development, rating quantification, and validation purposes.

With regard to sample size and sample homogeneity, it is difficult to create samples from a population over a long period using the same lending technology. Lending technology is most likely to change. Unfortunately, the changes result in less consistency between the data used to create the rating model and the population to which the model is applied.

The time horizon of the data may be problematic because the data should take into account a full credit cycle. If it is less than a full cycle, the estimates will be biased by the favorable or unfavorable stages during the selected period within the cycle.

Validating data quality focuses on the stability of the lending technology and the degree of calibration required to infer sample results to the population.

LO 47.4

Validating calibration looks at the variances from the expected probabilities of default and the actual default rates. Tests of calibration include (1) binomial test, (2) chi-square test (or Hosmer-Lemeshow), (3) normal test, and (4) traffic lights approach.

Validating discriminatory power involves backtesting of defaulting and non-defaulting items. Tests of discriminatory power include (1) statistical tests, (2) migration matrices, (3) accuracy indices, and (4) classification tests.

Concept Checkers

1. Which of the following statements regarding the model validation process is most accurate?
   A. The validation process places equal importance on quantitative and qualitative validation.
   B. The validation group could be involved with the rating system design and development process.
   C. The quantitative validation process involves an analysis of structure and model methodology.
   D. The breadth and depth of validation should be commensurate primarily with the dollar value of the loans outstanding.

2. Which of the following areas of quantitative validation would focus on rating systems stability?
   A. Calibration.
   B. Discriminatory power.
   C. Dynamic properties.
   D. Sample representativeness.

3. The increasing use of heuristic rating models versus statistical rating models would most likely be covered under which area of qualitative validation?
   A. Acceptance.
   B. Completeness.
   C. Consistency.
   D. Objectivity.

4. Which of the following statements regarding the validation of data quality is correct?
   A. Data should be created from a full credit cycle.
   B. Validating central tendency in the long term is done through normality testing.
   C. In practice, it is necessary to create samples from a population over a five-year period using the same lending technology.
   D. To make inferences about the population from the samples used in a model, it is necessary to calibrate appropriately and do in-sample testing.

5. Which of the following methods would most likely be used to validate both the calibration and the discriminatory power of a rating model?
   A. Accuracy indices.
   B. Classification tests.
   C. Migration matrices.
   D. Traffic lights approach.

Concept Checker Answers

1. **B** The validation group could be involved with the rating system design and development process as long as sufficient controls are in place to ensure independence. For example, the internal audit group could confirm that the validation group is acting independently.

   There is more emphasis on qualitative validation over quantitative validation. Structure and model methodology is dealt with under *qualitative* validation, not quantitative. The breadth and depth of validation is not primarily focused on the dollar value of the loans outstanding and takes a broader approach by considering the type of credit portfolios analyzed, the complexity of the financial institution, and the level of market volatility.

2. **C** Dynamic properties include rating systems stability and attributes of migration matrices. Calibration looks at the relative ability to estimate probability of default (PD). Discriminatory power is the relative ability of a rating model to accurately differentiate between defaulting and non-defaulting entities for a given forecast period. Sample representativeness is demonstrated when a sample from a population is taken and its characteristics match those of the total population.

3. **A** Heuristic models are *more easily accepted* since they mirror past experience and the credit assessments tend to be consistent with cultural norms. In contrast, statistical models are *less easily accepted* given the high technical knowledge demands to understand them and the high complexity that creates challenges when interpreting the output.

   Completeness refers to the sufficiency in number of factors used for credit granting purposes since many default-based models use very few borrower characteristics. In contrast, statistical-based models allow for many borrower characteristics to be used. *Consistency* refers to models making sense and being appropriate for their intended use. For example, statistical models may produce relationships between variables that are nonsensical, so the process of eliminating such variables increases consistency. *Objectivity* is achieved when the rating system can clearly define creditworthiness factors with the least amount of interpretation required, choosing between judgment-based versus statistical-based models.

4. **A** If data is created from less than a full credit cycle, the estimates will be biased by the favorable or unfavorable stages during the selected period within the cycle.

   Validating central tendency in the long term is done through backtesting and stress testing. In practice, it is almost impossible to have credit rules and regulations remain stable for even five years of a credit cycle. To make inferences about the population, it is necessary to use *out-of-sample* testing whereby the observations are created from the same lending technology but were not included in the development sample.

5. **B** Classification tests include the binomial test, chi-squared test, and normality test. Those tests are used to analyze discriminatory power and calibration.

   Accuracy indices and migration matrices are used only for discriminatory power. The traffic lights approach is used only for calibration.

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Model Risk

Topic 48

Exam Focus

Models are indispensible in modern finance in quantifying and managing asset-liability risk management, credit risk, market risk, and many other risks. Models rely on a range of data input based on a combination of historical data and risk assumptions, and are critical in managing risk exposures and financial positions. However, models rely on the accuracy of inputs, and errors give rise to model risk. Model risk can range from errors in inputs and assumptions to errors in implementing or incorrectly interpreting a model, and can result in significant losses to market participants. For the exam, be able to identify and explain common model errors, model implementation and valuation issues, and model error mitigation techniques. Also, be familiar with the two case studies discussed related to model risk: Long-Term Capital Management and the London Whale incident.

Sources of Model Risk

LO 48.1: Identify and explain errors in modeling assumptions that can introduce model risk.

Modeling is a critical component in the risk management of an organization. Models help quantify risk and other exposures as well as potential losses. However, models can be complex and are subject to **model risk**, which includes input errors, errors in assumptions, and errors in interpretation.

Model Complexity

When quantifying the risk of simple financial instruments such as stocks and bonds, model risk is less of a concern. These simple instruments exhibit less volatility in price and sensitivities relative to complex financial instruments so, therefore, their market values tend to be good indicators of asset values. However, model risk is a significantly more important consideration when quantifying the risk exposures of complex financial instruments, including instruments with embedded options, exotic over-the-counter (OTC) derivatives, synthetic credit derivatives, and many structured products. For these complex instruments, markets are often illiquid and do not provide sufficient price discovery mechanisms, which puts greater emphasis on models to value instruments, typically through a mark-to-model valuation approach. These models are important not only for valuing instruments and assessing risk exposure, but also to determine the proper hedging strategy.

As financial instruments increase in complexity, so do the models used to value them. More complex models, such as the Black-Scholes-Merton option pricing model, increased the threat of model risk, especially for the more complex derivatives such as interest rate caps and floors, swaptions, and credit and exotic derivatives. As technology advanced, so did the complexity of the models created and used. The growth in complexity of the models also increased the reliance on these models. In addition, managers often do not have a solid understanding of the more complex models. When models are difficult to understand, the risk of model errors and the risk of incorrect vetting, interpretation, and oversight increases.

The dangers of relying too heavily on complex models became especially apparent during the 2007–2009 financial crisis. When markets endure a prolonged period of turmoil, models tend to underestimate the volatilities, correlations, and risks of financial instruments, and can overstate values, all of which may lead to sustained losses by market participants. Since models are often used for valuing instruments, a model may show that a strategy is profitable when in fact it is experiencing losses. Following the global credit crisis, model risk became more regulated as the Basel Committee mandated that financial institutions more rigorously assess model risk.

Common Model Errors

Model risk has been apparent over the last several decades through various international crises. A model may be incorrect if it contains incorrect assumptions about a financial instrument's price or risk. One example of model error was the remarkable collapse in 1997 of a hedge fund run by Victor Niederhoffer, a well-known Wall Street trader. The fund's strategy was to write (sell) deep out-of-money put options on the S&P 500, based on the assumption that the index volatility would not exceed 5% daily, and therefore, the option would expire worthless. In October 1997, the Asian financial crisis created a contagion effect that impacted North American markets. As a result, market volatilities increased significantly above historical levels. This level of volatility was not priced into the advanced mathematical models used by the fund which instead assumed a normal distribution of risk and historical correlations. The fund ultimately experienced substantial losses as its equity was completely wiped out.

Losses from model errors can be due to errors in assumptions, carelessness, fraud, or intentional mistakes that undervalue risk or overvalue profit. The six common model errors are as follows:

1. *Assuming constant volatility*. One of the most common errors in modeling is the assumption that the distribution of asset price and risk is constant. The 2007–2009 financial crisis showed just how incorrect this assumption can be, when market volatilities not predicted by models increased significantly over a short period of time.

2. *Assuming a normal distribution of returns*. Market participants frequently make the simplifying assumption in their models that asset returns are normally distributed. Practice has shown, however, that returns typically do not follow a normal distribution, because distributions in fact have fat tails (i.e., unexpected large outliers).

3. *Underestimating the number of risk factors*. Many models assume a single risk factor. A single risk factor may produce accurate prices and hedge ratios for simple products such as a callable bond. For more complex products, including many exotic derivatives (e.g., Bermuda options), models need to incorporate multiple risk factors.

4. *Assuming perfect capital markets*. Models are generally derived with the assumption that capital markets behave perfectly. Consider a delta hedge strategy that requires active rebalancing based on the assumption that the underlying asset position is continuously adjusted in response to changes in the derivatives price. This strategy will not be effective if capital markets include imperfections, including limitations on short selling, various costs (e.g., fees and taxes), and a lack of continuous trading in the markets.

5. *Assuming adequate liquidity*. Models often assume liquid markets for long or short trading of financial products at current prices. During periods of volatility, especially extreme volatility, as seen during the recent financial crisis, liquidity could decline or dry up completely.

6. *Misapplying a model.* Historically, model assumptions have worked well in most world markets, but tend to break down during periods of greater uncertainty or volatility. For example, traditional models assuming normality did not work well in many countries, including the United States, Europe, and Japan in the post financial crisis period, which has been characterized by low or negative interest rates and unconventional monetary policies including quantitative easing. In these markets, models that include other statistical tools work better.

   Similarly, models that work well for traditional assets could yield incorrect results when complex factors including embedded options are factored in. Another example of misapplying a model is to use one that was created to value bonds with no embedded options (e.g., a non-callable, non-convertible bond) to now value bonds with embedded options (e.g., a callable, convertible bond).

LO 48.2: Explain how model risk can arise in the implementation of a model.

In the previous section, we looked at the most common model errors. However, even correct models can be incorrectly implemented. This section looks at the most common implementation issues. Models may be affected by programming bugs or approximation errors, and models that seemed to work under normal conditions may have errors when tested under stressed market conditions.

Common Model Implementation Errors

Implementation error could occur, for example, when models that require Monte Carlo simulations are not allowed to run a sufficient number of simulations. In such a case, even if all the model inputs and assumptions are correct, the results may still be incorrect if insufficient time is given for the computations.

For the implementation of models, important considerations should include how frequently the model parameters need to be refreshed, including volatilities and correlations. Analysts responsible for maintaining models must consider whether adjustments should occur periodically at scheduled dates, or only when material economic events occur. Similarly, the treatment of outliers should also be considered. For example, should outliers be considered extreme outcomes only (that is, not part of the true distribution), or should they be considered part of the true distribution? Correctly answering these questions became especially important in the post-financial crisis period.

Correctly estimating parameters like durations, volatilities, and correlations is very difficult, and implementing a model with input errors will result in inaccurate results. For example, in the 1970s the investment banking firm Merrill Lynch used incorrect hedge durations for government bonds, which resulted in a considerable loss to the firm. In another example, during the stressed conditions of the financial crisis, default correlations within structured products moved toward the binary extremes of +1 or –1. In other words, the cumulative default rates of collateralized debt obligations (CDOs) either all remained below a threshold with no defaults in any tranches, or all moved above a threshold, leading to defaults of even the AAA-rated tranches.

Common Valuation and Estimation Errors

Models also rely on the accuracy of inputs and values fed into the model, and are therefore subject to human error. *Human error* is particularly of concern in new or developing markets where adequate controls have not been fully defined and implemented.

Common valuation and estimation errors include:

1. *Inaccurate data*. Models may use both internal and external data sources, where the responsibility for data accuracy is not clearly assigned. This could lead to errors from using inaccurate data.

2. *Incorrect sampling period length*. Increasing the number of observations is expected to improve data accuracy and reduce estimation errors. However, including old (and therefore obsolete) statistics could put too much weight on stale data.

3. *Liquidity and valuation problems*. Accurate pricing and valuation may not be possible in all markets. Prices for a particular asset may not exist in certain markets, or the bid-ask spread may be too high to offer accurate valuation.

Mitigating Model Risk

LO 48.3: Explain methods and procedures risk managers can use to mitigate model risk.

Model risk can be mitigated either through investing in research to improve the model or through an independent vetting process. Investing in research leads to developing better and more accurate statistical tools, both internally and externally. Independent vetting includes the independent oversight of profit and loss calculations as well as the model selection and construction process. Vetting consists of the following six phases:

1. *Documentation*. Documentation should contain the assumptions of the underlying model and include the mathematical formulas used in the model. It should contain a term sheet to describe the transaction, a mathematical statement of the model (all the variables and processes, payoff function and pricing algorithms, calibrations, and hedge ratios and sensitivities), and the implementation features, including inputs, outputs, and any numerical methods.

2. *Model soundness*. Vetting should ensure that the model used is appropriate for the financial instrument being valued. For example, a model valuing option-free bonds would not be appropriate to value convertible or callable bonds.

3. *Independent access to rates*. To facilitate independent parameter estimation, the model vetter should ensure that the middle office has access to independent financial rates.

4. *Benchmark selection*. The vetting process should include selecting the appropriate benchmark based on assumptions made. Results from the benchmark test should be compared with the results from the model test.

5. *Health check and stress test*. Models should be vetted to ensure they contain all necessary properties and parameters. Models should also be stress tested to determine the range of values for which the model provides accurate pricing.

6. *Incorporate model risk into the risk management framework*. Model risk should be considered in the formal risk management governance and framework of an institution. In addition, models need to be periodically reevaluated for relevance and accuracy. Empirical evidence suggests that simple, robust models work better than more complex and less robust models.

Case Studies Related to Model Risk

LO 48.4: Explain the impact of model risk and poor risk governance in the 2012 London Whale trading loss and the 1998 collapse of Long Term Capital Management.

The impact of model risk has been felt significantly during two specific incidents: the 1997 collapse of Long-Term Capital Management (LTCM) and the 2012 "London Whale" trading loss at JPMorgan Chase (JPM). Both incidents illustrate the necessity to closely examine and vet models, and the importance of considering model risk within an organization's institutional risk governance framework.

Long-Term Capital Management

Background and Trading Strategies

LTCM was a U.S. hedge fund that existed between 1994 and 1998. The fund raised in excess of $1 billion in capital at its inception and grew rapidly over its initial years. LTCM's trading strategy relied on arbitrage positions based on market-neutral and relative-value trading. The fund began primarily as a bond arbitrage hedge fund that sought to make money by exploiting the spread differentials between bonds, including spread differences of European sovereign bonds and spread differences of corporate bonds and government Treasuries in the United States and United Kingdom.

LTCM relied on a combination of extensive empirical research and advanced financial modeling to formulate bets on convergence of prices in bond markets. For example, the fund was long (bought) Spanish and Italian sovereign debt and was short (sold) German sovereign debt. The strategy assumed that German sovereign bonds were overpriced relative to the weaker Spanish and Italian bonds, which were expected to increase in value with the imminent membership in the European economic and monetary union.

Another strategy was based on the expected convergence between the spreads of corporate and government bonds in the United States and United Kingdom, where spreads were expected to return to normal levels. This strategy was designed to make a profit regardless of the movement in price levels, assuming, however, that spreads moved in the appropriate direction and that correlations did not change materially.

Leverage, Correlations, and Volatility

LTCM's strategies were designed to generate only modest profits (around 1%). In order for the fund to generate strong performance, it needed to use extensive leverage of up to 25 times. Such leveraged positions relied on large institutional loans that were collateralized by bond investments. Shortly before the fund's collapse in 1998, LTCM had capital of close to $5 billion, assets of over $125 billion, and a notional value of investments in excess of $1.25 trillion. The magnitude of LTCM's leveraged investments was unprecedented in the markets.

LTCM's strategies worked as long as positions converged as anticipated, and as long as correlations did not deviate significantly from historical levels. Volatilities were calculated based on mathematical models to be approximately in line with the risk of investing in the S&P 500. However, at the time of the fund's collapse, its one-day volatility exceeded its model predicted volatility by 2.5 times, and the fund suffered losses of more than 3 times its 10-day predicted maximum loss.

Collapse and Lessons

In 1997, Asian markets experienced considerable economic and financial problems that quickly spread to several economies as contagion increased. These troubles ultimately affected Russia, which was forced to devalue its currency, the ruble, and default on its sovereign debt in August 1998. The Asian and Russian crisis triggered a flight-to-quality in European and North American markets with investors seeking the safe and predictable returns of high-quality sovereign bonds. As a result, the yields of the U.S. and German long-term sovereign bonds declined (their prices increased), while at the same time the yields on the riskier corporate bonds and riskier sovereign bonds (for example, Italy and Spain) increased (their prices fell). Credit spreads widened, volatilities increased beyond historical levels, and correlations in the market moved closer to +1 as the contagion effect of the crisis spread across markets.

With higher volatilities and dramatically widening spreads, the profits on LTCM's short positions were no longer sufficient to offset the losses on its long positions. With losses mounting, lenders demanded additional collateral. In order to meet collateral calls, LTCM had to unwind several unprofitable trades that put further downward pressure on markets given the size of the fund's trading positions. At the same time, liquidity in the markets quickly began to dry up, leaving many of LTCM's market-neutral positions now directionally exposed on the long side. Ultimately, the fund became insolvent in September 1998 and was bailed out by the Federal Reserve Bank of New York in order to curb a potential global financial crisis.

LTCM's collapse highlighted several flaws in its regulatory value at risk (VaR) calculations:

1. The fund's calculated 10-day VaR period was too short. A time horizon for economic capital should be sufficiently long enough to raise new capital, which is longer than the 10-day assumption.

2. The fund's VaR models did not incorporate liquidity assumptions. The assumption of perfectly liquid markets proved to be incorrect when the fund experienced liquidity droughts.

3. The fund's risk models did not incorporate correlation and volatility risks. This weakness was especially evident when markets moved to a correlation of close to +1 and volatility increased significantly above historical and model predicted levels.

London Whale

Background and Trading Strategy

JPMorgan Chase & Company (JPM), along with its principal banking subsidiary JPMorgan Chase Bank, is a U.S. financial company and one of the largest derivatives traders in the world. JPM garnered international headlines when in the first half of 2012 it sustained losses in excess of $6 billion due to risky synthetic credit derivatives trades executed by a trader, called the "London Whale", in its London office. The London trading desk belonged to JPM's Chief Investment Office (CIO), which was responsible for managing the bank's excess deposits.

The CIO was tasked with keeping the bank's risk level down and prudently managing the bank's $350 billion in excess deposits. Instead, the CIO used the deposits to engage in high-profit potential, high-risk derivatives trading strategies. In 2006, the CIO began a new series of synthetic credit derivatives trading strategies within its Synthetic Credit Portfolio (SCP). Trading focused less on hedging risk and more on earning profits from short positions.

Risk Culture, Model Risk, and Operational Risk

The CIO used various risk metrics for its trading activities, including VaR limits and credit spread widening limits.

In 2011, the CIO was instructed to reduce the bank's risk-weighted assets (RWA) in order to reduce regulatory capital requirements. Instead of the common practice of selling high risk assets, the CIO instead launched a trading strategy to offset its outstanding short positions by taking long positions in synthetic credit derivatives. This resulted not only in an increase in the portfolio's risk and size, but it also put the portfolio in a net long position, which reduced the hedging protection provided by the SCP.

Concurrently, in early 2012, and in response to breaching its own internal VaR limits as well as the bank's VaR limits, the CIO adopted a new VaR model which lowered its calculated VaR by 50%. The revised model allowed the CIO to remain within its VaR limit and at the same time engage in more higher-risk trading activities. However, the bank failed to seek regulatory approval of the new model. In addition, there were manual and calculation errors when implementing the model, which led to greater model and operational risk for the bank. Ultimately, the revised VaR model was reversed later in 2012 and the previous model was reinstated.

By 2012, the SCP was losing money on its strategies. In order to minimize its reported losses, the CIO changed its derivatives valuation practices from using midpoint prices (prices at the midpoint of the bid and ask) to using more favorable prices within the bid-ask spread during each day. As the losses in the SCP strategy increased, JPM's counterparties began to dispute the CIO's values, which led to frequent collateral disputes. Ultimately, JPM's positions soured and the bank lost close to $6.2 billion.

The losses from the London Whale trade and the subsequent investigations revealed a poor risk culture at JPM. Risk limits were routinely downplayed or ignored, limit breaches were disregarded, and risk models were altered to favor riskier trading activities.

Key Concepts

LO 48.1

Model risk becomes important when quantifying the risk exposures of complex financial instruments, including exotic or synthetic derivatives and structured products. Model risk can give rise to losses from model errors, errors in assumptions, carelessness, fraud, or intentional mistakes. These errors can lead to undervaluing risk, overvaluing profit, or both. Six common model errors include:

1. Assuming constant volatility.
2. Assuming a normal distribution of returns.
3. Underestimating the number of risk factors.
4. Assuming perfect capital markets.
5. Assuming adequate liquidity.
6. Misapplying a model.

LO 48.2

Implementation error could occur when models that require complex simulations are not allowed to run a sufficient number of runs. This may result in incorrect output and therefore an incorrect interpretation of results.

For model implementation, considerations include frequency of refreshing model parameters, including volatilities and correlations. Correctly estimating parameters (durations, volatilities, and correlations) is challenging, however, implementing a model with input errors will result in inaccurate results.

Common valuation and estimation errors include:

1. Inaccurate data.
2. Incorrect sampling period length.
3. Liquidity and valuation problems.

LO 48.3

Model risk can be mitigated either through investing in research to improve the model, or through an independent vetting process. Vetting consists of six phases:

1. Documentation.
2. Vetting the soundness of the model.
3. Ensuring independent access to rates.
4. Benchmark selection.
5. Health check and stress testing of the model.
6. Incorporating model risk into the risk management framework.

LO 48.4

Long-Term Capital Management (LTCM) was a U.S. hedge fund that used arbitrage strategies to exploit spread differentials between bonds, including spread differences of European sovereign bonds and spread differences in corporate bonds and government Treasuries. LTCM's strategy was to make predictable, low returns and then amplify them using extensive leverage.

The collapse of LTCM in 1998 highlights three important lessons:

1. Utilizing a 10-day VaR period as a proxy for the time horizon for economic capital is too short. A time horizon is needed that is sufficiently long enough to model the time to raise new capital.
2. The fund's VaR models ignored the possibility that liquidity may decline or even completely dry up in periods of extreme stress.
3. The fund's risk models ignored correlation and volatility risks. Specifically, the fund did not account for stressed scenarios with material rises in volatility or an increase in positive market correlation as contagion risk spread across international economies.

In 2012, JPMorgan Chase (JPM) and its Chief Investment Office (CIO) sustained severe losses due to risky synthetic credit derivatives trades executed by its London office. The losses from the London Whale trade and the subsequent investigations highlighted a poor risk culture at JPM, giving rise to both model and operational risks across the firm. Risk limits were routinely ignored and limit breaches were disregarded.

Concept Checkers

1. A risk analyst for a mid-sized bank believes that two common errors in model building include the assumption of constant volatility of returns and the assumption of a non-normal returns distribution. The analyst is correct with regard to the assumption(s) of:
   A. volatility of returns only.
   B. non-normal returns distribution only.
   C. both volatility of returns and non-normal returns distributions.
   D. neither volatility of returns nor non-normal returns distributions.

2. Which of the following scenarios is the best example of a model error?
   A. Assuming a non-normal distribution of returns.
   B. Assuming perfectly liquid markets.
   C. Assuming variable distribution of asset price.
   D. Assuming imperfect capital markets.

3. The chief risk officer (CRO) of a European corporation recommends increasing the length of the sampling period in order to minimize model risk. However, increasing the length of the sampling period will most likely:
   A. increase estimation errors.
   B. diminish the power of the statistical test.
   C. put higher weight on obsolete information.
   D. diminish the relevance of old data.

4. Gamma Investments, LLC (Gamma) uses monthly model vetting to mitigate potential model risk. Gamma's managers recently accepted the use of a model for valuing short-term options on 30-year corporate bonds, but rejected the same model to value short-term options on three-year government bonds. The managers also frequently test proposed analytical models against a simulation approach. These model vetting techniques are examples of which of the following vetting phases?

	Accepting/rejecting a model	Testing models against simulation
A.	Health check of the model	Stress testing
B.	Soundness of a model	Stress testing
C.	Health check of the model	Benchmark modeling
D.	Soundness of a model	Benchmark modeling

5. Which of the following flaws in Long-Term Capital Management's (LTCM) value at risk (VaR) calculations were most evident following its collapse in 1998?
   I. The calculated 10-day VaR period was too short.
   II. The fund's VaR model assumed strong positive correlation.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

Concept Checker Answers

1. **A** The analyst is correct with respect to the assumption of volatility of returns only. Another common model error is the assumption of a normal distribution of returns. Market participants frequently make the simplifying assumption in their models that asset returns are normally distributed. However, empirical research shows that returns tend to be non-normally distributed.

2. **B** Six common model errors include: (1) assuming constant volatility, (2) assuming a normal distribution of returns, (3) underestimating the number of risk factors, (4) assuming perfect capital markets, (5) assuming adequate liquidity, and (6) misapplying a model.

3. **C** Adding more observations to the model reduces estimation errors and improves the power of statistical tests. However, it gives greater relevance to old and potentially stale data and puts greater weight on obsolete information which may now be irrelevant.

4. **D** Accepting the model for one use but rejecting it for another (inappropriate) use is an example of vetting the soundness of the model. In other words, the model vetter (in this case the risk managers) should ensure that the mathematical model reasonably represents the asset being valued.

   Testing a proposed analytical model against a simulation approach or a numerical approximation technique is an example of benchmark modeling.

   Health check of the model ensures that the model contains all of the necessary properties. Stress testing a model uses simulations to check the model's reaction to different situations.

5. **A** LTCM's collapse highlighted several flaws in its regulatory VaR calculations. The fund relied on a VaR model that: (1) used a 10-day horizon, which proved to be too short to sufficiently model the time to raise new capital, (2) did not factor in liquidity risk (in other words, it assumed markets were perfectly liquid), and (3) did not incorporate correlation and volatility risks, where in fact markets exhibited strong positive correlation during periods of stress in 1997 and 1998.

The following is a review of the Operational and Integrated Risk Management principles designed to address the learning objectives set forth by GARP®. This topic is also covered in:

Risk Capital Attribution and Risk-Adjusted Performance Measurement

Topic 49

Exam Focus

This topic covers the application of the risk-adjusted return on capital (RAROC) approach to the allocation of economic capital. The application of a hurdle rate for capital budgeting decisions as well as an adjusted version of the traditional RAROC approach is also presented. For the exam, know the differences between economic capital and regulatory capital, and be able to compute RAROC for capital budgeting as well as adjusted RAROC. Also, be familiar with the qualitative concepts discussed, such as reasons for using economic capital to allocate risk capital, the benefits of RAROC, and best practices in implementing the RAROC approach.

Risk Capital, Economic Capital, and Regulatory Capital

LO 49.1: Define, compare, and contrast risk capital, economic capital, and regulatory capital, and explain methods and motivations for using economic capital approaches to allocate risk capital.

Risk capital provides protection against risk (i.e., unexpected losses). In other words, it can be defined as a (financial) buffer to shield a firm from the economic impact of risks taken. Should a disastrous event occur, those impacts could otherwise jeopardize the firm's financial security and its ability to remain a going concern. In short, risk capital provides assurance to the firm's stakeholders that their invested funds are safe. In most cases, risk capital and **economic capital** are treated synonymously, although an alternative definition of economic capital exists (discussed further in LO 49.3):

economic capital = risk capital + strategic risk capital

On the other hand, there are at least three distinct differences between risk capital and **regulatory capital** as follows:

1. Unlike risk capital, regulatory capital is relevant only for regulated industries such as banking and insurance.

2. Regulatory capital is computed using general benchmarks that apply to the industry. The result is a minimum required amount of capital adequacy that is usually far below the firm's risk capital.

3. Assuming that risk capital and regulatory capital are the same for the overall firm, the amounts may be different within the various divisions of the firm. From a risk capital allocation perspective, one solution is to allocate the greater of risk capital and regulatory capital to a certain division.

Professor's Note: We will examine the regulatory capital charges for credit, market, and operational risk in the Basel readings later in this book.

Given that Basel III requirements are sufficiently robust, it is probable that in certain areas (e.g., securitization), regulatory capital will be substantially higher than risk/economic capital. Although the two amounts may conflict, risk/economic capital must be computed in order to determine the economic viability of an activity or division. Assuming that regulatory capital is substantially higher than risk/economic capital for a given activity, then that activity will potentially move over to shadow banking (i.e., unregulated activities by regulated financial institutions) in order to provide more favorable pricing.

Using Economic Capital Approaches

From the perspective of financial institutions, the motivations for using economic capital are as follows:

Capital is used extensively to cushion risk. Compared to most other non-financial institutions, financial institutions can become highly leveraged (i.e., riskier) at a relatively low cost simply by accepting customer deposits or issuing debt. All of this may occur without having to issue equity. Additionally, many of the financial institutions will participate in transactions involving derivatives, guarantees, and other commitments that only require a relatively small amount of funding but always involve some risk. As a result, all of the firm's activities must be allocated an economic capital cost.

Financial institutions must be creditworthy. A unique aspect of financial institutions is that their main customers are also their main liability holders. Customers who deposit funds to a financial institution will be concerned about the default risk of the financial institution. With over-the-counter (OTC) derivatives, the concern is counterparty risk. As a result, a sufficient amount of economic capital must be maintained to provide assurance of creditworthiness.

There is difficulty in providing an external assessment of a financial institution's creditworthiness. It is challenging to provide an accurate credit assessment of a financial institution because its risk profile is likely to be constantly evolving. For example, an institution may engage in complicated hedging and derivatives transactions that could rapidly impact its liquidity. Therefore, having a sufficient store of economic capital could mitigate this problem and provide assurance of financial stability.

Profitability is greatly impacted by the cost of capital. Economic capital is similar to equity capital in the sense that the invested funds do not need to be repaid in the same manner as debt capital, for instance. In other words, economic capital serves as a reserve or a financial cushion in case of an economic downturn. As a result, economic capital is more expensive to hold than debt capital, thereby increasing the cost of capital and reducing the financial institution's profits. A proper balance between holding sufficient economic capital and partaking in risky transactions is necessary.

Risk-Adjusted Return on Capital

LO 49.2: Describe the RAROC (risk-adjusted return on capital) methodology and its use in capital budgeting.

The **risk-adjusted return on capital** (RAROC) methodology provides users with information pertaining to the risk-adjusted performance of the firm and its business units as opposed to merely the "raw" performance numbers. In measuring economic performance, this methodology involves allocating risk capital to the firm's business units and to specific transactions.

Benefits of RAROC include:

1. Performance measurement using economic profits instead of accounting profits. Accounting profits include historical and arbitrary measures such as depreciation, which may be less relevant.

2. Use in computing increases in shareholder value as part of incentive compensation (e.g., scorecards) within the firm and its divisions. The flexibility of RAROC may also allow for deferred/contingent compensation or clawbacks for subsequent poor performance.

3. Use in portfolio management for buy and sell decisions and use in capital management in estimating the incremental value-added through a new investment or discontinuing an existing investment.

4. Using risk-based pricing, which will allow proper pricing that takes into account the economic risks undertaken by a firm in a given transaction. Each transaction must consider the expected loss and the cost of economic capital allocated. Many firms use the "marginal economic capital requirement" portion of the RAROC equation for the purposes of pricing and determining incremental shareholder value.

LO 49.3: Compute and interpret the RAROC for a project, loan, or loan portfolio, and use RAROC to compare business unit performance.

The necessary amount of economic capital is a function of credit risk, market risk, and operational risk. The RAROC for a project or loan can be defined as risk-adjusted return divided by risk-adjusted capital. The basic RAROC equation is as follows:

$$\text{RAROC} = \frac{\text{after-tax expected risk-adjusted net income}}{\text{economic capital}}$$

There is a tradeoff between risk and return per unit of capital with the numerator acting as return and the denominator acting as risk. For example, a business unit's RAROC needs to be greater than its cost of equity in order to create shareholder value.

Furthermore, measures such as return on equity (ROE) or return on assets (ROA) are based on accounting book values only, and therefore are unable to account for the relevant risks. RAROC has two specific adjustments to these measures. In the numerator, it deducts expected loss (the risk factor) from the return. In the denominator, it replaces accounting capital with economic capital.

The underlying principles of the RAROC equation are similar to two other common measures of risk/return: (1) the Sharpe ratio, which equals: (expected return – risk-free rate) / standard deviation, and (2) the net present value (NPV), which equals the discounted value of future expected after-tax cash flows. The discount rate for the NPV is a risk-adjusted expected return that uses beta (captures systematic risk only) from the capital asset pricing model (CAPM). In contrast to NPV, RAROC takes into account both systematic and unsystematic risk in its earnings figure.

A more detailed RAROC equation to use for capital budgeting decisions is as follows:

$$\text{RAROC} = \frac{\begin{pmatrix}\text{expected revenues} - \text{costs} - \text{expected losses} \\ - \text{taxes} + \text{return on economic capital} \pm \text{transfers}\end{pmatrix}}{\text{economic capital}}$$

Where:

- *Expected revenues* assume no losses and *costs* refer to direct costs. *Taxes* are computed using the firm's effective tax rate and *transfers* include head office overhead cost allocations to the business unit as well as transactions between the business unit and the treasury group, such as borrowing and hedging costs.
- *Expected losses* (EL) consist mainly of expected default losses (i.e., loan loss reserve), which are captured in the numerator (i.e., higher funding cost) so there is no adjustment required in the denominator. Expected losses also arise due to market, operational, and counterparty risks.
- *Return on economic capital* refers to the return on risk-free investments based on the amount of allocated risk capital.
- *Economic capital* includes both risk capital and strategic risk capital.

Risk capital serves as a buffer against unexpected losses. It is the amount of funds that the firm must hold in reserve to cover a worst-case loss (an amount over the expected loss) at a specific confidence level that is usually 95% or more. Therefore, it is very similar to the annual value at risk (VaR).

Strategic risk capital pertains to the uncertainty surrounding the success and profitability of certain investments. An unsuccessful investment could result in financial losses and a negative reputational impact on the firm. Strategic risk capital includes goodwill and burned-out capital.

- **Goodwill** is the excess of the purchase price over the fair value (or replacement value) of the net assets recorded on the balance sheet. A premium price may exist because of the existence of valuable but unrecorded intangible assets.
- **Burned-out capital** represents the risk of amounts spent during the start-up phase of a venture that may be lost if the venture is not pursued because of low projected risk-adjusted returns. The venture may refer to a recent acquisition or an internally generated project. Burned-out capital is amortized over time as the strategic failure risk decreases.

Finally, firms may allocate risk capital to any unused risk limits (e.g., undrawn amounts on a line of credit) because risk capacity could be utilized any time. If risk capacity is utilized, the firm would then have to adjust the risk capital amount.

As mentioned, economic capital is designed to provide a cushion against *unexpected losses* at a specified confidence level. The confidence level at which economic capital is set can be viewed as the probability that the firm will be able to absorb unexpected losses over a specified period. A simple example can help illustrate the concept of unexpected loss and how it is equal to the risk capital allocation. Assume for a given transaction that the expected loss is 20 basis points (bps) and the worst-case loss is 190 bps at a 95% confidence level over one year. Based on this information, the unexpected loss is 170 bps (excess of worst-case loss over expected loss). There is also still a 5% probability that the actual loss will exceed 190 bps.

Example: RAROC calculation

Assume the following information for a commercial loan portfolio:

- $1.5 billion principal amount
- 7% pre-tax expected return on loan portfolio
- Direct annual operating costs of $10 million
- Loan portfolio is funded by $1.5 billion of retail deposits; interest rate = 5%
- Expected loss on the portfolio is 0.5% of principal per annum
- Unexpected loss of 8% of the principal amount, or $120 million of economic capital required
- Risk-free rate on government securities is 1% (based on the economic capital required)
- 25% effective tax rate
- Assume no transfer pricing issues

Compute the RAROC for this loan portfolio.

Answer:

First, calculate the following RAROC components:

Expected revenue = 0.07 × $1.5 billion = $105 million
Interest expense = 0.05 × $1.5 billion = $75 million
Expected loss = 0.005 × $1.5 billion = $7.5 million
Return on economic capital = 0.01 × $120 million = $1.2 million

Then, apply the RAROC equation:

$$\text{RAROC} = \frac{(105 - 10 - 75 - 7.5 + 1.2 + 0) \times (1 - 0.25)}{120} = 8.56\%$$

Therefore, maintenance of the commercial loan portfolio requires an after-tax expected rate of return on equity of at least 8.56%.

Note that for capital budgeting projects, *expected* revenues and losses should be used in the numerator since the analysis is being performed on an ex ante (or before the fact) basis. In contrast, for performance evaluation purposes on an ex post (or after the fact) basis, *realized* (or actual) revenues and losses should be used.

RAROC for Performance Measurement

LO 49.4: Explain challenges that arise when using RAROC for performance measurement, including choosing a time horizon, measuring default probability, and choosing a confidence level.

Time Horizon

In computing RAROC, the focus so far has been on one period (i.e., one-year time horizon) since it is convenient from a business planning cycle perspective and it represents the probable amount of time needed for a firm to recover from a significant unexpected loss. At the same time, it is possible to look at multi-period RAROC to obtain a more accurate RAROC measure for longer-term transactions and loans. One issue that arises is how much economic capital to allocate if the risk of a transaction changes dramatically in subsequent periods. For example, using an averaging method would give rise to periods of overcapitalization and periods of undercapitalization.

Risk capital could be thought of as the firm's one-year VaR at a specific confidence level (e.g., 95% or 99%). For both credit risk and operational risk, no adjustments are required from one-year VaR to compute risk capital. For market risk, short time horizons such as one day (risk monitoring) or 10 days (regulatory capital) require adjustments to determine the correct one-year risk capital allocation.

One basic approach is the "square root of time" rule whereby one-year VaR is estimated by multiplying the one-day VaR by the square root of 252 business days in the year. This approach needs to be fine-tuned by considering that even in a worst-case scenario, the firm might only be able to reduce its risk to a core risk level to retain its status as a financially viable business for the rest of the year. Furthermore, the computation must also factor in the time needed to lower the current risk level to the core risk level (i.e., "time to reduce"). That amount of time corresponds to the relative liquidity (during difficult market conditions) of the firm's investment positions taken. As a result, a large amount of time may be required for a reasonable liquidation of the positions.

Example: Risk capital for market risk

Assume the following information where the core risk level is below the current risk level:

- Daily value at risk (VaR) = 80
- Core risk level = 60
- Days needed to reduce current risk level to core risk level = 10 (i.e., risk reduction of 2 VaR per day)
- Number of business days per year = 252

Compute the required risk capital as a percentage of annualized VaR.

Answer:

$$\text{Risk capital} = \text{square root}\left\{\begin{bmatrix}\text{sum of squares} + \\ \left[\text{core risk level squared} \times (\text{number of business days per year} - \\ \text{days needed to reduce current to core})\right]\end{bmatrix}\right\}$$

$$= \text{square root}\left\{\begin{bmatrix}(80^2 + 78^2 + 76^2 + 74^2 + 72^2 + 70^2 + 68^2 + 66^2 + 64^2 + 62^2) + \\ \left[60^2 \times (252 - 10)\right]\end{bmatrix}\right\}$$

$$= \text{square root } [50{,}740 + (3{,}600 \times 242)]$$

$$= \sqrt{921{,}940} = 960.18$$

Note that annualized VaR = 80 × square root of 252 = 1,269.96

Therefore, the risk capital required is approximately 75.6% of annualized VaR (960.18 / 1,269.96).

There is a lot of subjectivity in selecting the time horizon for RAROC calculation purposes. A longer time horizon could be selected to account for the full business cycle; it may not always increase the risk capital required since the confidence level required to maintain a firm's solvency will fall as the time horizon is increased. A key consideration with the selection of a time horizon is the fact that risk and return data for periods over one year is likely to be of questionable reliability.

Default Probability

A **point-in-time** (PIT) probability of default could be used to compute short-term expected losses and to price financial instruments with credit risk exposure. A **through-the-cycle** (TTC) probability of default is more commonly used for computations involving economic capital, profitability, and strategic decisions.

A firm's rating is more likely to change when analyzed under the PIT approach versus the TTC approach. As a result, the TTC approach results in a lower volatility of economic capital versus the PIT approach. From time to time, it is advisable to compare the result of PIT versus TTC for RAROC computations at a stable portion of the economic cycle and at the lowest portion of the cycle.

Confidence Level

In computing economic capital, the confidence level chosen must correspond with the firm's desired credit rating. A high rating such as AA or AAA would require a confidence level in excess of 99.95%, for example. Choosing a lower confidence level will reduce the amount of risk capital required/allocated and it will impact the risk-adjusted performance measures. The reduction may be dramatic if the firm is primarily exposed to operational, credit, and settlement risks where large losses are rare.

Hurdle Rate for Capital Budgeting Decisions

LO 49.5: Calculate the hurdle rate and apply this rate in making business decisions using RAROC.

Similar to internal rate of return (IRR) analysis, the use of a **hurdle rate** (i.e., after-tax weighted average cost of equity capital) is compared to RAROC in making business decisions. In general, the hurdle rate should be revised perhaps once or twice a year or when it has moved by over 10%.

The hurdle rate, $h_{AT,}$ is computed as follows:

$$h_{AT} = \frac{\left[(CE \times R_{CE}) + (PE \times R_{PE})\right]}{(CE + PE)}$$

where:
CE = market value of common equity
PE = market value of preferred equity
R_{CE} = cost of common equity [could be derived from the capital asset pricing model (CAPM)]
R_{PE} = cost of preferred equity (yield on preferred shares)

Recall, that the CAPM formula is as follows:

$$R_{CE} = R_F + \beta_{CE}(R_M - R_F)$$

where:
R_F = risk-free rate
R_M = expected return on market portfolio
β_{CE} = firm's common equity market beta

Once the hurdle rate and the RAROC are calculated, the following rules apply:

- If RAROC > hurdle rate, there is value creation from the project and it should be accepted.
- If RAROC < hurdle rate, there is value destruction from the project and it should be rejected/discontinued.

Obviously, a shortcoming of the above rules is that higher return projects that have a RAROC > hurdle rate (accepted projects) also come with high risk that could ultimately result in losses and reduce the value of the firm. In addition, lower return projects that have a RAROC < hurdle rate (rejected projects) also come with low risk that could provide steady returns and increase the value of the firm. As a result, an adjusted RAROC measure should be computed.

Adjusted RAROC

LO 49.6: Compute the adjusted RAROC for a project to determine its viability.

RAROC should be adjusted to consider systematic risk and a consistent hurdle rate.

$$\text{Adjusted RAROC} = \text{RAROC} - \beta_E (R_M - R_F)$$

where:
R_F = risk-free rate = hurdle rate
R_M = expected return on market portfolio
β_E = firm's equity beta
$(R_M - R_F)$ = excess return over risk-free rate to account for the nondiversifiable systematic risk of the project

Therefore, the revised business decision rules are as follows:

- If adjusted RAROC > R_F, then accept the project
- If adjusted RAROC < R_F, then reject the project

Example: Adjusted RAROC

Suppose RAROC is 12%, the risk-free rate is 5%, the market return is 11%, and the firm's equity beta is 1.5. Use ARAROC to **determine** whether the project should be accepted or rejected.

Answer:

$$\text{Adjusted RAROC} = \text{RAROC} - \beta_E (R_M - R_F)$$
$$= 0.12 - 1.5(0.11 - 0.05) = 0.12 - 0.09 = 0.03$$

The project should be rejected because the ARAROC of 3% is less than the risk-free rate of 5%.

Risk Capital and Diversification

LO 49.7: Explain challenges in modeling diversification benefits, including aggregating a firm's risk capital and allocating economic capital to different business lines.

The overall risk capital for a firm should be less than the total of the individual risk capitals of the underlying business units. That is because the correlation of returns between the business units is likely to be less than +1. Such risk reduction due to diversification effects over risk types and business activities is very difficult to measure in practice. Instead of using an extremely high overall confidence level for the firm, the various business units may use lower confidence levels to avoid an excessively high aggregate risk capital amount.

For example, assume a firm is subject to only the following four types of risk (risk capital amounts are provided for each risk):

- Market risk = $400
- Credit risk = $300
- Liquidity risk = $200
- Operational risk = $500

Aggregate risk capital for the firm could be as high as $1,400 assuming a perfect correlation (i.e., sum of the four risk capital amounts). Or it could be as low as $734 assuming zero correlation (square root of the sum of squares of the four risk capital amounts). In taking into account the diversification effects, the firm's overall VaR should be computed as some value between $734 and $1,400, which is a very wide range. In addition, there is a lot of subjectivity involved in allocating the diversification benefits back to the business units in a fair manner especially since the allocation will impact the respective business units' performance measures (i.e., reduction of risk capital required).

It makes sense that a business unit with earnings or cash flows that are highly correlated to the overall firm would need to be allocated more risk capital than a business unit with earnings or cash flows that are negatively correlated (assuming similar volatility). Having business lines that are countercyclical in nature allows the overall firm to have stable earnings and to attain a given desired credit rating using less risk capital. In practice, the easiest allocation method is a pro-rata allocation based on standalone risk capital amounts.

For example, assume the following information pertaining to a business unit that engages in only two activities, A and B:

- Activity A alone requires $50 of risk capital
- Activity B alone requires $60 of risk capital
- Activities A and B together require a total of $90 of risk capital

Stand-alone capital looks at each activity independently and ignores any diversification benefits. Therefore, the stand-alone capital for Activities A and B are $50 and $60, respectively. The stand-alone capital for the business unit is $90.

Fully diversified capital takes into consideration the diversification benefits, which equal $20 ($50 + $60 – $90). For simplicity, the diversification benefit can be done on a pro-rata basis as follows: ($20 × $50) / $110 = $9.1 is allocated to Activity A and ($20 × $60) /$110 = $10.9 is allocated to Activity B. Therefore, Activities A and B have fully diversified capital of $40.9 and $49.1, respectively. Fully diversified capital should be used to determine a firm's solvency and to determine the minimum amount of risk capital required for a given activity.

Marginal capital is the extra capital needed as a result of a new activity added to the business unit. Diversification benefits are fully considered. The marginal risk capital for Activity A is $30 ($90 total – $60 for Activity B) and the marginal risk capital for Activity B is $40 ($90 total – $50 for Activity A). Total marginal risk capital ($70) is below the full risk capital of the business unit ($90). The general method for computing marginal capital of a new activity is to start with the total risk capital required for the business unit minus all of the risk capital required for the other activities. Marginal capital is useful for making active portfolio management and business mix decisions; such decisions need to fully consider diversification benefits.

In a performance measurement context, stand-alone risk capital is useful to determine incentive pay and fully diversified risk capital is useful to determine the incremental benefit due to diversification. In allocating the diversification benefits, caution must be taken especially since correlations between the risk factors usually change over time. In a more extreme situation such as a market crisis, correlations could move to –1 or +1, thereby reducing diversification benefits.

RAROC Best Practices

LO 49.8: Explain best practices in implementing an approach that uses RAROC to allocate economic capital.

Recommendations for implementing a RAROC approach are as follows:

Senior Management

The management team (including the CEO) needs to be actively involved with the implementation of a RAROC approach within the firm and promote it as a means of measuring shareholder value creation. The emphasis should be on the level of profits earned by the firm in relation to the level of risks taken as opposed to merely earning as much profit as possible.

Communication and Education

The RAROC process needs to be clearly explained to all levels of management of the firm in order to have sufficient "buy in" from management. Specifically, the process of allocating economic capital to the various business units needs to be fair and transparent in order to minimize the common concerns of excessive economic capital attribution to a given business unit. An open dialogue and debate with the various business unit leaders of issues concerning how economic capital is computed would also be helpful.

Ongoing Consultation

There are key metrics that impact the computation of economic capital. A committee consisting of members from the various business units as well as the risk management group should review these metrics periodically in order to promote fairness in the capital allocation process.

Metrics involving credit risk include: probability of default, credit migration frequencies, loss given default, and credit line usage given default. The metrics will change with time and will need to be updated accordingly. The historical period over which the metrics are adjusted is debatable—a shorter period may result in fluctuating economic capital amounts and a longer period may result in more stable amounts.

Metrics involving market risk focus on volatility and correlation, and should be updated at least monthly. Metrics involving operational risk are not as defined as they are for credit and market risk, so therefore, involve a significant amount of subjectivity and debate. Other key metrics, like core risk level and time to reduce, should be updated annually.

Data Quality Control

Information systems collect data (e.g., risk exposures and positions) required to perform the RAROC calculations. The data collection process should be centralized with built-in edit and reasonability checks to increase the accuracy of the data. In subdividing the general duties surrounding data, the RAROC team should be responsible for the data collection process, the computations, and the reporting. The business units and the accounting department should be responsible for putting controls in place to ensure the accuracy of the data being used for the RAROC calculations.

Complement RAROC with Qualitative Factors

A qualitative assessment of each business unit could be performed using a four-quadrant analysis. The horizontal axis would represent the expected RAROC return and the vertical axis would represent the quality of the earnings based on the importance of the business unit's activities to the overall firm, growth opportunities, long-run stability and volatility of earnings, and any synergies with other business units. There are four resulting possibilities:

- Low quality of earnings, low quantity of earnings: the firm should try to correct, reduce, or shut down the activities of any of its business units in this category.
- Low quality of earnings, high quantity of earnings (managed growth): the firm should maintain any business units that currently produce high returns but have low strategic importance to the firm.
- High quality of earnings, low quantity of earnings (investment): the firm should maintain any business units that currently produce low returns but have high strategic value and high growth potential.
- High quality of earnings, high quantity of earnings: the firm should allocate the most resources to business units in this category.

Active Capital Management

Business units should submit their limit requests (e.g., economic capital, leverage, liquidity, risk-weighted assets) quarterly to the RAROC team. The RAROC team performs the relevant analysis and sets the limits in a collaborative manner that allows business units to express any objections. Senior management will then make a final decision. The treasury group will ensure the limits make sense in the context of funding limits. The restriction placed on a firm's growth due to leverage limitations helps promote the optimal use of the limited amount of capital available.

Key Concepts

LO 49.1

Risk capital is a buffer to shield a firm from the economic impacts of the risks that it takes (i.e., protect against unexpected losses). In short, it provides assurance to the firm's stakeholders that their invested funds are safe.

In most cases, risk capital and economic capital are identical; however, strategic risk capital may be added to economic capital as follows:

economic capital = risk capital + strategic risk capital

Regulatory capital is relevant only for regulated industries such as banking and insurance. It is computed using general benchmarks that apply to the industry. Assuming that risk capital and regulatory capital are the same for the overall firm, the amounts may be different within the various divisions of the firm.

For financial institutions, there are four major reasons for using economic capital to allocate risk capital:

- Capital is used extensively to cushion risk.
- Financial institutions must be creditworthy.
- Difficulty in providing an external assessment of a financial institution's creditworthiness.
- Profitability is greatly impacted by the cost of capital.

LO 49.2

Benefits of using the risk-adjusted return on capital (RAROC) approach include:

1. Performance measurement using economic profits instead of accounting profits.

2. Use in computing increases in shareholder value as part of incentive compensation (e.g., scorecards) within the firm and its divisions.

3. Use in portfolio management for buy and sell decisions and use in capital management in estimating the incremental value-added through a new investment or discontinuing an existing investment.

4. Using risk-based pricing, which will allow proper pricing that takes into account the economic risks undertaken by a firm in a given transaction.

LO 49.3

The basic RAROC equation is as follows:

$$\text{RAROC} = \frac{\text{after-tax expected risk-adjusted net income}}{\text{economic capital}}$$

A more detailed RAROC equation for capital budgeting decisions is as follows:

$$\text{RAROC} = \frac{\begin{pmatrix}\text{expected revenues} - \text{costs} - \text{expected losses} \\ - \text{taxes} + \text{return on economic capital} \pm \text{transfers}\end{pmatrix}}{\text{economic capital}}$$

LO 49.4

In computing RAROC, the focus is often on a one-year time horizon. However, it is possible to look at multi-period RAROC to obtain a more accurate RAROC measure for longer-term transactions and loans. One issue that arises is how much economic capital to allocate if the risk of a transaction changes dramatically in subsequent periods. There is a lot of subjectivity in selecting the time horizon for RAROC calculation purposes. A longer time horizon could be selected to account for the full business cycle, for example. A key consideration with the selection of a time horizon is the fact that risk and return data for periods over one year is likely to be of questionable reliability.

A point-in-time (PIT) probability of default could be used for short-term expected losses and to price financial instruments with credit risk exposure. A through-the-cycle (TTC) probability of default is more commonly used for computations involving economic capital, profitability, and strategic decisions.

In computing economic capital, the confidence level chosen must correspond with the firm's desired credit rating. Choosing a lower confidence level will reduce the amount of risk capital required/allocated and it will impact risk-adjusted performance measures.

LO 49.5

The hurdle rate is computed as follows:

$$h_{AT} = \frac{\left[(CE \times R_{CE}) + (PE \times R_{PE})\right]}{(CE + PE)}$$

Once the hurdle rate and the RAROC are calculated, the following rules apply:

- If RAROC > hurdle rate, there is value creation from the project and it should be accepted.
- If RAROC < hurdle rate, there is value destruction from the project and it should be rejected/discontinued.

LO 49.6

RAROC should be adjusted to take into account systematic risk and a consistent hurdle rate as follows:

$$\text{Adjusted RAROC} = \text{RAROC} - \beta_E\left(R_M - R_F\right)$$

LO 49.7

The overall risk capital for a firm should be less than the total of the individual risk capitals of the underlying business units. This is because the correlation of returns between business units is likely to be less than +1.

A business unit with earnings or cash flows that are highly correlated to the overall firm should be allocated more risk capital than a business unit with earnings or cash flows that are negatively correlated (assuming similar volatility). Having business lines that are countercyclical in nature allows the overall firm to have stable earnings and to attain a given desired credit rating using less risk capital.

LO 49.8

The management team needs to be actively involved with the implementation of a RAROC approach within the firm and promote it as a means of measuring shareholder value creation.

The RAROC process needs to be clearly explained to all levels of management of the firm in order to have sufficient "buy in" from management.

A committee consisting of members from the various business units as well as the risk management group should periodically review the metrics that impact economic capital calculations in order to promote fairness in the capital allocation process.

The RAROC team should be responsible for the data collection process, the computations, and the reporting. The business units and the accounting department should be responsible for putting controls in place to ensure the accuracy of the data being used for the RAROC calculations.

A qualitative assessment of each business unit could be performed using a four-quadrant analysis. The horizontal axis would represent the expected RAROC return and the vertical axis would represent the quality of the earnings based on the importance of the business unit's activities to the overall firm, growth opportunities, long-run stability and volatility of earnings, and any synergies with other business units.

Business units should submit their limit requests (e.g., economic capital, leverage, liquidity, risk-weighted assets) quarterly to the RAROC team. The RAROC team performs the relevant analysis and sets the limits in a collaborative manner that allows business units to express any objections.

Concept Checkers

1. Which of the following statements regarding the risk-adjusted return on capital (RAROC) methodology is correct?
   A. In the context of performance measurement, RAROC uses accounting profits.
   B. In the numerator of the RAROC equation, expected loss is added to the return.
   C. If a business unit's cost of equity is greater than its RAROC, then the business unit is not adding value to shareholders.
   D. RAROC is useful for determining incentive compensation but it lacks the flexibility to consider deferred or contingent compensation.

2. Assume the following information for a commercial loan portfolio:
   - \$1.2 billion principal amount
   - 6% pre-tax expected return on loan portfolio
   - Direct annual operating costs of \$8 million
   - Loan portfolio funded by \$1.2 billion of retail deposits; interest rate = 4%
   - Expected loss on the portfolio is 0.4% of principal per annum
   - Unexpected loss of 7% of the principal amount
   - Risk-free rate on government securities is 1%
   - 30% effective tax rate
   - Assume no transfer pricing issues

   Based on the information provided, which of the following amounts is closest to the RAROC?
   A. 9.33%
   B. 10.03%.
   C. 12.33%.
   D. 14.66%.

3. Which of the following statements regarding the computation of economic capital is correct?
   I. Selecting a longer time horizon for RAROC calculations is preferable because risk and return data is more reliable with more time.
   II. Choosing a lower confidence level will not likely reduce the amount of risk capital required if the firm has little exposure to operational, credit, and settlement risks.
   A. I only.
   B. II only.
   C. Both I and II.
   D. Neither I nor II.

4 Which of the following statements regarding the choice of default probability approaches in computing economic capital is correct?

A. A through-the-cycle (TTC) approach should be used to price financial instruments with credit risk exposure.
B. A point-in-time (PIT) approach is more commonly used for computations involving profitability and strategic decisions.
C. A TTC approach is more likely to result in a lower volatility of capital compared to the PIT approach.
D. A firm's rating will not change when analyzed under the PIT approach versus the TTC approach.

5. Which of the following statements regarding best practices in implementing a RAROC approach is correct?

A. A successful RAROC approach is focused on maximizing profits earned by the firm.
B. A restriction on the firm's growth due to leverage limitations may result in higher profits.
C. The data collection process throughout the firm should be decentralized to allow the various business units to ensure the utmost accuracy of data.
D. Metrics involving credit risk, market risk, and operational risk to compute economic capital are generally clearly defined and may be computed objectively.

Concept Checker Answers

1. C The cost of equity represents the minimum rate of return on equity required by shareholders. Therefore, if RAROC is below the cost of equity, then there is no value being added.

   Response A is not correct because RAROC uses economic profits, not accounting profits. Response B is not correct because in the numerator of the RAROC equation, expected loss is deducted from the return. Response D is not correct because RAROC has the flexibility to consider deferred or contingent compensation.

2. B Unexpected loss ($1.2 billion × 7% = $84 million) is equal to the amount of economic capital required. The return on economic capital is then $84 million × 1% = $0.84 million. Also, expected revenues = 0.06 × $1.2 billion = $72 million; interest expense = 0.04 × $1.2 billion = $48 million; expected losses = 0.004 × $1.2 billion = $4.8 million.

$$\text{RAROC} = \frac{\begin{pmatrix}\text{expected revenues} - \text{costs} - \text{expected losses} \\ - \text{taxes} + \text{return on economic capital} \pm \text{transfers}\end{pmatrix}}{\text{economic capital}}$$

$$\text{RAROC} = \frac{(72 - 8 - 48 - 4.8 + 0.84 + 0) \times (1 - 0.3)}{84} = 10.03\%$$

3. B Choosing a lower confidence level will not likely reduce the amount of risk capital required if the firm has little exposure to operational, credit, and settlement risks. The reduction would be much more dramatic only if the firm has significant exposure to such risks because large losses would be rare.

   In selecting a time horizon for RAROC calculations, risk and return data for periods over one year is likely to be of questionable reliability.

4. C A firm's rating is more likely to change when analyzed under the point-in-time (PIT) approach compared to the through-the-cycle (TTC) approach. As a result, the TTC approach results in a lower volatility of economic capital compared to the PIT approach.

   A PIT approach should be used to price financial instruments with credit risk exposure and to compute short-term expected losses. A TTC approach is more commonly used for computations involving profitability, strategic decisions, and economic capital.

5. B A restriction on the firm's growth due to leverage limitations may result in higher profits because it requires the firm to be "creative" and to optimize a scarce resource (the limited amount of capital available).

   Response A is not correct. A successful RAROC approach is focused on the level of profits earned by the firm in relation to the level of risks taken. Response C is not correct. The data collection process should be the responsibility of the RAROC team; the process should be centralized with built-in edit and reasonability checks to increase the accuracy of the data. Response D is not correct. Metrics involving operational risk are not as defined as credit and market risk, therefore, there is often a significant amount of subjectivity involved in the computations.