Example 24.3: FRM Exam 2003—Question 65

c. Choices a., b., and d. are operational losses. Answer c. is the result of a bet on volatility, which is market risk.

Example 24.4: FRM Exam 2007—Question 56

b. Statement a. represents external fraud, which is included in operational risk. Statement c. represents a systems failure. Statement d. is a failure in internal processes.

Example 24.5: FRM Exam 2007—Question 139

c. This is a situation where the model price is significantly different from the market price, which is model risk. Liquidity risk could also explain part of the difference, but this is less likely to be the case given the emphasis on the complexity of the instrument.

Example 24.6: FRM Exam 2003—Question 50

c. The top-down approach is based on historical information from earnings volatility, so answers a. and b. are incorrect. Answer d. is also incorrect because the top-down approach is not based on specific mappings.

Example 24.7: FRM Exam 2007—Question 138

b. Loss severity distributions are bounded by zero but should include very large losses. So, they are asymmetrical with long right tails.

Example 24.8: FRM Exam 2000—Question 64

a. Constructing the operational loss requires the probability, or frequency, of the event as well as estimates of potential loss sizes. Answer b. is wrong as measurement of operational risk is still developing. Answer c. is wrong as the business unit is also responsible for controlling operational risk. Answer d. is wrong as losses can occur due to a combination of operational and market or credit risks.

Example 24.9: FRM Exam 2003—Question 33

a. Because VAR should include EL, there is no need to compute EL separately. The table shows that the lowest loss, such that the cumulative probability is 95% or more, is $100,000.

Loss	Probability		Cumulative
0	0.5	= 0.500	50.0%
1,000	0.3 × 0.6	= 0.180	68.0%
2,000	0.2 × 0.6 × 0.6	= 0.072	75.2%
10,000	0.3 × 0.3	= 0.090	84.2%
11,000	0.2 × 0.6 × 0.3 × 2	= 0.072	91.4%
20,000	0.2 × 0.3 × 0.3	= 0.018	93.2%
100,000	0.3 × 0.1	= 0.030	96.2%
101,000	0.2 × 0.1 × 0.6 × 2	= 0.024	98.6%
110,000	0.2 × 0.1 × 0.3 × 2	= 0.012	99.8%
200,000	0.2 × 0.1 × 0.1	= 0.002	100.0%

Example 24.10: FRM Exam 2006—Question 118

a. Operational loss distributions do have heavier tails than the lognormal, so statement I. is correct. Statements II. and III. are correct as well. Market risk distributions are typically short-term and can involve continuous distribution, as opposed to operational losses, which are discrete. Statement IV. is incorrect because the confidence level is set by the user.

Example 24.11: FRM Exam 2002—Question 102

c. Capital is supposed to absorb risks that have significant financial impact on the firm. Risks with extreme financial impact, such as systemic risk, cannot be absorbed by capital alone, so answer a. is wrong. Low-loss events are unimportant, so b. is wrong. Uncorrelated events tend to diversify, so d. is wrong.

Example 24.12: FRM Exam 2001—Question 49

b. Moral hazard arises when insured individuals have no incentive to control their losses because they are insured.

Example 24.13: FRM Exam 2003—Question 48

d. Answers a., b., and c. describe problems arising from the purchase of insurance against operational risk. This is irrespective of whether the bank has an operational VAR model.

Example 24.14: FRM Exam 2005—Question 48

b. The purpose of insurance is to reimburse large losses, or operational risk events with high severity. Answer c. is incorrect because this type of moral hazard should result in much higher premiums.

Example 24.15: FRM Exam 2005—Question 52

a. All the statements are valid, except for II. Even if a firm implements a hedge or purchases insurance, the news of a large operational loss will still damage its reputation.

APPENDIX: CAUSAL NETWORKS

Causal networks explain losses in terms of a sequence of random variables. Each variable itself can be due to a combination of other variables. For instance, settlement losses can be viewed as caused by a combination of (1) exposure and (2) time delay. In turn, exposure depends on (1) the value of the transaction and (2) whether it is a buy or a sell. Next, the causal factor for time delay can be chosen as (1) the exchange, (2) the domicile, (3) the counterparty, (4) the product, and (5) daily volume.

These links are displayed through graphical models based on process work flows. One approach is the **Bayesian network**. Here each node represents a random variable and each arrow represents a causal link.

Causes and effects are related through conditional probabilities, an application of Bayes' theorem. For instance, suppose we want to predict the probability of a settlement failure, or *fail*. Set $y = 1$ if there is a failure and $y = 0$ otherwise. The causal factor is, say, the quality of the back-office team, which can be either good or bad. Set $x = 1$ if the team is bad. Assume there is a 20% probability that the team is bad. If the team is good, the conditional probability of a fail is $P(y = 1 \mid x = 0) = 0.1$. If the team is bad, this probability is higher, $P(y = 1 \mid x = 1) = 0.7$. We can now construct the unconditional probability of a fail, which is

$$P(y = 1) = P(y = 1 \mid x = 0)P(x = 0) + P(y = 1 \mid x = 1)P(x = 1) \tag{24.5}$$

which is here $P(y = 1) = 0.1 \times (1 - 0.20) + 0.7 \times 0.20 = 0.22$. Armed with this information, we can now evaluate the benefit of changing the team from bad to good through training, for example, or through new hires. Or we could assess the probability that the team is bad given that a fail has occurred. Using Bayes' rule, this is

$$P(x = 1 \mid y = 1) = \frac{P(y = 1, x = 1)}{P(y = 1)} = \frac{P(y = 1 \mid x = 1)P(x = 1)}{P(y = 1)} \tag{24.6}$$

which is here $P(x = 1 \mid y = 1) = \frac{0.7 \times 0.20}{0.22} = 0.64$. In other words, the probability that the team is bad has increased from 20% to 64% based on the observed fail. Such an observation is useful for process diagnostics.

Once all initial nodes have been assigned probabilities, the Bayesian network is complete. The bank can now perform Monte Carlo simulations over the network, starting from the initial variables and continuing to the operational loss, to derive a distribution of losses.

CHAPTER 25

Liquidity Risk

Liquidity risk is an important source of financial risk, as we have witnessed in the latest credit crisis. The crisis of confidence that started with subprime losses suddenly accelerated after the Lehman bankruptcy. Many debt holders refused to roll over their investments, creating massive funding problems for financial institutions. These problems were compounded by their difficulties in selling assets to meeting funding needs.

Liquidity risk, unfortunately, is less amenable to formal risk measurement, unlike market risk, credit risk, and operational risk. This is why the Basel Committee did not institute formal capital charges against liquidity risk. Yet, it stated that "Liquidity is crucial to the ongoing viability of any banking organization. Banks' capital positions can have an effect on their ability to obtain liquidity, especially in a crisis."[1] Thus, it is crucial for financial institutions to assess, monitor, and manage their liquidity risk.

Section 25.1 describes sources of liquidity risk, which involve both asset liquidity risk and funding risk. Section 25.2 analyzes asset liquidity risk. The ability to liquidate assets to generate cash depends on market conditions, including bid–ask spreads and market impact, as well as the liquidation time horizon. To some extent, VAR can be expanded into a liquidity-adjusted VAR. Section 25.3 then analyzes funding liquidity risk. This is illustrated using the example of Northern Rock, the failed British bank. Funding claims can be evaluated by examining the structure of liabilities as well as off–balance sheet items. Finally, Section 25.4 discusses how banks can assess and control liquidity risk, primarily using gap analysis. It highlights the importance of contingency funding plans and illustrates disclosures about liquidity risk management.

25.1 SOURCES OF LIQUIDITY RISK

Lack of liquidity can cause the failure of an institution, even when it is technically solvent, i.e., when the value of its assets exceeds that of liabilities. We will see in Chapter 28 that commercial banks have an inherent liquidity imbalance between their assets (long-term loans) and their liabilities (retail deposits and capital market

[1] Paragraph 741 in BCBS (2006), *International Convergence of Capital Measurement and Capital Standards*, Basel: BIS.

debt). As a result, a crisis of confidence might lead to depositors demanding their money right away. Even if the bank has sufficient assets to cover deposits, it might not be able to liquidate its assets fast enough, or at reasonable prices, to meet the redemption requests. Similarly, hedge funds need to manage carefully the liquidity risk inherent in some balance sheets.

Liquidity risk consists of both asset liquidity risk and funding liquidity risk. The **Committee of European Banking Supervisors** (CEBS) provides these definitions.[2]

- **Asset liquidity risk**, also called **market/product liquidity risk**. This is the risk that a position cannot easily be unwound or offset at short notice without significantly influencing the market price, because of inadequate market depth or market disruption.
- **Funding liquidity risk**. This is the current or prospective risk arising from an institution's inability to meet its liabilities and obligations as they come due without incurring unacceptable losses.

These two types of risk interact with each other if the portfolio contains illiquid assets that must be sold at distressed prices to meet funding requirements.

25.2 ASSET LIQUIDITY RISK

25.2.1 Assessing Asset Liquidity Risk

To evaluate asset liquidity risk, we start with a characterization of market conditions for the asset to be traded. The **bid–ask spread** measures the round-trip transaction cost of buying and selling an amount within **normal market size** (NMS). If $P(\text{ask})$ is the ask price, $P(\text{bid})$ the bid price, and $P(\text{mid}) = [P(\text{ask}) + P(\text{bid})]/2$ the mid price, the spread is defined in relative terms as

$$S = \frac{[P(\text{ask}) - P(\text{bid})]}{P(\text{mid})} \tag{25.1}$$

Assets with good liquidity will have tight bid–ask spreads. **Tightness** is a measure of the divergence between actual transaction prices and quoted mid-market prices. Liquid assets are also characterized by good **depth**, which is a measure of the volume of trades possible without affecting prices too much (e.g., at the bid/offer prices). This is in contrast to **thinness**.

For larger transactions, asset liquidity can be assessed by a price-quantity function, called **market impact**, which describes how the price is affected by the quantity transacted. Sometimes, this is called **endogenous liquidity**, meaning that the price drop depends on the size of the position. In contrast, positions within normal market sizes are characterized by **exogenous liquidity**.

[2] CEBS (2008), *Second Part of CEBS's Technical Advice to the European Commission on Liquidity Risk Management*, London. Available at http://www.c-ebs.org.

When selling a large block of an asset in a liquid market, prices may drop temporarily but should recover quickly. **Resiliency** is a measure of the speed at which price fluctuations from trades are dissipated.

For liquid assets, such as the Treasury market, this function is rather flat, meaning that large volumes of transactions do not affect prices much. For instance, one can generally transact \$10 million of a Treasury bond at a cost of one-half the bid–ask spread of 0.10%, which translates into a cost of $\$10{,}000{,}000 \times 0.10\%/2 = \$5{,}000$, which is very low.

In contrast, illiquid assets are those where spreads are wide and where transactions can quickly affect prices. For example, bank loans are traded over-the-counter and can have spreads as wide as 10%. A sale of \$10 million would then push prices down by 5%, which is a cost of $\$10{,}000{,}000 \times 10\%/2 = \$500{,}000$, which is much higher than in the previous example. A sale of twice this amount might incur an even larger price drop, such as 8%, to clear the market. Thus, the prices of illiquid assets are more affected by current demand and supply conditions. As a result, they are usually more volatile than liquid assets, provided trading occurs.

The latter example also shows that liquidity is a function of the **time horizon.** If the price-quantity function is steep, an immediate sale will force price down by a large amount. A patient investor, on the other hand, would fetch a better price by splitting the sale order over several days, thereby incurring a lower market impact.

Figure 25.1 compares the price-quantity functions for a liquid and an illiquid asset. For the liquid asset, the bid–ask spread is tight, the market has more depth, implying larger normal market sizes, and the lines representing the market impact have lower slopes.

Generally, assets that have greater trading volumes are more liquid. Trading volume reflects differences of opinion across investors but also depends on the

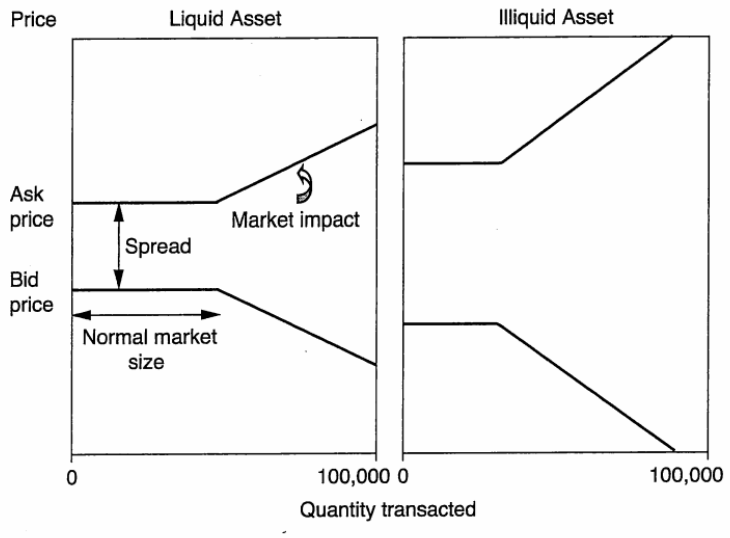

FIGURE 25.1 Comparison of Liquid and Illiquid Assets

presence of active speculators. Hedge funds, in particular, actively trade in many markets, which increases market liquidity.

Assets that are simple to price are also more liquid. At one extreme are Treasury bonds with fixed coupons, which are simple instruments and therefore easy to evaluate. At the other would be structured notes with complicated payoffs, which are harder for participants to evaluate and hedge. As a result, spreads on such notes will be much wider than on T-bonds.

Liquidity varies across asset classes and can be security-specific. Securities that have greater outstanding amounts or are issued more recently are generally more liquid. **On-the-run** securities are those that are issued most recently and hence are more active and liquid. Other securities are called **off-the-run.** Consider, for instance, the latest issued 30-year U.S. Treasury bond. This is on-the-run until another 30-year bond is issued, at which time it becomes off-the-run. Compared to the newest on-the-run, however, these two securities have the same credit risk (i.e., that of default by the U.S. government) and market risk (i.e., both have maturities close to 30 years). Because they are so similar, their yield spread must be a **liquidity premium.**

Asset liquidation costs also depend on **asset fungibility.** Contracts traded on centralized exchanges, such as futures or common stocks, easily can be resold to the highest bidder and therefore are fungible. On the other hand, privately negotiated derivatives require the agreement of the original counterparty to unwind the trade. In this situation, the counterparty may demand a discount to cancel the position.

In summary, asset liquidity risk depends on several factors: (1) market conditions (bid–ask spreads and market impact); (2) liquidation time horizon; (3) asset and security type; and (4) asset fungibility.

Illiquidity can also be market-wide and time-varying. Large-scale changes in market liquidity seem to occur on a regular basis, including the bond market rout of 1994, the Russian/LTCM crisis of 1998, and the credit crisis that started in 2007. Such crises are characterized by a **flight to quality,** which occurs when there is a shift in demand away from low-grade securities toward high-grade securities, in particular government bonds. The low-grade market then becomes illiquid with depressed prices. This is reflected in an increase in the yield spread between corporate and government issues.

25.2.2 Liquidity-Adjusted VAR

Asset liquidity risk is less amenable to formal measurement than traditional market risk. Illiquidity can be loosely factored into VAR measures, by increasing the horizon or by selectively increasing volatilities. These adjustments, however, are mainly adhoc.

We can attempt to incorporate the effect of bid/ask spreads in risk measures. When the spread S is fixed, **liquidity-adjusted VAR** (LVAR) can be defined as:

$$\text{LVAR} = \text{VAR} + L_1 = W\left[\alpha\sigma + \frac{1}{2}\left(S\right)\right] \tag{25.2}$$

where W is the initial wealth, or portfolio value. If VAR is to be measured from zero (relative to the initial portfolio value), instead of away from the mean, we need to subtract μ from $\alpha\sigma$.

For instance, assume we have \$10 million invested in a 30-year Treasury bond, with daily volatility of $\sigma = 1\%$ and spread of $S = 0.10\%$. The one-day LVAR at the 95% confidence level is

$$\$10{,}000{,}000\left[\left(1.645 \times 0.01\right) + \frac{1}{2}\left(0.0010\right)\right]$$

$$= \$164{,}500 + \$5{,}000 = \$169{,}500$$

Here, this correction term is small. In contrast, the correction term is \$500,000 for the bank loan in the previous example.

If bid–ask spreads vary substantially, Equation (25.2) can be adjusted to account for the worst increase in spread at some confidence level. The distribution of the spread can be described by its mean $\bar{S}$ and standard deviation σ_S. The worst-case LVAR is then:

$$\text{LVAR} = \text{VAR} + L_2 = W\left[\alpha\sigma + \frac{1}{2}\left(\bar{S} + \alpha'\sigma_S\right)\right] \tag{25.3}$$

By adding up the worst-case losses for market and liquidity risk, this effectively assumes a high correlation between these two risk drivers.

In practice, estimating the distribution of spreads is a challenge. Spreads tend to be stable for long periods and then explode in periods of crisis. Therefore, the distribution of spreads is highly non-normal. To measure risk at the top level, the risk manager also needs estimates of correlations across spreads. In addition, this analysis assumes that the quantity transacted is within normal market sizes. Otherwise, an immediate forced sale of a large quantity would also incur market impact.

25.2.3 Illiquidity and Risk Measures

Asset illiquidity poses special problems for risk measurement. In illiquid markets, fewer trades imply that prices do not move much. As a result, prices at the end of a reporting period generally will not represent market-clearing transactions and will tend to be sluggish in the absence of regular trading. This creates downward biases in measures of volatility and correlations with other asset classes.

In addition, news slowly impacts prices, creating positive autocorrelation in returns, which invalidate the square root of time rule when extrapolating VAR to longer horizons. These effects are further discussed in Section 17.4.2, in the context of hedge funds.

EXAMPLE 25.1: FRM EXAM 2003—QUESTION 15

Which of the following statements regarding liquidity risk is *correct*?

a. Asset liquidity risk arises when a financial institution cannot meet payment obligations.
b. Flight to quality is usually reflected in a decrease in the yield spread between corporate and government issues.
c. Yield spread between on-the-run and off-the-run securities mainly captures the liquidity premium, and not the market and credit risk premium.
d. Funding liquidity risk can be managed by setting limits on certain asset markets or products and by means of diversification.

EXAMPLE 25.2: FRM EXAM 2002—QUESTION 36

The following statements compare a highly liquid asset against an (otherwise similar) illiquid asset. Which statement is most likely to be *false*?

a. It is possible to trade a larger quantity of the liquid asset without affecting the price.
b. The liquid asset has a smaller bid–ask spread.
c. The liquid asset has higher price volatility since it trades more often.
d. The liquid asset has higher trading volume.

EXAMPLE 25.3: FRM EXAM 2007—QUESTION 78

A mutual fund investing in common stocks has adopted a liquidity risk measure limiting each of its holdings to a maximum of 30% of its 30-day average value traded. If the fund size is USD 3 billion, what is the maximum weight that the fund can hold in a stock with a 30-day average value traded of USD 2.4 million?

a. 24.00%
b. 0.08%
c. 0.024%
d. 80.0%

EXAMPLE 25.4: FRM EXAM 2000—QUESTION 74

In a market crash the following are usually *true*?

I. Fixed-income portfolios hedged with short Treasury bonds and futures lose less than those hedged with interest rate swaps given equivalent durations.
II. Bid–offer spreads widen because of lower liquidity.
III. The spreads between off-the-run bonds and benchmark issues widen.

a. I, II, and III
b. II and III
c. I and III
d. None of the above

EXAMPLE 25.5: FRM EXAM 2007—QUESTION 116

You are holding 100 Wheelbarrow Company shares with a current price of \$50. The daily mean and volatility of the stock return is 1% and 2%, respectively. VAR should be measured relative to the initial wealth. The bid–ask spread of the stock varies over time. The daily mean and volatility of the spread is 0.5% and 1%, respectively. Both the return and spread are normally distributed. Calculate the daily liquidity-adjusted VAR (LVAR) at a 99% confidence level.

a. USD 254
b. USD 229
c. USD 325
d. USD 275

25.3 FUNDING LIQUIDITY RISK

25.3.1 Indicators of Liquidity Risk

Liquidity risk has been a major risk factor in the credit crisis that started in 2007. As commercial and investment banks started to accumulate losses, initially due to subprime asset-backed securities, banks were reluctant to lend in fear of counterparty default.

Conditions in money markets can be gauged, for example, by comparing the three-month Treasury-bill rate, the three-month London interbank offer rate

(LIBOR), and the overnight **federal funds rate.**[3] To ensure comparability, all rates are in U.S. dollars. The T-bill rate has no credit risk—other than that of the U.S. government. In contrast, LIBOR and fed funds are for unsecured loans.

The difference between LIBOR and fed funds is a term spread. It can be viewed as the price of an option to call a loan. A bank that has lent overnight can choose not to renew the loan if bad news were to strike; conversely, a bank committed to a three-month loan has no such option. As usual, the value of an option increases in uncertain times, which explains why this term spread has sharply increased.

The credit spread between Eurodollar LIBOR and Treasuries is known as the **TED spread.** This reflects expected credit losses as well as a liquidity risk premium.

Figure 25.2 describes the behavior of these interest rates during 2007 and 2008. The sharp reduction in the fed funds rate shows that the Federal Reserve has aggressively eased monetary policy. Treasury yields have correspondingly gone down as well. LIBOR rates, however, have stayed stubbornly high, reflecting tight conditions in credit markets. In particular, the TED spread, which is usually around 25bp, has widened sharply, exceeding 500bp after the Lehman bankruptcy on September 15, 2008. Firms with a more shaky credit rating have had to face even higher rates—that is, when they were able to obtain any funding at all.

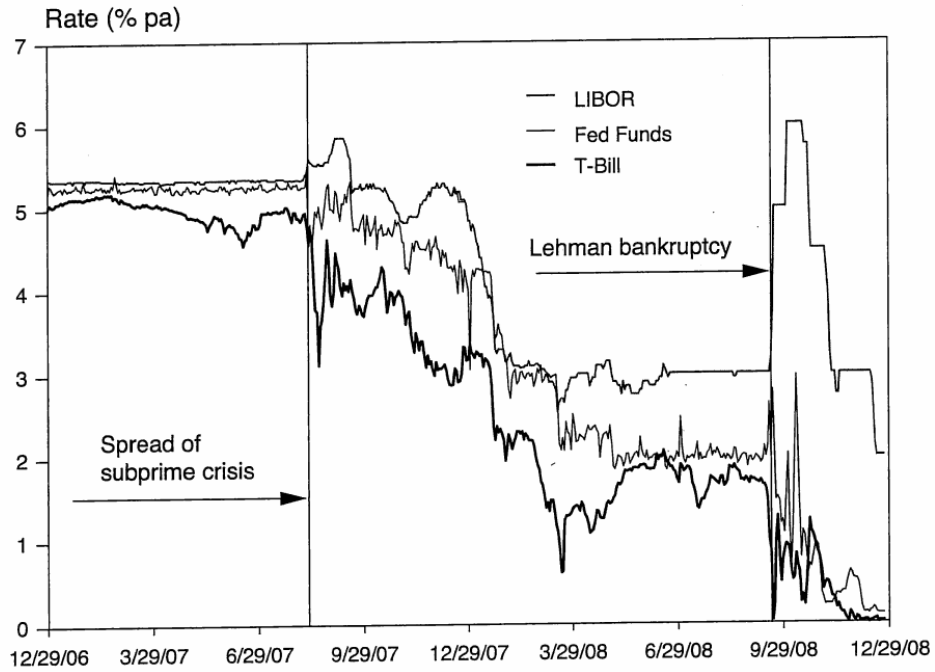

FIGURE 25.2 Comparison of Short-Term Dollar Interest Rates

[3] Fed funds are unsecured loans of reserve balances at the Federal Reserve Bank that banking institutions make to one another, usually overnight. The rate at which these transactions occur is called the fed funds rate. The central bank sets a target level for the fed funds rate, which is its primary tool for monetary policy.

25.3.2 Assessing Funding Liquidity Risk

The Basel Committee provides a comprehensive definition of this risk.[4]

> **Funding liquidity risk** *is the risk that the firm will not be able to meet efficiently both expected and unexpected current and future cash flow and collateral needs without affecting either daily operations or the financial condition of the firm.*

The consequences of this risk can be illustrated by the Northern Rock example.

Example: Northern Rock's Liquidity Risk

Northern Rock (NR) is a bank that was counted among the top five mortgage lenders in Britain. As shown in the table, total assets added up to 113.5 billion British pounds (BP) as of June 2007, about BP 81 billion of which was funded through capital markets, and only BP 30 billion through customer deposits. NR's business model was unusually reliant on funding from capital markets instead of retail deposits. Capital market funding, however, is more volatile than retail deposits. The bank had used this unusual structure to fuel its fast growth.

Northern Rock's Balance Sheet			
Assets		Debt	
Loans	96.7	Retail deposits	30.1
Cash	0.8	Debt securities	71.0
Securities	8.0	Other	10.1
Total	113.5	Total	111.2

Northern Rock stated that it was meeting FSA liquidity rules, which require enough liquidity for at least five business days. The bank had not expected such a long and widespread credit crisis, however.

During August 2007, NR started to run into difficulties rolling over its short-term debt and issuing securitized loans. Higher rates on new capital, when available, started to squeeze margins, leading to a free-fall in the bank's share price. Regulators believed that the bank was still solvent, however. On September 13, it was announced that the Bank of England had granted emergency financial support to Northern Rock. This news started a bank run. Because deposits are only partially insured in Britain, depositors panicked and withdrew billions of deposits in the following days. On Monday, September 17, the Chancellor of the Exchequer announced that the government would fully guarantee all deposits.

By the end of the year, the bank had been unable to roll over BP 8 billion in short-term debt and had lost BP 15 billion in customer accounts. The loan from the Bank of England had grown to BP 27 billion. After two unsuccessful bids to sell Northern Rock, it was nationalized on February 22, 2008.

Northern Rock was a victim of funding liquidity risk, as it had funded long-term loans by short-term debt that it could not roll over.

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[4] BCBS (2008), *Principles for Sound Liquidity Risk Management and Supervision*, Basel: BIS.

Table 25.1 provides a general framework for assessing liquidity risk. Funding liquidity risk arises from the liability side, either for on–balance sheet or off–balance sheet items. Liabilities can be classified into *stable* or *volatile*, where these terms refer to the predictability of cash flows.

For a public corporation, equity is stable.[5] Financial institutions can manage their equity liquidity profile by means of dividend policies, share repurchases, and new issues.

Next, we turn to the debt, which can be divided into unsecured and secured funding. For instance, Northern Rock had issued BP 45.7 billion in securitized notes and 8.1 billion in covered bonds. Investors should be more willing to provide funds secured by assets. In contrast, unsecured funding is subject to default risk by the issuer.

Within the unsecured funding category, retail deposits are more stable than capital market instruments.[6] For example, under conditions of stress, investors in money market instruments may demand higher compensation for risk, or require to roll over their investment for shorter maturities, or even refuse to extend financing at all.

Among off–balance sheet liabilities, loan commitments, letters of credit, and financial guarantees provided by a bank will create a contingent claim on liquidity if drawn. Derivatives may also create cash flow needs if counterparties demand more collateral as the position moves out-of-the-money, or if contracts contain credit trigger clauses that require additional collateral in the case of a downgrade. Indeed **special purpose vehicles** (SPVs) can also create contingent liquidity exposures. Some structures, such as bank-sponsored **conduits**, have explicit backing

TABLE 25.1 Managing Bank Liquidity Risk

Balance Sheet	
Assets	**Debt**
• Highly liquid (cash...)	• Unsecured funding
• Other, unencumbered (pledgeable as collateral)	• Retail deposits • Capital markets
• Other, encumbered	• Secured funding
	Equity
	• New stock issues
Off–Balance Sheet	
Assets	**Liabilities**
• Derivatives	• Derivatives
• Credit lines purchased	• Guarantees provided
	• Commitments
	• SPVs

[5] On the other hand, hedge funds need to worry about redemptions from equity investors, as discussed in Chapter 17.

[6] With the advent of Internet-based banking, however, deposits can move faster across banks.

from the issuing bank and can draw upon liquidity lines if the SPV is not able to roll over its debt. Other structures, such as **structured investment vehicles** (SIVs), may not have explicit backing, but the bank nevertheless may choose to provide liquidity support for business or reputational reasons.

Focusing now on the asset side of the balance sheet, **funding gaps** can be met with asset sales. Cash or liquid assets provide a cushion that can be used immediately. Unencumbered securities, defined as those that do not have claim against them, can be sold, perhaps at a discount that reflects asset liquidity risk. Alternatively, they can be sold through a repurchase agreement as collateral against cash either with a private counterparty or with the central bank if permitted.

In addition, cash can be forthcoming from derivatives positions that move in-the-money. Institutions can also establish bank credit lines, which can be drawn upon in case of liquidity needs.

Finally, this on– and off–balance sheet information should be integrated with cash flows. In particular, the banking system has expanded securitization as a means to reduce assets on the balance sheet. During the recent credit crisis, however, banks were forced to postpone some securitization, leading to a buildup of a large loan inventory that had to be financed.

Example: AIG's Liquidity Risk

American International Group (AIG) is a global insurance conglomerate that once was among the largest public companies in the world. Due to its strong revenues and capital base, AIG long enjoyed a top credit rating of AAA. As a result, it had allowed its Financial Products division to take on increasingly large positions. It sold credit default swaps on the senior tranches of CDOs for which, because of its high credit rating, it did not have to post collateral.

On March 14, 2005, AIG's CEO was forced to step down amid allegations of questionable business practices. The next day, its credit rating was downgraded to AA+. The downgrade triggered provisions requiring posting $1.2 billion in additional collateral for its swaps. At the time, this was still manageable, given that AIG had equity of about $80 billion.

Its CDS portfolio, however, continued to grow, reaching $500 billion. As the subprime crisis started to unfold, the CDOs tranches lost value quickly. AIG announced that it had lost $13 billion in the first half of 2008.

On September 15, 2008 S&P lowered AIG's credit rating from AA– to A–. As a result, AIG was required to post an additional $20 billion in collateral, which it did not have. Because a collapse of AIG would have had systemic consequences, the U.S. government stepped in and provided a $85 billion loan. In October, this amount had to be increased by $38 billion. In November, the U.S. Treasury invested an additional $40 billion in newly issued AIG senior preferred stock under the **Troubled Asset Relief Program** (TARP). This was the largest public bailout of a private company. Apparently, leaders at the Financial Products division had failed to prepare for downgrades in AIG's credit rating.

25.4 MANAGING LIQUIDITY RISK

25.4.1 Steps in Liquidity Risk Management

Liquidity risk management requires robust internal governance, implemented by adequate tools to identify, measure, monitor, and manage liquidity risk. The Board of Directors is ultimately responsible for the institution's liquidity strategy.

While there is no single measure of liquidity risk, a range of metrics can be used to assess liquidity risk. Liquidity risk management starts with **operational liquidity**, which lays out the *daily* payment queue, forecasting all cash inflows and outflows. This is no simple affair, however. In recent years, improvements in the design of payment and settlement systems, e.g., real-time gross settlement systems and the **CLS bank** for netting foreign currency payments, have compressed the time between payments. While such systems reduce credit risk and operational risk, they do place more strain on liquidity management.

The next step is *tactical* management, which assesses access to unsecured funding sources and the liquidity characteristics of the asset inventory. This involves an evaluation of asset liquidity risk.

Finally, this information is integrated in a *strategic* perspective, which starts from current assets and liabilities as well as off–balance sheet items. This information is used to build a **funding matrix**, which details the funding requirements for various maturities. Any **funding gap** should be covered by plans to raise additional funds, either through borrowing or by asset sales.

25.4.2 Funding Gaps

Table 25.2 gives a hypothetical example in a pure **run-off mode**, i.e., with no new business nor rollover of funding. Here, the funding matrix starts from balance sheet items, loans, retail deposits, other short-term debt, and long-term debt.

These items have cash flows that are either fixed or stochastic and maturities that are either fixed or stochastic. For example, coupons and amortization

TABLE 25.2 Example of Funding Gap Analysis

		Time Profile						
	Balance	O/N	7D	14D	1M	3M	1Y	Cumulative
Funding matrix								
Loans	100	5	5	3	15	5	5	38
Retail deposits	−50	−5	−5	−5	−8	−5	−5	−33
Short-term debt	−30	−10	−5	−5	−5	−5	0	−30
Long-term debt	−30	0	0	0	−5	0	0	−5
Total: Funding gap		−10	−5	−7	−3	−5	0	−30
Gap closure								
Cash	5	5	0	0	0	0	0	5
Unencumbered secs.	20	10	8	2	0	0	0	20
Total		15	8	2	0	0	0	25
Net funding gap		5	3	−5	−3	−5	0	−5
Cumulative		5	8	3	0	−5	−5	

payments of fixed-rate debt have both fixed cash flows and maturities. A second category are items such as floating rate loans and bonds where cash flows are stochastic but maturities are deterministic. A third category are items such as callable bonds or loans with flexible redemption schedules where maturities are stochastic but cash flows are deterministic. In the last category are items with stochastic cash flows and maturities, such as retail deposits, drawdowns on committed credit lines and revolving loans. Stochastic cash flows or maturities require modeling based on market experience and product knowledge.

In Table 25.2, the initial balance of loans is 100. The table lays out the cash inflows from this amount for various maturity buckets. A portion of these loans normally will be paid back over the next year. Next are retail deposits, short-term and long-term debt, for which cash outflows are forecast over the horizon. Note that all of the short-term debt is expected to be repaid within one year. The total creates a time profile of the **funding gap**. In this case, the cumulative funding gap to one year is −30.

The next part of the table lays out **gap closure** items. For instance, cash can be used immediately to cover funding outflows. Unencumbered securities can be sold over time as a function of their asset liquidity risk. The sum of the funding gap and the gap closure items creates the expected net funding gap. The longer the period with a positive flow, the safer the bank. In this case, the **survival period**, which is the time until which the cumulative net funding gap becomes negative, is one month.

25.4.3 Stress Tests

Risk management is about dealing with the unexpected, however. Hence, institutions should also evaluate stress scenarios where cash flows deviate from their expected path and sources of funding are unexpectedly cut off.[7] Institutions should consider a broad range of scenarios, including institution-specific, country-specific, and market-wide scenarios. An example of country-specific scenario would be sudden restrictions on currency convertibility.

In addition, in situations of extreme stress, funding liquidity risk is likely to interact negatively with asset liquidity risk as it may become more difficult to sell assets under these conditions. Due to the self-fulfilling nature of reputation risk, an institution's perceived liquidity problems can undermine its ability to sell its assets at a reasonable cost.

25.4.4 Controlling Liquidity Risk

Liquidity risk can be controlled by various means, including reliance on more stable sources of funding and diversification across sources of funds, geographical location, and debt maturities. Similarly, asset liquidity risk can be controlled by setting limits on certain markets or products and by means of diversification. Funding gaps should also be subject to limits over various horizons. Some

[7] In theory, the entire distribution of cash flows could be estimated instead of a stress test, which is just a particular realization. This leads to **liquidity-at-risk** (LAR) models. The problem, however, is that liquidity behavior is difficult to model and that recent historical data may not be relevant.

regulators do require minimum levels of liquid assets, limits on maturity mismatches, or limits on the reliance on a particular funding source.

Another tool to control liquidity risk is to penalize business units or instruments that can generate claims on liquidity. According to the SSG (2008) report, institutions that performed better than others during the crisis had adopted a firm-wide perspective that explicitly accounted for liquidity risk.[8] These firms has charged business lines appropriately for building contingent liquidity exposures to reflect the cost of obtaining liquidity in a more difficult market environment. Institutions that did well also had effective management of funding liquidity, capital, and their balance sheet.

25.4.5 Contingency Funding Plans

The goal of **contingency funding plans** (CFP) is to establish a plan of action should one of the liquidity stress scenarios develop. In a crisis situation, management usually does not have much time to react, which is why a pre-established plan is useful. The CFP should define the trigger events, clear lines of responsibilities for implementation, and a plan for alternative sources of funding. It should also take into account the reputational effects of announcement of the execution of the funding plan.

Generally, public disclosures about liquidity risk management procedures should help reassure investors that the institution has developed a process to deal with liquidity risk. A bank that is perceived as having liquidity is less likely to lose the confidence of funds providers. The following is an example of liquidity risk disclosures by Deutsche Bank.

Example: Deutsche Bank's Liquidity Management

Deutsche Bank (DB) is a leading German commercial bank. As of December 2007, it had 2,020 billion euros in assets and 329 billion euros in risk-weighted assets. With 37 billion euros in shareholder equity, its tier 1 capital ratio was 8.6%.

DB's liquidity risk management approach starts at the *intraday level* forecasting daily cash flows and factoring in access to central banks. It then covers *tactical* liquidity risk management dealing with the access to unsecured funding sources and the liquidity characteristics of its assets. For example, the bank generates 25% of its unsecured funding from retail deposits and 20% from capital markets. In terms of asset liquidity, the bank assigns liquidity values to different assets; it also holds a portfolio of 25 billion euros in highly liquid securities to protect against short-term liquidity squeezes. Finally, the *strategic* perspective comprises the maturity profile of all assets and liabilities on its balance sheet as well as its issuance strategy.

The bank employs stress testing and scenario analysis to evaluate the impact of sudden stress events on its liquidity position. The hypothetical events encompass

[8] See Senior Supervisor Group (2008), *Observations on Risk Management Practices during the Recent Market Turbulence*, Basel: BIS.

external shocks, such as market risk events, emerging market crises, and systemic shocks, as well as internal shocks, such as operational risk events and ratings downgrades (e.g., from AA to AA– for a 1-notch downgrade). Under each of these scenarios, the bank assumes that all maturing loans to customers will need to be rolled over and require funding, whereas rollover of liabilities will be partially impaired resulting in a funding gap. The bank then models the steps it would take to counterbalance the resulting net shortfall in funding, which includes selling assets and switching from unsecured to secured funding. For each scenario, the table shows the cumulative funding gap over an eight-week horizon, in billions of euros, and how much counterbalancing liquidity could be generated.

Scenario	Funding Gap	Gap Closure
Market risk	5.5	98.9
Emerging markets	27.7	117.1
Systemic shock	20.4	70.9
Operational risk	13.9	106.7
1-notch downgrade	28.1	129.3
3-notch downgrade	108.6	129.3

EXAMPLE 25.6: FRM EXAM 2007—QUESTION 57

You have been asked to review a memo on how market liquidity is affected by shocks to the financial system. Which of the following observations made in the memo is *incorrect*?

a. In periods of acute market stress, market liquidity typically increases in the most liquid markets, creating a self-correcting loop that will ultimately remove downward pressure on asset prices.
b. Evaporation of market liquidity is an important factor in determining whether and at what speed financial disturbances become financial shocks with potentially systemic threats.
c. Market shocks may not be reflected in marked-to-market portfolio values immediately for portfolios with illiquid assets. As a result, it is possible for market shocks to have delayed effects on financial institutions.
d. The impact of a market shock on the liquidity of a specific asset depends on the characteristics of the investors who own the asset.

25.5 IMPORTANT FORMULAS

Relative bid–ask spread: $S = \frac{[P(\text{ask}) - P(\text{bid})]}{P(\text{mid})}$

Liquidity-adjusted VAR (LVAR):

$$\text{LVAR} = \text{VAR} + L_1 = W[\alpha\sigma + \tfrac{1}{2}(S)]$$

Worst-case liquidity-adjusted VAR (LVAR):

$$\text{LVAR} = \text{VAR} + L_2 = W[\alpha\sigma + \tfrac{1}{2}(\bar{S} + \alpha'\sigma_S)]$$

25.6 ANSWERS TO CHAPTER EXAMPLES

Example 25.1: FRM Exam 2003—Question 15

c. The yield spread between on-the-run and off-the-run reflects a liquidity premium because the bonds are otherwise nearly identical. In answers a. and d., asset and funding risk should be interchanged. Finally, for b., a flight to quality increases the yield spread.

Example 25.2: FRM Exam 2002—Question 36

c. Compare two stocks. The liquid stock typically has higher trading volumes and lower bid-ask spreads, so b. and d. are true. It also has greater depth, meaning that large quantities can be traded without affecting prices too much, so a. is true. As a result, the remaining answer c. must be wrong. There is no necessary relationship between trading activity and volatility.

Example 25.3 FRM Exam 2007—Question 78

c. The maximum weight w is given by $\$3{,}000 \times w = 30\% \times \$2.4$, or $w = 0.024\%$.

Example 25.4: FRM Exam 2000—Question 74

b. In a crash, bid offer spreads widen, as do liquidity spreads. Answer I. is incorrect because Treasuries usually rally more than swaps, which leads to *greater* losses for a portfolio short Treasuries than swaps.

Example 25.5: FRM Exam 2007—Question 116

a. The regular VAR relative to the initial portfolio value is $\text{VAR} = W(\alpha\sigma - \mu) = \$5{,}000(2.33 \times 2\% - 1\%) = \$183$. (Note that this estimate of the mean is abnormally high.) To this must be added $L_2 = \frac{1}{2}W(\bar{S} + \alpha'\sigma_S) = \frac{1}{2}\$5{,}000(0.5\% + 2.33 \times 1\%) = \$70.75$, for a total of \$254.

Example 25.6: FRM Exam 2007—Question 57

a. Answer b. is correct, as proved by the events of 2007. Answer c. correctly states that the prices of illiquid assets reflect a delayed reaction to events. Answer d. explains that asset liquidity depends on investor positions, which is correct. An asset that is mainly owned by leveraged investors can experience a sharp swing in prices if the investors are forced to sell.

CHAPTER 26

Firm-Wide Risk Management

This chapter turns to best practices for firm-wide management of financial risks. The financial industry has come to realize that risk management should be implemented on a firm-wide basis, across business lines and types of risk. This is due to a number of factors, including (1) increased exposures to more global sources of risk as institutions expand their operations, (2) interactions between risk factors, and (3) linkages in products across types of market risks as well as types of financial risks. These linkages make it important to consider correlations among risks and products.

Interactions between types of risk bear emphasis, as they are too often ignored. The industry has made great strides in recent years in the measurement of market and credit risk. Once measured, risk can be penalized, as with **risk-adjusted return on capital** (RAROC) measures. The danger is that this creates an incentive to move risk to areas where it is not well measured or controlled.

This explains the trend toward integrated, or firm-wide, risk management. **Integrated risk management** provides a consistent and global picture of risk across the whole institution. This requires measuring risk across all business units and all risk factors, using consistent methodologies, systems, and data.

Section 26.1 reviews different types of financial risks. Section 26.2 discusses the three pillars of global risk management: best-practices policies, methods, and infrastructure. Section 26.3 then turns to a description of organizational structures that are consistent with these best practices. Section 26.4 shows how traders can be controlled through compensation adjustment and limits. Finally, Section 26.5 shows how risk measures can be integrated in the measurement of performance of traders and business units through RAROC-type measures.

26.1 INTEGRATED RISK MANAGEMENT

26.1.1 Types of Risk

We first briefly review various types of financial risks.

- **Market risk** is the risk of loss due to movements in the level or volatility of market prices. This is covered in Chapters 10 to 15.
- **Liquidity risk** takes two forms, asset liquidity risk and funding liquidity risk. **Asset liquidity risk**, also known as **market/product liquidity risk**, arises when a

transaction cannot be conducted at prevailing market prices due to the size of the position relative to normal trading lots. **Funding liquidity risk**, also known as **cash-flow risk**, refers to the inability to meet payment obligations. Asset liquidity risk generally falls under the market risk management function. This is covered in Chapter 25.

- **Credit risk** is the risk of loss due to the fact that counterparties may be unwilling or unable to fulfill their contractual obligations. This is covered in Chapters 18 to 23.
- **Operational risk** is generally defined as the risk of loss resulting from failed or inadequate internal processes, systems, and people, or from external events. This is covered in Chapter 24.

Institutions should attempt to measure all of these risks in a consistent fashion and across the entire firm. Otherwise, risk will tend to flow to areas where it is least penalized, or with the weakest measures.

The previous chapter illustrated this point with liquidity risk during the recent credit crisis. Banks that did not properly assess this risk nor penalize business units for the claims on liquidity they generated ended up with much worse liquidity problems than others. Another example are the banks that had weak systems to measure the risk of senior tranches of subprime-backed debt. Because their systems showed very little risk, these institutions did not monitor large build-ups in these securities. During 2007, for example, UBS ended up with losses of $19 billion on these securities, which were found in the CDO warehousing book, in the trading book, in the liquid Treasury book, and in a hedge fund subsidiary.[1] Apparently, there was no monitoring of net nor gross concentrations of positions in this asset class at the firm-wide level.

26.1.2 Risk Interactions

Risk categories do not always fit into neat, separate silos. Operational risk can create market and credit risk, and vice versa. For instance, collateral payments in swaps decrease credit risk by marking to market on a regular basis but create a greater need for cash flow management, which increases operational and liquidity risk. The reverse can also occur as an operational failure, such as incorrect confirmation of a trade, can lead to inappropriate hedging or greater market risk. Incorrect data entry of swap terms can create incorrect market risk measurement as well as incorrect credit exposures.

Another important example is the interaction between market risk and credit risk. **Wrong-way trades** are those where market risk amplifies credit risk. Consider, for example, a swap between a bank and a speculator. If the bank loses money on the swap, credit risk is not an issue. On the other hand, if the bank makes a large profit on the swap, this must be at the expense of the speculator. If the loss to the other party is sufficiently large, the speculator could default precisely because of the swap. Therefore, such trades are inherently more dangerous than those where

[1] UBS (2008), *Shareholder Report on UBS's Write-Downs*, Zurich: UBS.

the counterparty is a hedger. This is because the loss on the swap to the hedger should be offset by a gain on the hedged position. As a result, such trades are safer for the bank.

This is easier said than done, however. In theory, interactions between different types of risk should be taken into account. In practice, banks that now report VAR estimates for market, credit, and operational risk most often simply add up the three risk measures to get an estimate of the bank's total risk. This consolidation, however, overstates the risk because it assumes that the worst loss will occur simultaneously across the three risk categories.

26.1.3 Illustration

Table 26.1 illustrates a firm-wide economic capital analysis reported by Deutsche Bank. The bank estimates separately the worst loss at a 99.98% level of confidence over one year for the three risk categories, market, credit, and operational risk. Market risk includes both trading risk as well as that of the banking book, e.g., the interest rate risk of loans and deposits. Nontrading market risk is sometimes referred to as **asset/liability management,** or mismatch, (ALM) risk. For trading risk, the traditional one-day, 99% VAR measures have been extrapolated to the parameters for economic capital.

Credit risk accounts for the largest fraction of the economic capital, as is typical of a commercial bank or universal bank with substantial lending activities. In latter years, operational risk is second in importance, before market risk, especially when considering trading risk only. Recent surveys have confirmed this ranking for a broad sample of global banks. In terms of importance, first comes credit risk, then operational risk, then market risk.[2] In contrast, market risk is relatively more important for investment banks and life insurance companies.

The table also shows that, during the first three years, the bank made no allowance for diversification effects across risk categories. This effectively assumes perfect correlations. Over time, the bank has refined its risk models. For 2004 and 2005, the bank estimated a diversification effect across credit and market risk.

TABLE 26.1 Firm-Wide Economic Capital—Deutsche Bank (Millions of Euros)

By source	2007	2006	2005	2004	2003	2002	2001	2000
(1) Credit risk	8,506	7,351	7,125	5,971	7,363	8,942	9,064	8,200
(2) Market risk	3,481	2,994	3,042	5,476	5,912	9,057	7,257	3,700
Trading	1,763	1,605	1,595	1,581	972	765		
Nontrading	1,718	1,389	1,447	3,895	4,940	8,292		
Diversification (1,2)			(563)	(870)				
(3) Operational risk	3,974	3,323	2,270	2,243	2,282	2,449	2,538	2,800
Diversification (1,2,3)	(2,651)	(2,158)						
Total	13,310	11,509	11,874	12,820	15,557	20,448	18,859	14,700
Actual core capital	28,320	23,539	21,898	18,727	21,618	22,742	24,803	23,504

[2] Kuritzkes, A., T. Schuermann, and S. Weiner (2003), Risk Measurement, Risk Management, and Capital Adequacy in Financial Institutions, *Working Paper*, Wharton.

For 2006 and 2007, the diversification effect was extended to all three categories. This is achieved by copula methods, which join the marginal distributions, and use Monte Carlo analysis to construct the firm-wide risk distribution. As of 2007, total economic capital was estimated at 13 billion euros. The bank had actual core capital of 28.3 billion euros, which is well above its estimate of economic capital.[3]

For all their apparent elegance, however, these models have limitations. These are complex models that require many assumptions and simplifications, as well as fitting distributions and parameters. This creates model risk. In addition, because the confidence level is so high, the estimates of economic capital must be rather imprecisely measured. Yet financial reports never provide any information on this. Finally, these measures inherit all of the drawbacks of internal credit risk models, which have not been tested on a full credit cycle.

EXAMPLE 26.1: FRM EXAM 2005—QUESTION 110

Which of the following problems are *not* serious obstacles to estimating a firm-wide risk measure?

a. Operational, market, and credit risks follow different statistical distributions.
b. Firms typically have different time horizons for their analysis of operational, market, and credit risks.
c. Operational risks are not financial risks, so that it is not possible to compute a return on operational risk.
d. All of the above.

EXAMPLE 26.2: FRM EXAM 2002—QUESTION 103

Consider a bank that wants to have an amount of capital so that it can absorb unexpected losses corresponding to a firm-wide VAR at the 1% level. It measures firm-wide VAR by adding up the VARs for market risk, operational risk, and credit risk. There is a risk that the bank has too little capital because

a. It does not take into account the correlations among risks.
b. It ignores risks that are not market, operational, or credit risks.
c. It mistakenly uses VAR to measure operational risk because operational risks that matter are rare events.
d. It is meaningless to add VARs.

[3] Core capital is mainly book equity, as explained in Chapter 29.

EXAMPLE 26.3: FRM EXAM 2006—QUESTION 109

Large banks typically allocate risk capital for credit, operational, and market/ALM risks. Which of the following statements ranks the typical amount of risk capital allocated to these different risks correctly?

a. Market/ALM risk requires more risk capital than credit risk.
b. Credit risk requires more risk capital than market/ALM risk, which requires more risk capital than operational risk.
c. Market/ALM risk requires more risk capital than operational risk but less than credit risk.
d. Credit risk requires more risk capital than operational risk, which requires more risk capital than market/ALM.

EXAMPLE 26.4: FRM EXAM 2005—QUESTION 33

Counterparty A is an American company with manufacturing operations in Indonesia and its main customers in the United States, while counterparty B is an American company that manufactures its goods domestically and exports solely to Indonesia. Which one of the following transactions with either counterparty will be a wrong-way exposure for a bank?

a. A five-year plain-vanilla IDR/USD cross-currency swap between the bank and counterparty A where the bank is USD interest rate receiver.
b. A five-year plain-vanilla IDR/USD currency option sold by the bank to counterparty A for it to buy IDR at a certain rate.
c. A five-year plain-vanilla IDR/USD cross-currency swap between the bank and counterparty B where the bank is USD interest rate receiver.
d. A five-year plain-vanilla IDR/USD currency option bought by the bank from counterparty B for the bank to buy IDR at a certain rate.

26.2 BEST PRACTICES REPORTS

Best practices in the industry have evolved from the lessons of financial disasters. Some well-publicized losses in the early 1990s led to the threat of regulatory action against derivatives.

Financial institutions then realized that it was in their best interests to promote a set of best practices to forestall regulatory action. This led to the Group of Thirty (G-30) report, which was issued in July 1993. The 1995 Barings failure

was followed by an in-depth report from the Bank of England in July. Similarly, the 1998 near-failure of Long-Term Capital Management (LTCM) was analyzed in a report produced by the Counterparty Risk Management Policy Group (CRMPG) in June 1999, followed by updates in 2005 and in 2008. These reports added to the collective wisdom about best practices.

26.2.1 The G-30 Report

The Group of Thirty (G-30) is a private, nonprofit association, consisting of senior representatives of the private and public sectors and academia. In the wake of the derivatives disasters of the early 1990s, the G-30 issued a report in 1993 that has become a milestone document for risk management.[4] The report provides a set of 24 sound management practices. The most important ones are summarized here.

- **Role of senior management.** *Dealers and end-users should use derivatives in a manner consistent with the overall risk management and capital policies approved by their boards of directors.... Policies governing derivatives use should be clearly defined, including the purposes for which these transactions are to be undertaken. Senior management should approve procedures and controls to implement these policies, and management at all levels should enforce them.*

  In other words, derivatives policies should be set by top management.
- **Marking-to-market.** *Dealers should mark their derivatives positions to market, on at least a daily basis, for risk management purposes.*

  In other words, marking to market is the most appropriate valuation technique. Countless mistakes have resulted when institutions valued instruments using a historical, accrual method.
- **Measuring market risk.** *Dealers should use a consistent measure to calculate daily the market risk of their derivatives positions and compare it with market risk limits. Market risk is best measured as "value at risk" using probability analysis based on a common confidence interval and time horizon.*

  This recommendation endorsed VAR as the most appropriate quantitative measure of market risk.
- **Stress simulations.** *Dealers should regularly perform simulations to determine how their portfolios would perform under stress conditions.*
- **Investing and funding forecasts.** *Dealers should periodically forecast the cash investing and funding requirements arising from their derivatives portfolios.*
- **Independent market risk management.** *Dealers should have a market risk management function, with clear independence and authority, to ensure that the following responsibilities are carried out: risk limits; stress tests; revenue reports; back-testing VAR; review of pricing models and reconciliation procedures.*
- **Independent credit risk management.** *Dealers and end-users should have a credit risk management function with clear independence and authority,...*

[4] Group of Thirty (1993), *Derivatives: Practices and Principles*, New York: Group of Thirty.

responsible for: approving credit exposure measurement standards; setting credit limits and monitoring their use; reviewing credits and concentrations of credit risk; reviewing and monitoring risk reduction arrangements.

These recommendations stress the need for risk management functions with "clear independence and authority."

26.2.2 The Bank of England Report on Barings

Violation of the fundamental principle of separation of functions was the primary cause of the Barings failure. Nick Leeson had control over both the front office and the back office. This organizational structure allowed him to falsify trading entries, hiding losses in a special account.

But new lessons were also described in the main report on Barings, produced by the Bank of England (BoE).[5] The report mentioned for the first time **reputational risk.** This is the risk of indirect losses to earnings arising from negative public opinion. These losses are distinct from the direct monetary loss ascribed to an event.

The BoE report listed several lessons from this disaster.

- **Duty to understand.** Management teams have a duty to understand fully the businesses they manage. Senior Barings management later claimed they did not fully understand the nature of their business (which is equivalent to claiming financial insanity, or that one is not responsible for financial losses due to a lack of understanding).
- **Clear responsibility.** Responsibility for each business activity must be clearly established. Barings had a *matrix* structure, with responsibilities assigned by product and region, which made it harder to assign responsibility to one person.
- **Relevant internal controls.** Internal controls, including clear segregation of duties, is fundamental to any effective risk control system.
- **Quick resolution of weaknesses.** Any weakness identified by an internal or external audit must be addressed quickly. In the Barings case, an internal audit report in the summer of 1994 had identified the lack of segregation of duties as a significant weakness. Yet this was not addressed by Barings top management.

26.2.3 The CRMPG Report on LTCM

The near-failure of the hedge fund Long-Term Capital Management (LTCM) also led to useful lessons for the industry. The Counterparty Risk Management Policy Group (CRMPG) was established in the wake of the LTCM setback to strengthen practices related to the management of financial risks.

The CRMPG consists of senior-level practitioners from the financial industry, including many banks that provided funding to LTCM. The industry came under criticism for allowing LTCM to build up so much leverage. Apparently, loans to

[5] Bank of England (1995), *Report of the Board of Banking Supervision Inquiry into the Circumstances of the Collapse of Barings*, London: HMSO Publications.

LTCM were fully collateralized as to their current, but not potential, exposure. In fact, it was fear of the disruption of markets and the potential for large losses that led the New York Federal Reserve Bank to orchestrate a bailout of LTCM.

In response, the CRMPG report provides a set of recommendations, which are summarized here.[6]

- **Information sharing.** Financial institutions should obtain more information from their counterparties, especially when significant credit exposures are involved. This includes the capital condition and market risk of the counterparty. This information should be kept confidential.
- **Leverage, market risk, and liquidity.** Financial risk managers should monitor the risks of large counterparties better, focusing on the interactions between leverage, liquidity, and market risk.
- **Liquidation-based estimates of exposure.** When exposures are large, information on exposures based on marked-to-market values should be supplemented by liquidation-based values. This should include current and potential exposures.
- **Stress testing.** Institutions should stress-test their market and credit exposure, taking into account the concentration risk to groups of counterparties and the risk that liquidating positions could move the markets.
- **Collateralization.** Loans to highly leveraged institutions should require appropriate collateral, taking into account liquidation costs.
- **Management responsibilities.** Senior management should convey clearly its tolerance for risk, expressed in terms of potential losses. The function of risk managers is then to design a reporting system that enables senior management to monitor the risk profile.

The report makes a number of other recommendations related to market practices and conventions, as well as regulatory reporting. In particular, the report identifies areas for improvements in standard industry documents, which should help to ensure that netting arrangements are carried out in a timely fashion.

Perhaps the most important lesson from LTCM for lenders is the relationship between market risk and credit risk. The G-30 report recommends the establishment of market and credit risk functions but does not discuss integration of these functions. When LTCM was about to fail, lenders realized that they had no protection for potential exposure and that many of their positions were similar to those of LTCM. Had LTCM defaulted (a credit event), lenders could have lost billions of dollars from market risk.

The second lesson from LTCM is the need for risk managers to make adjustments for large or illiquid positions. The third lesson from LTCM is that institutions should perform systematic stress tests, because VAR models based on recent history can fail to capture the extent of losses in a disrupted market. This seems obvious, as VAR purports to give only a first-order magnitude of the size of losses in a normal market environment.

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[6] Counterparty Risk Management Policy Group (1999), *Improving Counterparty Risk Management Practices,* New York: CRMPG.

26.2.4 The CRMPG II and III Reports

The CRMPG provided an update in a next report, called CRMPG II.[7] CRMPG II notes that many of the earlier recommendations had been put into practice. In particular, there is now a greater focus on liquidity-based adjustments to close-out values. However, the report notes that market developments have introduced new risks, including the dispersion of credit products with embedded leverage among industry participants, which lessens transparency.

In response to the credit crisis that started in 2007, the CRMPG has provided a new set of recommendations, in a report called CRMPG III.[8]

- **Improved corporate governance.** Comparing how various institutions fared during the crisis, it has been apparent that the culture of corporate governance is important. Institutions that rely heavily on judgment, communication, and coordination across the entire firm did better than others. Also, the system of incentives has produced behavior that focused on short-tem profits at the expense of financial stability. Incentives need to be better aligned with the long-term success of institutions and their risk tolerance.
- **Risk monitoring.** Financial institutions should be able to monitor risk concentrations to asset classes on a net and gross basis and to provide coherent reports to top management.
- **Estimating risk appetite.** Financial institutions should conduct regularly comprehensive exercises aimed at estimating risk appetite, using stress tests and a combination of qualitative and quantitative factors.
- **Focusing on contagion.** Financial institutions should regularly assess the effect of **contagion,** or the channels and linkages through which local financial disturbances can take on systemic characteristics.
- **Enhancing oversight.** Large financial institutions are subject to oversight by their boards of directors and by official supervisory bodies. Given the complexities of such institutions, the CRMPG recommends annual meetings of these two groups to share views on the condition of the institution.

EXAMPLE 26.5: FRM EXAM 2004—QUESTION 47

The failure of Barings Bank is a typical example of a lack in control pertaining to which one of the following risks:

a. Liquidity risk
b. Credit risk
c. Operational risk
d. Foreign exchange risk

[7] Counterparty Risk Management Policy Group (2005), *Toward Greater Financial Stability: A Private Sector Perspective*, New York: CRMPG.
[8] Counterparty Risk Management Policy Group (2008), *Containing Systemic Risk: The Road to Reform*, New York: CRMPG.

26.3 ORGANIZATIONAL STRUCTURE

To be effective, the organizational structure must be designed to reflect the policy of effective firm-wide risk management. Figure 26.1 reflects a typical organizational structure of an old-style commercial bank.

Here risk is monitored mainly by the business lines. Within the credit function, the risk manager approves transactions, sets exposure limits, and monitors the exposure limits as well as the counterparty's financial health. Treasury and trading implement proprietary trading and hedging. Within this unit, the risk manager measures and monitors positions. Line management deals with business and product strategy. It also controls operations. Finally, the audit function, external or internal, provides an independent review of business processes.

There are numerous problems with such a structure. Perhaps the main one is that market risk management reports to trading, which violates the principle of independence of risk management. In addition, the decentralization of risk management among separate lines leads to a lack of coordination and failure to capture correlations between different types of risk. The credit risk manager, for instance, will prefer an instrument that transforms credit risk into operational risk, which is under another manager's watch. Situations where credit risk and market risk exacerbate each other (as in the case of LTCM) will also be missed. Finally, models and databases may be inconsistent across lines.

To maintain independence, risk managers should report not to traders but directly to top management. Ideally, the risk management function should be a firm-wide function, covering market, credit, and operational risks. Such a structure will avoid situations where risks are pushed from one area, where they are well measured, toward other areas. Firm-wide risk management should also be able to capture interactions between different types of risks.

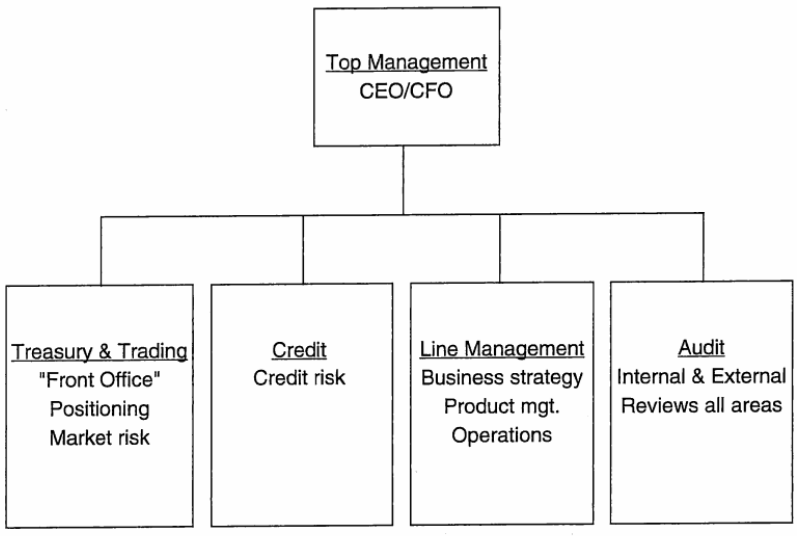

FIGURE 26.1 Old-Style Organizational Structure

EXAMPLE 26.6: BEST PRACTICES

When would it be prudent for a trader to direct accounting entries?

a. Never
b. When senior management of the firm and the board of directors are aware and have approved the practice on an exception basis
c. When audit controls are such that the entries are reviewed on a regular basis to ensure detection of irregularities
d. Solely during such times as staffing turnover requires the trader to back-fill until additional personnel can be hired and trained

EXAMPLE 26.7: FRM EXAM 2005—QUESTION 17

Which of the following is *not* a proper practice of risk management and control for a financial institution with assets in excess of $100 million?

a. A firm's sole mechanism to monitor the implementation of the control policies defined by the board is an external audit firm.
b. A subcommittee of the board is responsible for the approval of risk limits, risk management policies, and delegation of exceptional approval authorities.
c. Senior management is responsible for the day-to-day oversight of the firm's activities, implementing appropriate risk management and control policies, and monitoring the risks and exposures of the firm.
d. Senior management is responsible for establishing written documentation about control procedures at each level of the control hierarchy.

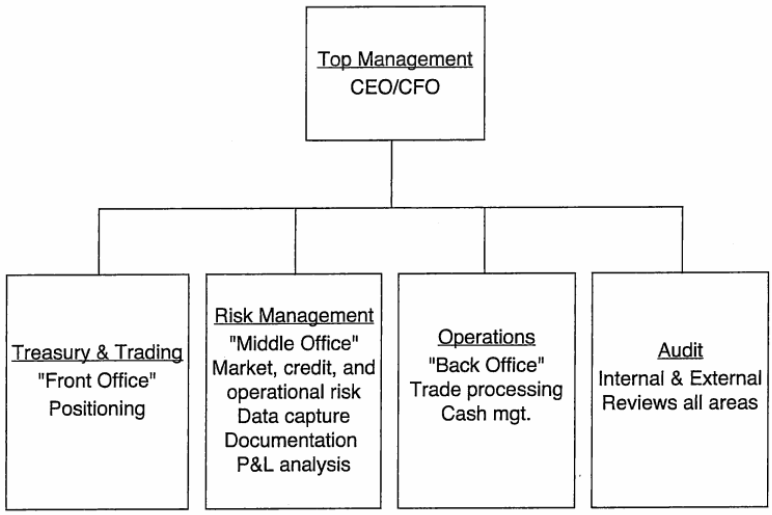

FIGURE 26.2 Modern Organizational Structure

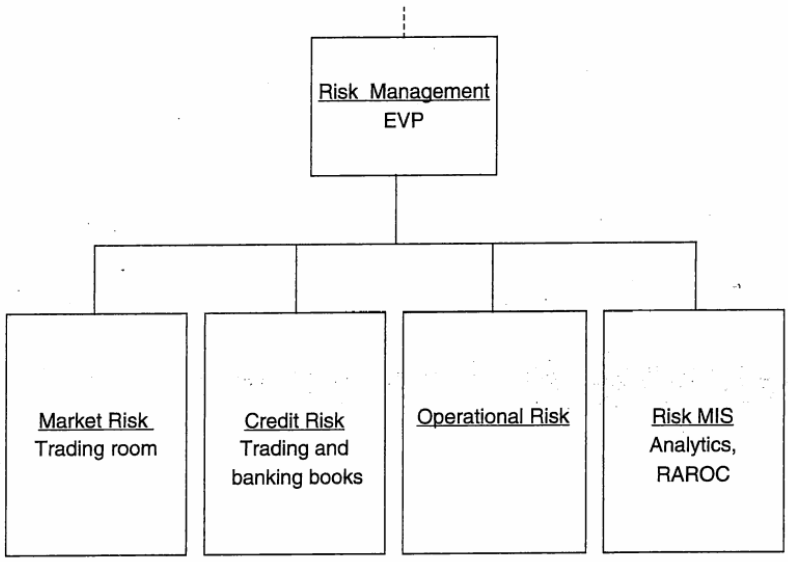

FIGURE 26.3 Risk Management Organizational Structure

The philosophy of separation of functions and independence of risk management must be embodied in the organizational structure of the institution. Figure 26.2 describes one such implementation. The most important aspect of this flowchart is that the risk management unit is independent of the trading unit.

The **front office** is concerned with positioning and perhaps some local hedging, subject to position and VAR limits established by risk management. The **back office** deals with trade processing and reconciliation as well as cash management. The **middle office** has expanded functions, which include risk measurement and control.

The **chief risk officer** is responsible for

- Establishing risk management policies, methodologies, and procedures consistent with firm-wide policies
- Reviewing and approving models used for pricing and risk measurement
- Measuring risk on a global basis as well as monitoring exposures and movements in risk factors
- Enforcing risk limits with traders
- Communicating risk management results to senior management

Figure 26.3 describes the centralization of the risk management function under an executive vice president or chief risk officer. The figure shows the units reporting to this new function. To this officer report *market risk management*, which monitors risk in the trading book; *credit risk management*, which monitors risk in the banking and trading books; *operational risk management*, which monitors operational risks; and systems. The latter unit deals with *risk management information systems (MIS)*, which include hardware, software, and data capture; *analytics*, which develops and tests risk management methodologies; and RAROC, which ensures that economic capital is allocated according to risk.

26.4 CONTROLLING TRADERS

26.4.1 Trader Compensation

The compensation structure for traders should also be given due thought. Usually, traders are paid a bonus that is directly related to their performance—for instance, 20% of profits—when positive. Note that the design of this compensation contract is asymmetrical, like that of an option. If the trader is successful, he can become a millionaire at a very young age. If the trader loses money, he is simply fired. In many cases, the trader will find another employer since he now has "experience."

Such a compensation scheme is designed to attract the very best talents into trading. The downside is that the trader, who is now long an option, has an incentive to increase the value of this option by increasing the risk of the positions. This, however, may not be in the best interests of the company.

Such a tendency for risk taking can be controlled by various means:

- By modifying the structure of the compensation contract to better align the interests of the trader and the company (e.g., by paying with company stock or tying compensation to longer-term performance)
- By subtracting a risk-based capital charge from trading profits, as in a RAROC-type system
- By appointing an independent risk manager

To be effective, the compensation structure for *risk managers* must be independent of how well traders perform. The compensation for risk managers needs to be attractive enough to draw talented individuals, however.

26.4.2 Trader Limits

To some extent, trading risk can be managed by appropriately altering the incentives of traders. Alternatively, this risk can be controlled by imposing limits. These can be separated into backward-looking and forward-looking limits. The former consist of stop-loss limits. The latter consist of exposure or VAR limits.

Stop-loss limits are restrictions on traders' positions that are imposed after a trader has accumulated losses. Because their design is backward-looking, they cannot prevent losses from occurring. What they do prevent, however, are attempts by traders who lose money to recover their losses by "doubling their bets," that is, taking bigger bets in the hope that a future gain will be sufficient to wipe out a string of previous losses. These limits may also be useful if markets are trending, which would amplify the losses.

Exposure limits are systematically imposed on traders as a means to control losses before they occur. These are defined in terms of notional principal, duration, or other exposure measures. For example, the maximum position for a yen trader could be set at the equivalent of $10 million. These limits are typically set by considering the worst loss a unit could absorb, combined with an extreme move in the risk factor.

The problem with such limits is that they do not account for diversification or movements in market risks. Also, complex products for which the notional does not represent the worst loss lend themselves to a form of limit "arbitrage," where the trader abides by the letter of the guideline but not its spirit. For instance, a trader may have a $10 million limit on notes with maturities up to five years. Typically, such notes will have duration of, say, four years. The spirit of the limit is to cap the interest rate exposure. The trader, however, may circumvent the spirit of the limit by investing in inverse floaters with a duration of 12 years.

VAR limits are becoming a more common addition to conventional limits. These account for diversification and time variation in risk. For example, the VAR limit for a business unit may be less than the sum of the VAR limits for individual desks due to diversification. In practice, VAR limits are also susceptible to arbitrage, so they are used together with exposure limits.

EXAMPLE 26.8: FRM EXAM 2002—QUESTION 132

The following is *not* a problem of having one employee perform trading functions and back-office functions.

a. The employee gets paid more because she performs two functions.
b. The employee can hide trading mistakes when processing the trades.
c. The employee can hide the size of her book.
d. The employee's firm may not know its true exposure.

EXAMPLE 26.9: FRM EXAM 2000—QUESTION 69

Which of the following strategies can contribute to minimizing operational risk?

I. Individuals responsible for committing to transactions should perform clearance and accounting functions.
II. To value current positions, price information should be obtained from external sources.
III. Compensation schemes for traders should be directly linked to calendar revenues.
IV. Trade tickets need to be confirmed with the counterparty.

a. I and II
b. II and IV
c. III and IV
d. I, II, and III

EXAMPLE 26.10: FRM EXAM 2007—QUESTION 36

To control risk-taking by traders, your bank links trader compensation with their compliance with imposed VAR limits on their trading book. Why should your bank be careful in tying compensation to the VAR of each trader?

a. It encourages traders to select positions with high estimated risks, which leads to an underestimation of the VAR limits.
b. It encourages traders to select positions with high estimated risks, which leads to an overestimation of the VAR limits.
c. It encourages traders to select positions with low estimated risks, which leads to an underestimation of the VAR limits.
d. It encourages traders to select positions with low estimated risks, which leads to an overestimation of the VAR limits.

26.5 RISK-ADJUSTED PERFORMANCE AND RAROC

The ability to measure risk has profound implications for performance measurement. In the past, performance was measured by yardsticks such as **return on assets** (ROA), which adjusts profits for the associated book value of assets, or **return on equity** (ROE), which adjusts profits for the associated book value of equity. Such measures are simple to compute but are fundamentally flawed because they ignore risks. As a result, these measures could lead to dangerous behavior, such as expanding operations in markets or lines of business where expected returns are high but where risks are much higher.

Risk managers now have tools to control for this behavior. They can assess the total risk of an operation in terms of economic capital required to support all categories of risk, including market, credit, and operational risk. This capital, also called **risk capital**, is basically a value-at-risk (VAR) measure at a high confidence level.

Armed with this information, institutions can make better-informed decisions about business lines. Each activity should provide sufficient profit to compensate for the risks involved. Thus, product pricing should account not only for expected losses but also for the remuneration of risk capital.

Some activities may require large amounts of risk capital, which in turn requires higher returns. This is the essence of **risk-adjusted return on capital** (RAROC) measures. The central objective is to establish benchmarks to evaluate the economic return of business activities. This includes transactions, products, customer trades, and business lines, as well as the entire business.

26.5.1 Risk Capital

RAROC was developed by Bankers Trust in the late 1970s. The bank was faced with the problem of evaluating traders involved in activities with different risk profiles.

RAROC is part of the family of **risk-adjusted performance measures (RAPM)**. Consider, for instance, two traders that each returned a profit of $10 million over the last year. The first is a foreign currency trader, the second a bond trader. The question is, how do we compare their performance? This is important in providing appropriate compensation as well as deciding which line of activity to expand.

Assume the FX and bond traders have notional amount and volatility as described in Table 26.2. The notional amount is also the market value of their book. The bond trader deals in larger amounts, $200 million, but in a market with lower volatility, at 4% per annum, against $100 million and 12% for the FX trader. The **risk capital** (RC) can be computed as a VAR measure, say at the 99% level over a year, as Bankers Trust did. Assuming normal distributions, this translates into a risk capital of

$$\text{RC} = \text{VAR} = \$100{,}000{,}000 \times 0.12 \times 2.33 = \$28 \text{ million}$$

for the FX trader and $19 million for the bond trader. More precisely, Bankers Trust computes risk capital from a weekly standard deviation σ_w as

$$\text{RC} = 2.33 \times \sigma_w \times \sqrt{52} \times (1 - \text{Tax rate}) \times \text{Notional} \tag{26.1}$$

which includes a tax factor that determines the amount required on an after-tax basis.

The risk-adjusted performance is then measured as the dollar profit divided by the risk capital,

$$\text{RAPM} = \frac{\text{Profit}}{\text{RC}} \tag{26.2}$$

and is shown in the last column. Thus the bond trader is actually performing better than the FX trader, as the activity requires less risk capital. More generally, risk capital should account for credit risk, operational risk, and any interaction.

It should be noted that this approach views risk on a standalone basis, that is, using each product's volatility. In theory, for capital allocation purposes, risk

TABLE 26.2 Computing RAPM

	Profit	Notional	Volatility	VAR	RAPM
FX trader	$10	$100	12%	$28	36%
Bond trader	$10	$200	4%	$19	54%

should be viewed in the context of the bank's whole portfolio and measured in terms of its marginal contribution to the bank's overall risk. In practice, however, it is best to charge traders for risks under their control, which means the volatility of their portfolios.

26.5.2 RAROC

This RAROC methodology can be applied at the level of a transaction, of a desk, or of a business unit. In each case, the first step is to compute the **economic capital** (EC) required to support the operation. This includes market, credit, and operational risk.

RAROC is formally defined as

$$\text{RAROC} = \text{Net Profit/EC} = [\text{Expected Profit} - \text{Costs} + k(\text{EC})]/\text{EC} \qquad (26.3)$$

where the net profit includes: (1) revenues, net of expected losses; (2) minus any direct operating cost; (3) minus financing costs; (4) plus the return on economic capital.

EXAMPLE 26.11: FRM EXAM 2006—QUESTION 3

A risk manager for ABC Bank has compiled the following data regarding a bond trader and an equity trader. Assume that the returns are normally distributed and that there are 52 trading weeks per year. ABC Bank computes its capital using a 99% VAR. Dollar amounts are in millions.

	After-Tax Profit	Net Book Market Value	Weekly Volatility	Tax Rate
Bond Trader	USD 8	USD 120	1.10%	40%
Equity Trader	USD 18	USD 180	1.94%	40%

Calculate the risk-adjusted performance measure (RAPM) for the bond trader.

a. 25.24%
b. 36.08%
c. 60.15%
d. 84.92%

EXAMPLE 26.12: FRM EXAM 2006—QUESTION 4

Continuing with the same ABC Bank data, which of the following statements are correct in relation to the equity trader?

I. The equity trader has an annual, after-tax VAR at a 99% confidence level of USD 33.2 million.
II. In comparing the RAROC for both traders, the equity trader is performing better than the bond trader.

a. I only
b. II only
c. Both
d. Neither

EXAMPLE 26.13: FRM EXAM 2007—QUESTION 124

The bank you work for has a RAROC model. The RAROC model, computed for each specific activity, measures the ratio of the expected yearly net income to the yearly VAR risk estimate. You are asked to estimate the RAROC of its \$500 million loan business. The average interest rate is 10%. All loans have the same probability of default of 2% with a loss given default of 50%. Operating costs are \$10 million. The funding cost of the business is \$30 million. RAROC is estimated using a credit-VAR for loan businesses, in this case, 7.5%.

The economic capital is invested and earns 6%. The RAROC is:

a. 19.33%
b. 46.00%
c. 32.67%
d. 13.33%

26.6 IMPORTANT FORMULAS

Economic risk capital (RC): $RC = VAR$

Risk-adjusted performance measure (RAPM): $RAPM = \frac{\text{Profit}}{RC}$

Risk-adjusted return on capital (RAROC):

$$RAROC = [\text{Expected Profit} - \text{Costs} + k(EC)]/EC$$

26.7 ANSWERS TO CHAPTER EXAMPLES

Example 26.1: FRM Exam 2005—Question 110

d. Statement a. is not a problem, as risk managers use simulations to bring together distributions for different types of risk. Statement b. is not a problem. Indeed different horizons are used, but these can be translated to a common horizon, typically annual. Statement c. is not a problem, as demonstrated in Chapter 24.

Example 26.2: FRM Exam 2002—Question 103

b. VAR can be added across different types of risk, but this will provide a conservative estimate of capital as diversification effects are ignored. So answer a. would be for *too much* capital. Answer c. is not correct because rare events can be factored into operational VAR. Most likely, the bank may have too little capital for other types of risk than those measured by these three categories.

Example 26.3: FRM Exam 2006—Question 109

d. For most global banks, the order of importance is, first, credit risk, then operational risk, then market/ALM risk. Also, answers b. and c. are the same.

Example 26.4: FRM Exam 2005—Question 33

c. This is an example of a wrong-way exposure, where a gain on the instrument for the bank is associated with a higher PD for its counterparty. If the IDR depreciates, company A will make a profit because its costs will go down in dollars. Conversely for company B, because its dollar revenues will decrease. Under c., the company pays USD and receives IDR. This transaction will create a loss if the IDR depreciates. In this situation, company B will lose money as well on its exports. Hence, this is a wrong-way trade.

Example 26.5: FRM Exam 2004—Question 47

c. The Barings failure falls in the category of operational risk because of a breakdown in procedures. The trader, Nick Leeson, had control of the back office.

Example 26.6: Best Practices

a. As one risk manager has said, this is one of the few instances where *never* means *absolutely never*. Allowing traders to tabulate their own profits and losses is a recipe for disaster.

Example 26.7: FRM Exam 2005—Question 17

a. Control policies also need to be verified by an internal audit function.

Example 26.8: FRM Exam 2002—Question 132

a. Answers b., c., and d. all can lead to a situation where the trader loses money and hides the losses. Answer a. is not a problem per se.

Example 26.9: FRM Exam 2000—Question 69

b. Answer I violates the principle of separation of functions. Answer III. may create problems of traders taking too much risk. Answer II. advises the use of external sources for valuing positions, as traders may affect internal price data.

Example 26.10: FRM Exam 2007—Question 36

c. Traders may engage in VAR arbitrage, trying to exploit weaknesses in VAR measures. With a VAR limit, they may seek positions that have low measured VAR, in which case the VAR limits will be less effective.

Example 26.11: FRM Exam 2006—Question 3

c. The 99% VAR is $2.33 \times 1.10\% \times \sqrt{52} \times (1 - 40\%) \times \$120 = \$13.3$m. Hence, RAPM $= 8/13.3 = 60.1\%$.

Example 26.12: FRM Exam 2006—Question 4

d. The equity trader's VAR is $2.33 \times 1.94\% \times \sqrt{52} \times (1 - 40\%) \times \$180 = \$35.2$ million, so statement I. is incorrect. The RAPM is 18/35.2, or 51.1%, which is worse than that of the bond trader, so statement II. is incorrect as well.

Example 26.13: FRM Exam 2007—Question 124

a. First, we compute the numerator. The net interest is, after expected losses, $\$500 \times (10\% - 2\%(1 - 50\%)) = \$45$. Next, we compute economic capital, or $\$500 \times 7.5\% = \$37.5$. To revenues, we then add the return on economic capital, or $\$37.5 \times 6\% = \$2.25$. From this, we deduct operating and funding costs, which gives $\$47.25 - 10 - 30 = \$7.25$. Finally, we divide by \$37.5 and get 19.33%.

CHAPTER 27

Legal Issues

We now turn to legal issues in risk management. **Legal risk** can be defined as the risk that a contract is not legally enforceable or documented correctly. More generally, this is "the risk that a transaction cannot be consummated because of some legal barrier, such as inadequate documentation, a regulatory prohibition on a specific counterparty, and non-enforceability of bilateral and multilateral close-out netting and collateral arrangements in bankruptcy."[1] This includes changes in law, mistakes, liabilities of agents, and political risks.

Legal risk invariably arises when the counterparty lost money on a transaction and is more likely to sue as a result. Legal risk is also intimately related to credit risk, as situations of default require enforcement of contracts, which creates legal uncertainty.

This chapter will focus on legal risk for derivatives, although many of the concepts developed here also apply to legal risks for other financial instruments, such as loans or bonds. Section 27.1 briefly reviews the history of legal risks in the derivatives markets. Section 27.2 discusses netting, an important feature of swaps that has been developed to control market, credit, and legal risk. Section 27.3 summarizes the master netting agreement established by the **International Swaps and Derivatives Association** (ISDA) in 1992. Readers, however, should also be familiar with the full text of the agreement. Finally, Section 27.4 contains a glossary of useful legal terms.

27.1 LEGAL RISKS WITH DERIVATIVES

While legal risks have always existed in derivatives contracts, they became more significant with the inception of the swap markets. Unlike exchange-traded futures, which are standardized, the essence of the over-the-counter market is to *tailor* contracts to the counterparty. This, however, requires not only customizing financial terms (prices, quantities, maturities) but also the legal documentation to the counterparty, which creates additional risk.

Legal risks are also intermingled with market and credit risks. When a counterparty loses a large amount of money on a transaction, reflecting market risk,

[1] See the Federal Reserve Board's in-depth guide, *Trading and Capital Markets Activities Manual* (1998), Section 1000.1.

there may be a tendency to resort to legal action as a means to recover some of the losses. For example, when Procter & Gamble lost $157 million on swaps arranged by Bankers Trust, the company sued the bank and recovered its losses.

Another famous example of legal risk is the case of **Hammersmith & Fulham.** City councils in the United Kingdom had entered into a series of interest rate swaps, which turned out to produce major losses as U.K. interest rates almost doubled from 1988 to 1989. The swaps were later ruled invalid by the U.K. high court. The court decreed that the city councils did not have the authority to enter these transactions, which were found to be **ultra vires** (or "beyond the power" of the cities to enter). All the contracts were deemed void and hence the cities were not responsible for the losses. As a result, losses of $178 million had to be absorbed by their counterparty banks.

After this experience, banks have tried to control their legal risks by verifying that the counterparty indeed has the right to enter into a transaction. Even so, this is not always easy to assess. Before the Hammersmith verdict, for instance, many lawyers were convinced that the swaps in question would withstand legal scrutiny.

Until recently, the Hammersmith loss was the greatest single credit loss in the swap markets. For instance, a study by the ISDA noted that total losses amounted to only $358 million by the end of 1991. About 50% of this sum was due to the Hammersmith case.

Even so, these losses are relatively small compared with the size of the market. The total of $358 million represents only 0.012% of the notional amount of $4.3 trillion at that time. As we have learned, however, notionals provide an exaggerated measure of the size of derivatives markets. A more relevant measure is the credit exposure, which is the maximum amount that can be lost. Current exposure is measured by marked-to-market values, which amounted to $77.5 billion in 1991. Compared with this number, the loss percentage is still very small, only 0.46%.

For more recent data, we can turn to information provided by the **Office of the Comptroller of the Currency (OCC)** for U.S. commercial banks.[2] The OCC provides quarterly reports on the charge-offs from derivatives (or credit losses). Figure 27.1 presents quarterly charge-offs since 1996. By the end of the sample period, these losses had accumulated to approximately $2,600 million.

The peak quarterly losses occurred in the third quarter of 1998, as a result of the Asian financial crisis and the Russian default. Even this number, $445 million, represents only 0.0014% of the total notional of $33 trillion, or 0.11% of the total credit exposure at that time. Another perspective would be to compare this peak number with the charge-offs on loans, which was 0.49% in the same quarter. Overall, derivatives credit losses are very small relative to the size of these markets. The low incidence of losses results from two main factors. First, the credit quality of the derivatives counterparty is typically high. Second, most of the exposures are collateralized on a daily basis.

[2] The OCC is an agency overseeing U.S. commercial banks. Chapter 28 will present an overview of bank regulators.

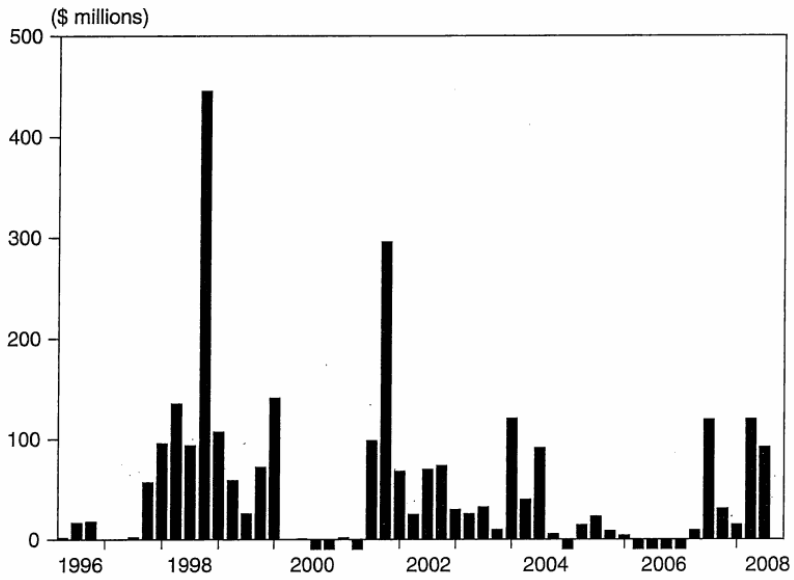

FIGURE 27.1 Charge-Offs on Derivatives: U.S. Commercial Banks
Source: Office of the Comptroller of the Currency Bank Derivatives Reports

Legal risks can arise from a number of sources:

- *A failure in contracting.* This can happen if the contract is not properly authorized or executed, as in the Hammersmith case. Even in the United States, there was some uncertainty as to the legal status of swaps until recently. The Commodity Exchange Act did not make it clear that swaps are legally distinct from futures contracts. If swaps had been ruled to be futures contract, they could have been found illegal and thus void. This changed only with the passage of the **Commodity Futures Modernization Act** of 2000, which secured legal certainty for OTC derivatives transactions.
- *A failure in contract documentation.* Mistakes can arise in contract documentation, such as incorrect number of entries.
- *Bankruptcy risks.* By nature, the bankruptcy process is fraught with uncertainties. For instance, the bankruptcy court could "cherry-pick" the contracts, or choose to honor the contracts having the greatest value for the defaulting party only, to the detriment of counterparties.

Special protection is accorded, however, for the set-off of margin payments and liquidation of collateral under securities contracts and commodities contracts. In the United States, close-out netting agreements (to be defined in the next section) are specifically exempted from the automatic stay provision that applies upon the filing of a bankruptcy petition. This protection was adopted by the **Financial Institutions Reform Recovery and Enforcement Act (FIRREA)** of 1989, which also confirmed the right to access the collateral posted by the defaulting counterparty.

Even so, there is often uncertainty in the application of these laws. The case of Long-Term Capital Management (LTCM) is a good example, because LTCM was chartered in the Cayman Islands. Had LTCM declared bankruptcy

in the Cayman Islands, there would have been legal uncertainty as to whether counterparty banks would have the right to liquidate their collateral under the U.S. Bankruptcy Code. This uncertainty is reportedly one reason why the same banks wanted to avoid a messy bankruptcy scenario and agreed to bail out LTCM.

- *Changes in laws and regulations*. Contracts may contain clauses protecting one party against changes in tax or regulatory treatments. As an example, coupons on Eurobonds are exempt from withholding taxes. If the country of the bond issuer suddenly imposes new taxes, the issuer may be subject to a so-called **gross-up clause** that requires it to pay the investor additional money to make up for the new tax.[3] Changes in the regulatory environment may also lead to changes in the value of contracts.

EXAMPLE 27.1: FRM EXAM 2002—QUESTION 60

Lawsuits involving derivatives to major corporations are most likely to involve which of the following issues?

a. The type of derivative
b. Broker size
c. Breach of fiduciary duty
d. Enforceability of contract

27.2 NETTING

As we have seen in analyzing credit risk, netting has developed over time as a powerful mechanism to reduce credit exposure. The purpose of **netting** is to offset transactions between two parties, with settlement of the *net* difference in cash flows across all contracts covered by a netting agreement. In the case of bankruptcy, however, netting is fully beneficial only when enforced by the courts.

ISDA keeps track of countries that have adopted or are considering changes in legislation to allow netting. It has obtained legal opinions that netting would be upheld in most leading jurisdictions. Similarly, the Bank for International Settlements has issued a report concluding that bilateral netting is likely to be effective in G-10 countries.[4]

27.2.1 Netting under the Basel Accord

In 1995 the Basel Committee on Banking Supervision (BCBS) lowered capital charges to recognize, and encourage, netting agreements.[5] The BCBS recognizes

[3] Additional complications may arise if the issuer has the right to redeem the bond at par. If the bond is trading at a premium, this provides a windfall profit for the issuer.

[4] Bank for International Settlements (1990), *Report of the Committee on Interbank Netting Schemes of the Central Banks of the Group of Ten Countries (Lamfalussy Report)*, available at http://www.bis.org/publ/cpss04.pdf.

[5] See BCBS (1995), *Basel Capital Accord: Treatment of Potential Exposure for Off-Balance Sheet Items*. Available at http://www.bis.org/publ/bcbs18.pdf .

netting under **novation**, which substitutes outstanding debt payments for new ones that provide for *net* payment obligations. Under novation, any obligation between a bank and its counterparty to deliver a given currency on a given value date is automatically amalgamated with all other obligations for the same currency and value date, legally substituting one single amount for the previous gross obligations.

Another form is the **close-out netting agreement**, which is a bilateral contract specifying that upon default, the non-defaulting party nets gains and losses with the defaulting counterparty to a single payment for all covered transactions.

The ability to **terminate** financial market contracts upon an event of default is central to the effective management of financial risk. Without a close-out or termination clause, counterparties would helplessly watch their contracts fluctuate in value during the bankruptcy process, which could take years.

The Basel Accord recognizes netting, as long as the bank can assure its national supervisor that it has:

> *(1) A netting contract or agreement with the counterparty which creates a single legal obligation, covering all included transactions, such that the bank would have either a claim to receive or obligation to pay only the net sum of the positive and negative mark-to-market values of included individual transactions in the event a counterparty fails to perform due to any of the following: default, bankruptcy, liquidation or similar circumstances*
> *(2) Written and reasoned legal opinions that, in the event of a legal challenge, the relevant courts and administrative authorities would find the bank's exposure to be such a net amount under:*
> *– the law of the jurisdiction in which the counterparty is chartered and, if the foreign branch of a counterparty is involved, then also under the law of the jurisdiction in which the branch is located;*
> *– the law that governs the individual transactions; and*
> *– the law that governs any contract or agreement necessary to effect the netting.*
> *The national supervisor, after consultation when necessary with other relevant supervisors, must be satisfied that the netting is enforceable under the laws of each of the relevant jurisdictions*
> *(3) Procedures in place to ensure that the legal characteristics of netting arrangements are kept under review in the light of possible changes in relevant law*

27.2.2 Walk-Away Clauses

Netting, however, attracts a favorable capital treatment only for contracts without **walk-away clauses**. These clauses, also known as **limited two-way payment provisions**, allow both parties to walk away from the contract in case of default.

Consider, for example, the collapse in 1990 of the Drexel Burnham Lambert Group (DBL Group), which placed its swap subsidiary, DBL Products, in default. Some swaps were out-of-the-money for DBL Products, in which case counterparties had a claim against DBL Products. This placed them in the same position as other unsecured senior creditors, which seems normal.

Other swaps, however, were in-the-money for DBL Products, which means that counterparties owed money. In theory, the walk-away clause would have permitted them to reap a windfall profit, randomly benefiting from the misfortune of others, which seems questionable.

Even so, nearly all in-the-money contracts were fully paid. Counterparties settled to avoid expensive litigation over the enforceability of these contracts. Financial institutions also recognized that walk-away clauses create uncertainty for financial markets. Contracts have now evolved to contain a **full two-way payment provision**, which provides for full payment to the counterparty, subject to a bankruptcy distribution rule.

The final nail in the coffin for the walk-away clause was the ruling by the Basel Committee that such contracts are not provided any regulatory relief in terms of lower capital requirement.

27.2.3 Netting and Exchange Margins

Netting also applies to the credit risk that futures traders face from their brokers. Clients deposit margins with their brokers. Assuming the broker is a clearing member, the broker in turn deposits margins with the clearinghouse.

If a broker goes bankrupt, clients could lose the part of their margins held by the broker. In the United States, two clearinghouses (CME and NYMEX) collect *gross margins*, that is, a separate margin for all client positions. Others collect *net margins*, allowing the broker to offset long and short positions by different customers. This netting decreases the margin held by the clearinghouse. Normally, a gross margin system is safer for the client because a greater fraction of the margin is held by the clearinghouse. The risk of a net margin system is lessened, however, if the broker properly *segregates* client accounts by holding them separately from its own accounts.

EXAMPLE 27.2: FRM EXAM 2002—QUESTION 117

You are an investment manager trying to decide whether the Chicago Mercantile Exchange, the Chicago Board of Trade, or the OTC marketplace is where you will place part of your portfolio hedge. You will have to make an OTC transaction with your broker in any case. You also are considering a direct OTC deal with your broker for the whole hedge. You want to carry out the transaction that will result in the lowest possible exposure to your broker. Assuming that the size of the OTC hedge, if you use an exchange, is the same regardless of the exchange and that the effectiveness of the hedge is the same absent counterparty risks, how would you hedge?

a. Hedge on the Chicago Mercantile Exchange and with your broker.
b. Hedge on the Chicago Board of Trade and with your broker.
c. It doesn't matter, as the broker exposure is the same for each exchange.
d. Hedge your portfolio with a series of over-the-counter transactions, with your broker as counterparty.

27.3 ISDA MASTER NETTING AGREEMENT

At the beginning of the 1980s, swaps were tailor-made financial contracts that required documentation to be drafted on a case-by-case basis. This was very time-consuming and costly, and it introduced a time lag between the commercial agreement and the signing of the legally binding contract.

In response, the industry developed standardized terms for swaps. As with futures, this made it easier to offset the contracts, increasing liquidity and decreasing legal uncertainty. Out of this effort came the **master netting agreement** established by the ISDA in 1987 and revised in 1992 and in 2002. This form establishes (1) a template for a standardized contract, which is supplemented by (2) a **schedule to the master agreement** and (3) the actual **confirmation of contract.** Parties have the flexibility to select parts of the agreement or to amend the base document through the schedule. The more specific clauses (e.g., confirmation) override more general clauses. Thus, the order of precedence in the case of conflict is, first the confirmation, then the schedule, and finally the master agreement. In addition, the **credit support annex** (CSA) manages the exchange of collateral betwen parties.

The ISDA master agreement contains the following provisions:

- A list of *obligations*, detailing the mechanics of payment conditions (section 2 in the ISDA agreement), including the netting of obligations.
- A list of *credit provisions*, which describe events of default and termination (section 5), early termination (section 6), and credit support provisions (e.g., the system of collateral payments). The event of default includes:
  - Failure to pay
  - Breach of agreement
  - Credit support default (e.g., failure to provide collateral when due)
  - Misrepresentation
  - Default under a specified transaction
  - Cross-default, which is optional
  - Acts pertaining to bankruptcy or liquidation
  - Mergers without the successor assuming the obligation to perform under the swap

  Termination includes:
  - An illegality in which a party is unable to perform due to a change in law or regulation
  - A tax event such as a change in tax law that causes a party to make an additional payment (called gross-up)
  - A tax event upon merger
  - A credit event upon merger where the creditworthiness of the successor is materially weaker than the original entity
- A list of contractual *boilerplate statements*, including representations (section 3), agreements (section 4), transfer provisions (section 7), governing law (section 13), and so on.

Although the ISDA forms attempt to provide comprehensive and standardized coverage of swap events, they cannot anticipate every eventuality. When Russia defaulted on its domestic-currency debt on August 17, 1998, it imposed a moratorium on foreign-currency debt payments as well as a 90-day freeze on forward foreign exchange contracts. It has maintained payment on its foreign debt, however. Whether this constitutes a credit event on the foreign debt was not clearly defined by the swap agreements in place. This has created considerable disagreement over the interpretation of standard contracts. By 1999, the ISDA had published a revised set of definitions for credit derivatives that considers both sovereign and non-sovereign entities. This list is provided in the credit derivatives chapter.

EXAMPLE 27.3: FRM EXAM 2001—QUESTION 124

Most credit derivatives contracts

a. Are based on English law.
b. Are written on a one-off basis.
c. Have a clause about restructuring.
d. Are based on the ISDA agreement.

EXAMPLE 27.4: FRM EXAM 2000—QUESTION 22

A typical master netting agreement as established by the ISDA will contain all of the following *except* a list of

a. Obligations.
b. Historical market prices.
c. Credit provisions.
d. Contractual boilerplate statements.

EXAMPLE 27.5: FRM EXAM 2004—QUESTION 62

Which of the following are *not* considered events of termination under the ISDA Master Agreement?

I. Misrepresentation
II. Tax event upon corporate take-over
III. Change in tax law that results in gross-up
IV. Bankruptcy

a. I and IV only
b. I and III only
c. II and III only
d. II and IV only

27.4 GLOSSARY

27.4.1 General Legal Terms

Civil law: (1) Legal system whose law is centered around a comprehensive legislative code (e.g., such as that established by Napoléon in France). (2) In the United States, law under which a person (the plaintiff) may sue another person (the defendant) to obtain redress for a wrong committed by the defendant, for example, a breach of contract. This is in contrast with criminal law.

Common law: System of law derived from the English system of laws "common to the population," produced primarily by a group of judges to harmonize their decisions with those in other parts of the country. It was introduced after the Norman conquest of England as a means of unifying the country. Common law builds on precedents. This is in contrast to the French-type system of civil law.

Criminal law: Law that defines public offenses against the state or government and prescribes their punishment. This is a part of public law, which also includes constitutional and administrative law.

27.4.2 Bankruptcy Terms

Absolute priority rule (APR): Hierarchical rule for the distribution of a firm's assets: Payments go first to secured creditors, then to priority creditors (e.g., to cover taxes and bankruptcy costs), then to unsecured creditors (such as bondholders and bank depositors), then to subordinated-debt holders, and finally to stockholders. (See also the credit derivatives chapter.)

Automatic stay: In bankruptcy, the suspension of legal actions (other than the bankruptcy proceeding itself) until the bankruptcy case is over.

Bankruptcy: A legal process under which (1) a financially troubled debtor is declared to be insolvent, or incapable of meeting debt payments; (2) the assets of the debtor are distributed to creditors according to bankruptcy law; and (3) the debtor, if honest, is discharged from liability for remaining unpaid debt.

The word *bankruptcy* comes from the Italian *banca rotta*, or "broken bench." The tradition was that when a medieval trader failed to pay his creditors, his trading bench was broken.

Liquidating proceeding: A bankruptcy proceeding in which the debtor's assets are converted to cash and distributed to creditors. In the United States, liquidation is covered under Chapter 7 of the U.S. Bankruptcy Code.

Reorganization proceeding: A bankruptcy proceeding in which the troubled firm may stay in business as it reorganizes in a process of financial rehabilitation. In the United States, reorganization is covered under Chapter 11 of the U.S. Bankruptcy Code. A majority of creditors and equity holders must approve the plan; otherwise, liquidation proceeds under Chapter 7.

27.4.3 Contract Terms

Acceleration clause: A provision in a promissory note permitting the debtor to make, or the creditor to receive, payment before the due date.

Close-out or termination clause: A provision that gives the right to terminate a contract upon certain specified events and to calculate a termination amount due to, or due from, the defaulting party.

Covenant: A contractual provision whereby one party promises to take certain specific actions (positive covenant) or to refrain from taking certain actions (negative covenant). Bond covenants contain clauses prohibiting, for instance, the creditor from selling major assets or paying too large a dividend to stockholders.

Cross-default clause: A contractual provision whereby default on a contract occurs whenever the counterparty defaults on *any* other obligation.

Negative pledge clause: A provision that prevents the subordination of a contract to secured creditors, by pledging assets for new debt, for instance.

Netting: A provision that gives the right to *set off*, or net, claims or payment obligations between two or more parties, with the goal of arriving at a single net payment.

Novation: The extinguishment of a party's obligation (e.g., the debt of the obligee) through an agreement between the old obligor, a new obligor, and the obligee to substitute the old obligor for a new one.

Pari passu: Equal ranking (from Latin), meaning that all creditors within the same class will be treated equally. This term often used in bankruptcy proceedings where creditors are paid pro rata in accordance with the amount of their claims.

Secured transaction: An arrangement such that the creditor is provided with a backup source of payment if the debtor defaults.

Security agreement: An agreement between a debtor and a creditor whereby the creditor receives security interest, or property, to secure debt payments.

Ultra vires: Outside the power of a person or corporation (from Latin). This is in contrast to *intra vires*.

27.5 ANSWERS TO CHAPTER EXAMPLES

Example 27.1: FRM Exam 2002—Question 60

d. Most derivatives lawsuits arise from interpretation of the provisions of the contract. There is generally no fiduciary duty issue, as most contracts are with major corporations, which are supposed to be more informed than individual investors.