Solutions for End-of-Chapter Questions and Problems: Chapter Fifteen

1. What is meant by *market risk*?

Market risk is the risk related to the uncertainty of an FI’s earnings on its trading portfolio. Market risk is caused by changes in market conditions such as interest rate risk and foreign exchange risk. Market risk emphasizes the risks to FIs that actively trade assets and liabilities rather than hold them for longer term investment, funding, or hedging purposes.

2. Why is the measurement of market risk important to the manager of a financial institution?

Measurement of market risk can help an FI manager in the following ways:

a. Provide information on the risk positions taken by individual traders.

b. Establish limit positions on each trader based on the market risk of their portfolios.

c. Help allocate resources to departments with lower market risks and appropriate returns.

d. Evaluate performance based on risks undertaken by traders in determining optimal bonuses.

e. Help develop more efficient internal models so as to avoid using standardized regulatory models.

3. What is meant by daily earnings at risk (DEAR)? What are the three measurable components? What is the price volatility component?

DEAR or daily earnings at risk is defined as the estimated potential loss of a portfolio's value over a one-day period as a result of adverse moves in market conditions, such as changes in interest rates, foreign exchange rates, and market volatility. DEAR is comprised of (a) the dollar value of the position, (b) the price sensitivity of the asset to changes in the risk factor, and (c) the adverse move in the yield. The product of the price sensitivity of the asset and the adverse move in the yield provides the price volatility component.

4. Follow Bank has a $1 million position in a five-year, zero-coupon bond with a face value of $1,402,552. The bond is trading at a yield to maturity of 7.00 percent. The historical mean change in daily yields is 0.0 percent and the standard deviation is 12 basis points.

a. What is the modified duration of the bond?

MD = D/(1 + R) = 5/(1.07) = 4.6729 years

b. What is the maximum adverse daily yield move given that we desire no more than a 1 percent chance that yield changes will be greater than this maximum?

Potential adverse move in yield at 1 percent = 2.33σ = 2.33 x 0.0012 = 0.002796

c. What is the price volatility of this bond?

Price volatility = MD x potential adverse move in yield

= 4.6729 x 0.002796 = 0.013065 or 1.3065 percent

d. What is the daily earnings at risk for this bond?

DEAR = ($ value of position) x (price volatility)

= $1,000,000 x 0.013065 = $13,065

5. How canDEAR be adjusted to account for potential losses over multiple days? What would be the VAR for the bond in problem 4 for a 10-day period? What statistical assumption is needed for this calculation? Could this treatment be critical?

The DEAR can be adjusted to account for losses over multiple days using the formula N-day VAR = DEAR x [N]½, where N is the number of days over which potential loss is estimated. N-day VAR is a more realistic measure when it requires a longer period for an FI to unwind a position, that is, if markets are less liquid. The value for the 10-day VAR in problem 4 above is $13,065 x [10]½ = $41,315.

According to the above formula, the relationship assumes that yield changes are independent and daily volatility is approximately constant. This means that losses incurred one day are not related to losses incurred the next day. Recent studies have indicated that this is not the case, but that shocks are autocorrelated in many markets over long periods of time.

6. The DEAR for a bank is $8,500. What is the VAR for a 10-day period? A 20-day period? Why is the VAR for a 20-day period not twice as much as that for a 10-day period?

For the 10-day period: VAR = 8,500 x [10]½ = 8,500 x 3.1623 = $26,879

For the 20-day period: VAR = 8,500 x [20]½ = 8,500 x 4.4721 = $38,013

The reason that 20-day VAR ≠ (2 x 10-day VAR) is because [20]½ ≠ (2 x [10]½). The interpretation is that the daily effects of an adverse event become less as time moves farther away from the event.

7. The mean change in the daily yields of a 15-year, zero-coupon bond has been five basis points (bp) over the past year with a standard deviation of 15 bp. Use these data and assume that the yield changes are normally distributed.

a. What is the highest yield change expected if a 99 percent confidence limit is required; that is, adverse moves will not occur more than 1 day in 100?

If yield changes are normally distributed, 98 percent of the area of a normal distribution will be 2.33 standard deviations (2.33σ) from the mean – that is, 2.33σ – and 2 percent of the area under the normal distribution is found beyond ± 2.33 (1 percent under each tail, -2.33σ and +2.33σ, respectively). Thus, for a one-tailed distribution, the 99 percent confidence level will represent adverse moves that not occur more than 1 day in 100. In this example, it means 2.33 x 15 = 34.95 bp. Thus, the maximum adverse yield change expected for this zero-coupon bond is an increase of 34.95 basis points, or 0.3495 percent, in interest rates.

b. What is the highest yield change expected if a 95 percent confidence limit is required?

If yield changes are normally distributed, 90 percent of the area of a normal distribution will be 1.65 standard deviations (1.65σ) from the mean – that is, 1.65σ – and 10 percent of the area under the normal distribution is found beyond ± 1.65 (5 percent under each tail, -1.65σ and +1.65σ, respectively). Thus, for a one-tailed distribution, the 95 percent confidence level will represent adverse moves that not occur more than 1 day in 20.Thus, the maximum adverse yield change expected for this zero-coupon bond is an increase of (1.65 x 15 =) 24.75 basis points, or 0.2475 percent, in interest rates.

8. In what sense is duration a measure of market risk?

Market risk calculations are typically based on the trading portion of an FIs fixed-rate asset portfolio because these assets must reflect changes in value as market interest rates change. As such, duration or modified duration provides an easily measured and usable link between changes in the market interest rates and changes in the market value of fixed-income assets.

9. Bank Alpha has an inventory of AAA-rated, 15-year zero-coupon bonds with a face value of $400 million. The bonds currently are yielding 9.5 percent in the over-the-counter market.

a. What is the modified duration of these bonds?

MD = D/(1 + R) = 15/(1.095) = 13.6986

b. What is the price volatility if the potential adverse move in yields is 25 basis points?

Price volatility = (MD) x (potential adverse move in yield)

= (13.6986) x (0.0025) = 0.03425 or 3.425 percent.

c. What is the DEAR?

Daily earnings at risk (DEAR) = ($ value of position) x (Price volatility)Dollar value of position = $400m/(1 + 0.095)15 = $102,529,350. Therefore,

DEAR = $102,529,350 x 0.03425 = $3,511,279.

d. If the price volatility is based on a 99 percent confidence limit and a mean historical change in daily yields of 0.0 percent, what is the implied standard deviation of daily yield changes?

The potential adverse move in yields = confidence limit value x standard deviation value. Therefore, 25 basis points = 2.33 x σ, and σ = 0.0025/2.33 = 0.001073 or 10.73 basis points.

10. Bank Beta has an inventory of AAA-rated, 10-year zero-coupon bonds with a face value of $100 million. The modified duration of these bonds is 12.5 years, the DEAR is $2,150,000, and the potential adverse move in yields is 35 basis points. What is the market value of the bonds, the yield on the bonds, and the duration of the bonds?

Price volatility = (MD) x (potential adverse move in yield)

= (12.5) x (0.0035) = 0.04375 or 4.375 percent

DEAR = ($ value of position) x (Price volatility)DEAR = $2,150,000 = ($ value of position) x 0.04375

= > ($ value of position) = $2,150,000/0.04375 = $49,142,857 = market value

Dollar value of position = $100m/(1 + yield)10 = $49,142,857.

= > yield = ($100m/$49,142,857)1/10 – 1 = 7.36%

Therefore, the bonds currently are yielding 7.36 percent in the over-the-counter market.

MD = D/(1 + R) = 12.5 = D/(1.0736) = > D = 12.5 x 1.0736 = 13.42 years

11. Bank Two has a portfolio of bonds with a market value of $200 million. The bonds have an estimated price volatility of 0.95 percent. What are the DEAR and the 10-day VAR for these bonds?

DEAR = ($ value of position) x (Price volatility) = $200 million x 0.0095

= $1,900,000

10-day VAR = DEAR x √N = $1,900,000 x √10

= $1,900,000 x 3.1623 = $6,008,328

12. Suppose that an FI has a €1.6 million long trading position in spot euros at the close of business on a particular day. Looking back at the daily percentage changes in the exchange rate of the €/$ for the past year, the volatility or standard deviation (σ) of daily percentage changes in the €/$ spot exchange rate was 62.5 basis points (bp). Calculate the FI’s daily earnings at risk from this position (i.e., adverse moves in the FX markets with respect to the value of the euro against the dollar will not occur more than 1 percent of the time, or 1 day in every 100 days) if the spot exchange rate is €0.80/$1, or $1.25/€, at the daily close.

The first step is to calculate the dollar-equivalent amount of the position.

Dollar equivalent value of position = FX position x ($ per unit of foreign currency)

= €1.6 million x $1.25/€

= $2 million

If changes in exchange rates are historically normally distributed, the exchange rate must change in the adverse direction by 2.33σ, or

FX volatility = 2.33 x 62.5 bp = 145.625 bp or 1.45625%

As a result,

DEAR = Dollar value of position x FX volatility

= $2 million x 0.0145625

= $29,125

This is the potential daily earnings at risk exposure to adverse euro to dollar exchange rate changes for the bank from the €1.6 million spot currency holding.

13. Bank of Southern Vermont has determined that its inventory of 20 million euros (€) and 25 million British pounds (£) is subject to market risk. The spot exchange rates are $1.25/€ and $1.60/£, respectively. The σ’s of the spot exchange rates of the € and £, based on the daily changes of spot rates over the past six months, are 65 bp and 45 bp, respectively. Determine the bank’s 10-day VAR for both currencies. Use adverse rate changes in the 99th percentile.

FX position of € = €20m x 1.25 = $24 million FX position of £ = £25m x 1.60 = $40 million FX volatility € = 2.33 x 65bp = 151.45bp, or 1.5145%

FX volatility £ = 2.33 x 45bp = 104.85bp, or 1.0485%

DEAR = ($ value of position) x (Price volatility)

DEAR of € = $24m x .015145 = $348,941

DEAR of £ = $40m x .010485 = $419,400

10-day VAR of € = $348,941 x √10 = $348,841 x 3.1623 = $1,103,448

10-day VAR of £ = $419,400 x √10 = $419,400 x 3.1623 = $1,326,259

14. Bank of Bentley has determined that its inventory of yen (¥) and Swiss franc (SF) denominated securities is subject to market risk. The spot exchange rates are ¥80.00/$ and SF0.9600/$, respectively. The σ’s of the spot exchange rates of the ¥ and SF, based on the daily changes of spot rates over the past six months, are 75 bp and 55 bp, respectively. Using adverse rate changes in the 99th percentile, the 10-day VARs for the two currencies, ¥ and SF, are $350,000 and $500,000, respectively. Calculate the yen and Swiss franc-denominated value positions for Bank of Bentley.

10-day VAR = DEAR x √N =>

10-day VAR of ¥ = $350,000 = DEAR x √10 = > DEAR = $350,000/√10 = $110,680

10-day VAR of SF = $500,000 = DEAR x √10 = > DEAR = $500,000/√10 = $158,114

FX volatility = 2.335 x daily changes of spot rates over the past six months =>

FX volatility ¥ = 2.33 x 75bp = 0.017475, or 1.7475%

FX volatility SF = 2.33 x 55bp = 0.012815, or 1.2815%

DEAR = ($ value of position) x (Price volatility)

DEAR of ¥ = $110,680 = ($ value of position) x 0.017475

=> ($ value of position) = $110,680/0.017475 = $6,333,603

DEAR of SF = $158,114 = ($ value of position) x 0.012815

=> ($ value of position) = $158,114/0.012815 = $12,338,188

FX position in ¥ = Yen position/80.00 = $6,333,603 = > Yen position = 90.00 x $6,333,603 = ¥570,024,299

FX position in SF = SF position/0.9600 = $12,338,188 = > SF position = 0.9600 x $12,338,188 = SF11,844,661

15. Suppose that an FI holds a $15 million trading position in stocks that reflect the U.S. stock market index (e.g., the S&P 500). Over the last year, the σ*m* of the daily returns on the stock market index was 156 bp. Calculate the DEAR for this portfolio of stocks using a 99 percent confidence limit.

Since the portfolio of stocks reflect the U.S. stock market index, the β = 1. Thus, the DEAR for equities is:

DEAR = Dollar market value of position x Stock market return volatility

= $15,000,000 x 2.33 σm

The σ*m* of the daily returns on the stock market index was 156 bp over the last year. So,

Stock market return volatility = 2.33 x 1.56% = 3.6348%

and

DEAR = $15,000,000 x 0.036348 = $545,220

That is, the FI stands to lose at least $545,220 in value if adverse stock market returns materialize tomorrow.

16. Bank of Alaska’s stock portfolio has a market value of $10 million. The beta of the

portfolio approximates the market portfolio, whose standard deviation (σm) has been estimated at 1.5 percent. What is the five-day VAR of this portfolio using adverse rate changes in the 99th percentile?

DEAR = ($ value of portfolio) x (2.33 x σm ) = $10m x (2.33 x 0.015)

= $10m x 0.03495 = $349,500

5-day VAR = $349,500 x √5 = $349,500 x 2.2361 = $781,506

17. Jeff Resnick, vice president of operations at Choice Bank, is estimating the aggregate daily DEAR of the bank’s portfolio of assets consisting of loans (L), foreign currencies (FX), and common stock (EQ). The individual DEARs are $300,700, $274,000, and $126,700 respectively. If the correlation coefficients (ρij) between L and FX, L and EQ, and FX and EQ are 0.3, 0.7, and 0.0, respectively, what is the DEAR of the aggregate portfolio?



18. Calculate the DEAR for the following portfolio with the correlation coefficients and then with perfect positive correlation between various asset groups.

**Estimated**

**Assets DEAR (ρS,FX) (ρS,B) (ρFX,B)**

Stocks (S) $300,000 -0.10 0.75 0.20

Foreign Exchange (FX) 200,000

Bonds (B) 250,000



What is the amount of risk reduction resulting from the lack of perfect positive correlation between the various assets groups?



The DEAR for a portfolio with perfect correlation would be $750,000. Therefore, the risk reduction is $750,000 - $559,464 = $190,536.

19. What are the advantages of using the back simulation approach to estimate market risk? Explain how this approach would be implemented.

The advantages of the back simulation approach to estimating market risk are that (a) it is a simple process, (b) it does not require that asset returns be normally distributed, and (c) it does not require the calculation of correlations or standard deviations of returns. Implementation requires the calculation of the value of the current portfolio of assets based on the prices or yields that were in place on each of the preceding 500 days (or some large sample of days). These data are rank-ordered from worst to best case and percentile limits are determined. For example, the one percent worst case scenario provides an estimate with 99 percent confidence that the value of the portfolio will not fall more than this amount.

20. Export Bank has a trading position in Japanese yen and Swiss francs. At the close of business on February 4, the bank had ¥300 million and SF10 million. The exchange rates for the most recent six days are given below:

**Exchange Rates per U.S. Dollar at the Close of Business**

2/4 2/3 2/2 2/1 1/29 1/28

Japanese yen 80.13 80.84 80.14 83.05 84.35 84.32

Swiss francs 0.9540 0.9575 0.9533 0.9617 0.9557 0.9523

a. What is the foreign exchange (FX) position in dollar equivalents using the FX rates on February 4?

Japanese yen: ¥300,000,000/¥80.13 = $3,743,916

Swiss francs: SF10,000,000/SF0.9540 = $10,482,180

b. What is the definition of delta as it relates to the FX position?

Delta measures the change in the dollar value of each FX position if the foreign currency depreciates by 1 percent against the dollar.

c. What is the sensitivity of each FX position; that is, what is the value of delta for each currency on February 4?

Japanese yen: 1.01 x current exchange rate = 1.01 x ¥80.13 = ¥80.9313/$

Revalued position in $s = ¥300,000,000/80.9313 = $3,706,848

Delta of $ position to Yen = $3,706,848 - $3,743,916

= -$37,068

Swiss francs: 1.01 x current exchange rate = 1.01 x SF0.9540 = SF0.96354

Revalued position in $s = SF10,000,000/0.96354 = $10,378,396

Delta of $ position to SF = $10,378,396 - $10,482,180

= -$103,784

d. What is the daily percentage change in exchange rates for each currency over the five-day period?

Day Japanese yen: Swiss franc

2/4 -0.87828 -0.36554 % Change = (Ratet/Ratet-1) - 1 x 100

2/3 0.87347 0.44057

2/2 -3.50391 -0.87345

2/1 -1.54120 0.62781

1/29 0.03558 0.35703

e. What is the total risk faced by the bank on each day? What is the worst-case day? What is the best-case day?

Japanese yen Swiss francs Total

Day Delta % Rate Δ Risk Delta % Rate Δ Risk Risk

2/4 -$37,068 -0.87828 $32,556 -$103,784 -0.36554 $37,937 $70,493

2/3 -$37,068 0.87347 -$32,378 -$103,784 0.44057 -$45,724 -$78,102

2/2 -$37,068 -3.50391 $129,883 -$103,784 -0.87345 $90,650 $220,533

2/1 -$37,068 -1.54120 $57,129 -$103,784 0.62781 -$65,157 -$8,028

1/29 -$37,068 0.03558 -$1,319 -$103,784 0.35703 -$37,054 -$38,373

The worst-case day is February 3, and the best-case day is February 2.

f. Assume that you have data for the 500 trading days preceding February 4. Explain how you would identify the worst-case scenario with a 99 percent degree of confidence?

The appropriate procedure would be to repeat the process illustrated in part (e) above for all 500 days. The 500 days would be ranked on the basis of total risk from the worst-case to the best-case. The one percent from the absolute worst-case situation would be day 5 in the ranking.

g. Explain how the 1 percent value at risk (VAR) position would be interpreted for business on February 5.

Management would expect with a confidence level of 99 percent that the total risk on February 5 would be no worse than the total risk value for the 5th worst day in the previous 500 days. This value represents the VAR for the portfolio.

h. How would the simulation change at the end of the day on February 5? What variables and/or processes in the analysis may change? What variables and/or processes will not change?

The analysis can be upgraded at the end of the each day. The values for delta may change for each of the assets in the analysis. As such, the value for VAR may also change. Any historical data used in the analysis will not change.

21. Export Bank has a trading position in euros and Australian dollars. At the close of business on October 20, the bank had €20 million and A$30 million. The exchange rates for the most recent six days are given below:

**Exchange Rates per U.S. Dollar at the Close of Business**

10/20 10/19 10/18 10/17 10/16 10/15

Euros 0.8000 0.7970 0.7775 0.7875 0.7950 0.8115

Australian $s 0.9700 0.9550 0.9800 0.9655 0.9505 0.9460

a. What is the foreign exchange (FX) position in dollar equivalents using the FX rates on October 20?

Euros: €20 million/€0.8000 = $25,000,000

Australian $s: A$30 million/A$0.9700 = $30,927,835

b. What is the sensitivity of each FX position; that is, what is the value of delta for each currency on October 20?

Euros: 1.01 x current exchange rate = 1.01 x €0.8000 = €0.8080/$

Revalued position in $s = €20 million/€0.8080 = $24,752,475

Delta of $ position to € = $24,752,475 - $25,000,000

= -$247,525

Australian $s: 1.01 x current exchange rate = 1.01 x A$0.9700 = A$0.9797

Revalued position in $s = A$30 million/0.9797 = $30,621,619

Delta of $ position to A$ = $30,621,619 - $30,927,835

= -$306,216

c. What is the daily percentage change in exchange rates for each currency over the five-day period?

Day Euro: Australian $s

10/20 0.37641 1.57068 % Change = (Ratet/Ratet-1) - 1 \* 100

10/19 2.50804 -2.55102

10/18 -1.26984 1.50181

10/17 -0.94340 1.57812

10/16 -2.03327 0.47569

d. What is the total risk faced by the bank on each day? What is the worst-case day? What is the best-case day?

Euro Australian $s Total

Day Delta % Rate Δ Risk Delta % Rate Δ Risk Risk

10/20 -$247,525 0.37641 -$93,171 -$306,216 1.57068 -$480,967 -$574,138

10/19 -$247,525 2.50804 -$620,803 -$306,216 -2.55102 $781,163 $160,361

10/18 -$247,525 -1.26984 $314,317 -$306,216 1.50181 -$459,878 -$145,561

10/17 -$247,525 -0.94340 $233,515 -$306,216 1.57812 -$483,246 -$249,731

10/16 -$247,525 -2.03327 $503,285 -$306,216 0.47569 -$145,664 $357,621

The worst-case day is October 20, and the best-case day is October 16.

22. What is the primary disadvantage to the back simulation approach in measuring market risk? What effect does the inclusion of more observation days have as a remedy for this disadvantage? What other remedies can be used to deal with the disadvantage?

The primary disadvantage of the back simulation approach is the confidence level contained in the number of days over which the analysis is performed. Further, all observation days typically are given equal weight, a treatment that may not reflect changes in markets accurately. As a result, the VAR number may be biased upward or downward depending on how markets are trending. Possible adjustments to the analysis would be to give more weight to more recent observations, or to use Monte Carlo simulation techniques.

23. How is Monte Carlo simulation useful in addressing the disadvantages of back simulation? What is the primary statistical assumption underlying its use?

Monte Carlo simulation can be used to generate additional observations that more closely capture the statistical characteristics of recent experience. The generating process is based on the historical variance-covariance matrix of value changes. The values in this matrix are multiplied by random numbers that produce results that pattern closely the actual observations of recent historic experience.

24. What is the difference between VAR and expected shortfall (ES) as measure of market risk?

VAR corresponds to a specific point of loss on the probability distribution. It does not provide information about the potential size of the loss that exceeds it, i.e., VAR completely ignores the patterns and the severity of the losses in the extreme tail. Thus, VAR gives only partial information about the extent of possible losses, particularly when probability distributions are non-normal. The drawbacks of VAR became painfully evident during the financial crisis as asset returns plummeted into the “fat tail” region of non-normally shaped distributions. FIs managers and regulators were forced to recognize that VAR projections of possible losses far underestimated actual losses on extreme bad days. Expected shortfall (ES), also referred to as conditional VAR and expected tail loss, is a measure of market risk that estimates the expected value of losses beyond a given confidence level, i.e., it is the average of VARs beyond a given confidence level. ES, which incorporates points to the left of VAR, is larger when the probability distribution exhibits fat tail losses. Accordingly, ES provides more information about possible market risk losses than VAR. For situations in which probability distributions exhibit fat tail losses, VAR may look relatively small, but ES may be very large.

25. Consider the following discrete probability distribution of payoffs for two securities, A and B, held in the trading portfolio of an FI:

Probability A Probability B

50.00% $80m 50.00% $80m

49.00 60m 49.00 68m

1.00 -740m 0.40 -740m

0.60 -1,393m

Which of the two securities will add more market risk to the FI’s trading portfolio according to the VAR and ES measures?

The expected return on security A = 0.50($80m) + 0.49($60m) + 0.01(-$740m) = $62m

The expected return on security B = 0.50($80m) + 0.49($68m) + 0.0040(-$740m) + 0.0060(-$1,393m)

= $62m

For a 99% confidence level, VARA = VARB = -$740m

For a 99% confidence level, ESA = -$740m, while ESB = 0.40(-$740m) + 0.60(-$1,393m) = -$1,131.8m

While the VAR is identical for both securities, the ES finds that security B has the potential to subject the FI to much greater losses than security A. Specifically, if tomorrow is a bad day, VAR finds that there is a 1 percent probability that the FI’s losses will exceed $740 million on either security. However, if tomorrow is a bad day, ES finds that there is a 1 percent probability that the FI’s losses will exceed $740 million if security A is in its trading portfolio, but losses will exceed $1,131.8 million if security B is in its trading portfolio.

26. Consider the following discrete probability distribution of payoffs for two securities, A and B, held in the trading portfolio of an FI:

Probability A Probability B

55.00% $120m 55.00% $120m

44.00 95m 44.00 100m

1.00 -1,100m 0.30 -1,100m

0.70 -1,414m

Which of the two securities will add more market risk to the FI’s trading portfolio according to the VAR and ES measures?

The expected return on security A = 0.55($120m) + 0.44($95m) + 0.01(-$1,100m) = $96.8m

The expected return on security B = 0.55($120m) + 0.44($100m) + 0.0030(-$1,100m)

+ 0.0070(-$1,414m) = $96.8m

For a 99% confidence level, VARA = VARB = -$1,100m

For a 99% confidence level, ESA = -$1,100m, while ESB = 0.30(-$1,100m) + 0.70(-$1,414m)

= -$1,319.8m

Thus, while the VAR is identical for both securities, the ES finds that security B has the potential to subject the FI to much greater losses than security A. Specifically, if tomorrow is a bad day, VAR finds that there is a 1 percent probability that the FI’s losses will exceed $1,100 million on either security. However, if tomorrow is a bad day, ES finds that there is a 1 percent probability that the FI’s losses will exceed $1,100 million if security A is in its trading portfolio, but losses will exceed $1,319.8m if security B is in its trading portfolio.

27. An FI has ₤5 million in its trading portfolio on the close of business on a particular day. The current exchange rate of pounds for dollars is ₤0.6400/$, or dollars for pounds is $1.5625, at the daily close. The volatility, or standard deviation (σ), of daily percentage changes in the spot ₤/$ exchange rate over the past year was 58.5 bp. The FI is interested in adverse moves – bad moves that will not occur more than 1 percent of the time, or 1 day in every 100. Calculate the one-day VAR and ES from this position.

The first step is to calculate the dollar value position:

Dollar value of position = pound value of position x dollar for pound exchange rate

= ₤5 million x 1.5625 = $7,812,500

Using VAR, which assumes that changes in exchange rates are normally distributed, the exchange rate must change in the adverse direction by 2.33σ (2.33 x 58.5 bp) for this change to be viewed as likely to occur only 1 day in every 100 days:

FX volatility = 2.33 x 58.5 bp = 136.305 bp

In other words, using VAR during the last year the pound declined in value against the dollar by 136.305 bp 1 percent of the time. As a result, the one-day VAR is:

VAR = $7,812,500 x 0.0136305 = $106,488

Using ES, which assumes that changes in exchange rates are normally distributed but with fat tails, the exchange rate must change in the adverse direction by 2.665σ (2.665 x 58.5 bp) for this change to be viewed as likely to occur only 1 day in every 100 days:

FX volatility = 2.665 x 58.5 bp = 155.9025 bp

In other words, using ES during the last year the pound declined in value against the dollar by 155.9025 bp 1 percent of the time. As a result, the one-day ES is:

ES = $7,812,500 x 0.01559025 = $121,799

The potential loss exposure to adverse pound to dollar exchange rate changes for the FI from the ₤5 million spot currency holdings are higher using the ES measure of market risk. ES estimates potential losses that are $15,311 higher than VAR. This is because VAR focuses on the location of the extreme tail of the probability distribution. ES also considers the shape of the probability distribution once VAR is exceeded.

28. An FI has ¥500 million in its trading portfolio on the close of business on a particular day. The current exchange rate of yen for dollars is ¥80.00/$, or dollars for yen is $0.0125, at the daily close. The volatility, or standard deviation (σ), of daily percentage changes in the spot ¥/$ exchange rate over the past year was 121.6 bp. The FI is interested in adverse moves – bad moves that will not occur more than 1 percent of the time, or 1 day in every 100. Calculate the one-day VAR and ES from this position.

The first step is to calculate the dollar value position:

Dollar value of position = yen value of position x dollar for pound exchange rate

= ¥500 million x 0.0125 = $6,250,000

Using VAR, which assumes that changes in exchange rates are normally distributed, the exchange rate must change in the adverse direction by 2.33σ (2.33 x 121.6 bp) for this change to be viewed as likely to occur only 1 day in every 100 days:

FX volatility = 2.33 x 121.6 bp = 283.328 bp

In other words, using VAR during the last year the yen declined in value against the dollar by 283.328 bp 1 percent of the time. As a result, the one-day VAR is:

VAR = $6,250,000 x 0.0283328 = $177,080

Using ES, which assumes that changes in exchange rates are normally distributed but with fat tails, the exchange rate must change in the adverse direction by 2.665σ (2.665 x 121.6 bp) for this change to be viewed as likely to occur only 1 day in every 100 days:

FX volatility = 2.665 x 121.6 bp = 324.064 bp

In other words, using ES during the last year the yen declined in value against the dollar by 324.064 bp 1 percent of the time. As a result, the one-day ES is:

ES = $6,250,000 x 0.0324064 = $202,540

The potential loss exposure to adverse yen to dollar exchange rate changes for the FI from the ¥500 million spot currency holdings are higher using the ES measure of market risk. ES estimates potential losses that are $25,460 higher than VAR. This is because VAR focuses on the location of the extreme tail of the probability distribution. ES also considers the shape of the probability distribution once VAR is exceeded.

29. Bank of Hawaii’s stock portfolio has a market value of $250 million. The beta of the portfolio approximates the market portfolio, whose standard deviation (σm) has been estimated at 2.25 percent. What are the five-day VAR and ES of this portfolio using adverse rate changes in the 99th percentile?

Daily VAR = ($ value of portfolio) x (2.33 x σm ) = $250m x (2.33 x 0.0225)

= $250m x 0.052425 = $13,106,250

5-day VAR = $13,106,250 x √5 = $13,106,250 x 2.2361 = $29,306,466

Daily ES = ($ value of portfolio) x (2.665 x σm ) = $250m x (2.665 x 0.0225)

= $250m x 0.0599625 = $14,990,625

5-day ES = $14,990,625 x √5 = $14,990,625 x 2.2361 = $33,520,057

30. Despite the fact that market risk capital requirements have been imposed on FIs since the 1990s, huge losses in value were recorded from losses incurred in FIs’ trading portfolios. Why did this happen? What changes to capital requirements did regulators propose to prevent such losses from reoccurring?

During the financial crisis, losses due to market risk were significantly higher than the minimum market risk capital requirements under BIS Basel I and Basel II rules. The financial crisis exposed a number of shortcomings in the way market risk was being measured in accordance with Basel II rules. Although the crisis largely exposed problems with the large-bank internal models approach to measuring market risk, the BIS also identified shortcomings with the standardized approach. These included a lack of risk sensitivity, a very limited recognition of hedging and diversification benefits, and an inability to sufficiently capture risks associated with more complex instruments. As a result in July 2009, the BIS announced Basel 2.5, a final version of revised rules for market risk capital requirements.

To address shortcomings of the standardized approach to measuring market risk, Basel III proposes a “partial risk factor” approach as a revised standardized approach. Basel III also introduces a “fuller risk factor” approach as an alternative to the revised partial risk factor standardized approach. To address shortcomings in the internal models approach, in addition to the risk capital charge already in place, an incremental capital charge is assessed which includes a “stressed value at risk” capital requirement taking into account a one year observation period of significant financial stress relevant to the FI’s portfolio. The introduction of stressed VAR in Basel 2.5 is intended to reduce the cyclicality of the VAR measure and alleviate the problem of market stress periods dropping out of the data period used to calculate VAR after some time. Basel 2.5 requires the following process be followed by large FIs using internal models to calculate the market risk capital charge.

Basel III proposes to replace VAR models with those based on Extreme Value Theory and Expected Shortfall (ES) (discussed above). The ES measure analyzes the size and likelihood of losses above the 99th percentile in a crisis period for a traded asset and thus measures “tail risk” more precisely. Thus, ES is a risk measure that considers a more comprehensive set of potential outcomes than VAR. The BIS change to ES highlights the importance of maintaining sufficient regulatory capital not only in stable market conditions, but also in periods of significant financial stress. Indeed, it is precisely during periods of stress that capital is vital for absorbing losses and safeguarding the stability of the banking system. Accordingly, the Committee intends to move to a framework that is calibrated to a period of significant financial stress. Two methods of identifying the stress period and calculating capital requirements under the internal models are the direct method and the indirect method. The direct method is based on the approach used in the Basel 2.5 stressed VAR. The FI would search the entire historical period and identify the period which produces the highest ES result when all risk factors are included. However Basel III would require the FI to determine the stressed period on the basis of a reduced set of risk factors. Once the FI has identified the stressed period, it must then determine the ES for the full set of risk factors for the stress period. The indirect method identifies the relevant historical period of stress by using a reduced set of risk factors. However, instead of calculating the full ES model to that period the FI calculates a loss based on the reduced set of risk factors. This loss is then scaled using the ratio of the full ES model using current market data to the full ES model using the reduced set of risk factors using current market data.

31. In its trading portfolio, an FI holds 10,000 Exxon Mobil (XOM) shares at a share price of $86.50 and has sold 5,000 General Electric (GE) shares under a forward contract that matures in one year. The current share price for GE is $20.50. The shift risk factor (i.e., standard deviation) for level 1 risk factor is 4 percent, for level II risk factor is 6 percent, for level III long positions is 9 percent, for level III short positions is -9 percent, and for non-hedgeable risk is 1 percent. Using the risk factors listed in Table 15-8, calculate the market risk capital charge on these securities.

*Step 1. Assign each instrument to applicable risk factors*

From Table 15-8, hedgeable risk factors for these equities include level I worldwide equity index, level II equity index by broad industry category, and level III movements in the prices of individual equity. XOM and GE have the same hedgeable risk factors at levels I and II, i.e., global and industry specific equity indices. However, movements in the prices of the two firms are unique. Thus, they do not have the same risk factor at level III and as a result they are mapped to different individual equity risk factors. There is also a non-hedgeable risk factor for the GE equity price to capture basis risk from the forward contract.

*Step 2. Determine the size of the net risk position in each risk factor*

For each risk factor the FI determines a net risk position, calculated as the sum of gross risk positions for all instruments that are subject to that risk factor.The table below shows the gross and net positions for XOM and GE equities for the equity risk factor. The size of the gross position in XOM for the three applicable risk factors is $865,000 (10,000 shares x $86.50) and for the short position in GE is -$102,500 (5,000 shares x $20.50). Note again that the two securities do not have the same risk factor at level III. Thus, they are mapped to different individual equity risk factors. Further, to capture basis risk from the forward contract, there is a non-hedgeable risk factor for the GE equity price, -$102,500. The net risk position of the two securities for each risk factor, listed in the last column of the table, is the sum of the gross risk factors for the securities at each level i.e., $762,500 for levels I and II, $865,000 and -$102,500, respectively, for level III, and -$102,500 for non-hedgeable risk.

XOM Gross GE Gross Total size of

Level Equity risk risk position risk position net risk position

I Worldwide equity index $865,000 -$102,500 $762,500

II Industry equity index $865,000 -$102,500 $762,500

III Daimler share price $865,000 - $865,000

Volkswagen share price - -$102,500 -$102,500

N-h\* Volkswagen share price - -$102,500 -$102,500

*Step 3. Aggregate overall risk position across risk factors*

The net risk positions is then converted into a capital charge by multiplying by regulator specified standard deviations (i.e., shift risk factors). The table below shows the calculations of the capital charge for market risk. The net risk positions (listed in column 3 for each risk level) are multiplied by the standard deviations assigned for each level (column 4) to produce the standard deviations of the net risk position. For example, the standard deviation of the net risk position for the level I worldwide equity index is equal to the net risk ($762,500) times the regulator set shift risk factor (4%) to give the standard deviation associated with level I risk factor, $30,500). The square of the standard deviation (the variance) is then listed in column 5 (i.e., $930,250,000 for level I). Summing the squared standard deviations gives the portfolio variance $9,170,086,250) and taking the square root of this gives the portfolio standard deviation ($95,761). Finally, this portfolio standard deviation is multiplied by a scalar (currently set at 4) to achieve the overall expected shortfall for the portfolio ($383,042).

Standard Square of the

Net risk Standard deviation of standard deviation

Level Equity risk position deviation net risk position net risk position

I Worldwide equity index $762,500 4% $30,500 $930,250,000

II Industry equity index $762,500 6% $45,750 $2,093,062,500

III Daimler share price $865,000 9% $77,850 $6,060,622,500

Volkswagen share price -$102,500 -9% $9,225 $85,100,625

N-h\* Volkswagen share price -$102,500 1% $1,025 $1,050,625

Portfolio Sum the squared standard deviation (portfolio variance) $9,170,086,250

Portfolio Take the square root (portfolio standard deviation) $95,761

Portfolio Multiply by scalar (currently equal to 4) to obtain expected shortfall $383,042

32. In its trading portfolio, a U.S. FI is long ₤20 million worth of pound FX forward contracts and has sold €40 million of euro FX forward contracts that mature in one year. The current exchange rate of dollars for pounds is $1.5625 and the exchange rate of euros for pounds is $1.25 at the daily close. The shift risk factor (i.e., standard deviation) for level 1 risk factor is 5 percent, for level II risk factor for pounds is 8 percent, and for level II risk factors for euros is 12 percent. Using the risk factors listed in Table 15-8, calculate the market risk capital charge on these securities.

*Step 1. Assign each instrument to applicable risk factors*

From Table 15-8, hedgeable risk factors for these FX contracts include level I exchange rate of U.S. currency to worldwide currency basket, and level II exchange rate of worldwide currency basket to respective foreign currency. The pound FX forward contract and the euro FX forward contract have the same hedgeable risk factors at level I, i.e., exchange rate of U.S. dollar to worldwide currency basket. However, movements in the prices of the British pound and the euro are unique. Thus, they do not have the same risk factor at level II and as a result they are mapped to different individual FX risk factors (i.e., exchange rate of worldwide currency basket to the pound and exchange rate of worldwide currency basket to the euro, respectively).

*Step 2. Determine the size of the net risk position in each risk factor*

For each risk factor the FI determines a net risk position, calculated as the sum of gross risk positions for all instruments that are subject to that risk factor.

The dollar value of the positions of the two contracts are

Dollar value of pound contract = ₤20 million x 1.5625 = $31,250,000

Dollar value of euro contract = €40 million x 1.25 = $50,000,000

The table below shows the gross and net positions for the pound FX forward contract and the euro FX forward contract for the FX risk factor. Note again that the two securities do not have the same risk factor at level II. Thus, they are mapped to different individual FX risk factors. The net risk position of the two securities for each risk factor, listed in the last column of the table, is the sum of the gross risk factors for the securities at each level i.e., -$18,750,000 for level I and $31,250,000 and -$50,000,000, respectively, for level II.

₤ Gross € Gross Total size of

Level Equity risk risk position risk position net risk position

I Exchange rate of U.S.

dollar/worldwide

currency basket $31,250,000 -$50,000,000 -$18,750,000

II Exchange rate of

worldwide currency

basket/₤ $31,250,000 - $31,250,000

III Exchange rate of

worldwide currency

basket/€ - -$50,000,000 -$50,000,000

*Step 3. Aggregate overall risk position across risk factors*

The net risk positions is then converted into a capital charge by multiplying by regulator specified standard deviations (i.e., shift risk factors). The table below shows the calculations of the capital charge for market risk. The net risk positions (listed in column 3 for each risk level) are multiplied by the standard deviations assigned for each level (column 4) to produce the standard deviations of the net risk position. For example, the standard deviation of the net risk position for the level I exchange rate of U.S. currency to worldwide currency basket is equal to the net risk ($18,750,000) times the regulator set shift risk factor (5%) to give the standard deviation associated with level I risk factor, $937,500. The square of the standard deviation (the variance) is then listed in column 5 (i.e., $878,906,300,000 for level I). Summing the squared standard deviations gives the portfolio variance $43,128,910,000,000) and taking the square root of this gives the portfolio standard deviation ($6,567,260). Finally, this portfolio standard deviation is multiplied by a scalar (currently set at 4) to achieve the overall expected shortfall for the portfolio ($26,269,041).

Standard Square of the

Net risk Standard deviation of standard deviation

Level Equity risk position deviation net risk position net risk position

I Exchange rate of U.S.

dollar/worldwide

currency basket -$18,750,000 5% $937,500 $878,906,300,000

II Exchange rate of

worldwide currency

basket/₤ $31,250,000 8% $2,500,000 $6,250,000,000,000

III Exchange rate of

worldwide currency

basket/€ -$50,000,000 -12% $6,000,000 $36,000,000,000,000

Portfolio Sum the squared standard deviation (portfolio variance) $43,128,910,000,000

Portfolio Take the square root (portfolio standard deviation) $6,567,260

Portfolio Multiply by scalar (currently equal to 4) to obtain expected shortfall $26,269,041

33. Suppose an FI’s portfolio VAR for the previous 60 days was $3 million and stressed VAR for the previous 60 days was $8 million using the 1 percent worst case (or 99th percentile). Calculate the minimum capital charge for market risk for this FI.

Capital charge = ($3 million x √10 x 3) + ($8 million x √10 x 3) = $104.355 million

**Integrated Mini Case: Calculating DEAR on an FI’s Trading Portfolio**

An FI wants to obtain the DEAR on its trading portfolio. The portfolio consists of the following securities.

*Fixed-income securities:*

i) The FI has a $1 million position in a six-year zero bonds with a face value of $1,543,302. The bond is trading at a yield to maturity of 7.50 percent. The historical mean change in daily yields is 0.0 percent, and the standard deviation is 22 basis points.

ii) The FI also holds a 12-year zero bond with a face value of $1,000,000. The bond is trading at a yield to maturity of 6.75 percent. The price volatility if the potential adverse move in yields is 65 basis points.

*Foreign exchange contracts:*

The FI has a €2.0 million long trading position in spot euros at the close of business on a particular day. The exchange rate is €0.80/$1, or $1.25/€, at the daily close. Looking back at the daily changes in the exchange rate of the euro to dollars for the past year, the FI finds that the volatility or standard deviation (σ) of the spot exchange rate was 55.5 basis points (bp).

*Equities:*

The FI holds a $2.5 million trading position in stocks that reflect the U.S. stock market index (e.g., the S&P 500). The β = 1. Over the last year, the standard deviation of the stock market index was 175 basis points.

Correlations (ρij) among Assets

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_

Six-year zero-coupon 12-year zero-coupon €/$ U.S. stock index

Six‑year, zero-coupon - 0.75 ‑0.2 0.40

12-year, zero-coupon - - -0.3 0.45

€/$ - - - 0.25

U.S. stock index - - - -

Calculate the DEAR of this trading portfolio.

Solution:

*Fixed-income securities:*

i) MD = D/(1 + R) = 6/(1.075) = 5.581395

=> Potential adverse move in yield at 5 percent = 1.65σ = 1.65 x 0.0022 = .00363

=> Price volatility = MD x potential adverse move in yield

= 5.581395 x 0.00363 = 0.02026 or 2.026 percent

and the daily earnings at risk for this bond is:

DEAR = ($ value of position) x (price volatility)

= $1,000,000 x 0.02026 = $20,260

ii) Dollar value of position = $1m./(1 + 0.0675)12 = $456,652. The modified duration of these bonds is:

MD = D/(1 + R) = 12/(1.0675) = 11.24122

=> Price volatility = (MD) x (potential adverse move in yield)

= (11.24122) x (0.0065) = 0.073068 or 7.3068 percent.

=> DEAR = $456,652 x 0.073068 = $33,367

*Foreign exchange contracts:*

Dollar equivalent value of € position = FX position x ($/€ spot exchange rate)

= €3.5 million x $ per unit of foreign currency

Dollar value of € position = €2.0 million x $1.25/€

= $2,500,000

FX volatility = 1.65 x 55.5 bp = 91.575 bp or 0.91575%

=> DEAR = Dollar value of DM position x FX volatility

= $2,500,000 x 0.0091575

= $22,894

*Equities:*

Stock market return volatility = 1.65 σm = 1.65 x 175 bp = 0.28875 = 2.8875%

=> DEAR = Dollar market value of position x Stock market return volatility

= $2,500,000 x 0.28875 = $72,187

*Portfolio DEAR:*

Using the correlation matrix along with the individual asset DEARs the risk (or standard deviation) of the whole (four‑asset) trading portfolio is:

DEAR portfolio=[(DEAR*z6*)2 + (DEAR*z12*)2 + (DEAR*€*)2 + (DEAR*US*)2

+ (2 x ρ*z6,z12* x DEAR*z6* x DEAR*z12*) + (2 x ρ*z6€* x DEAR*z6* x DEAR*€*)

+ (2 x ρ*z6,US* x DEARz6 x DEAR*US*) + (2 x ρ*z12€* x DEAR*z12* x DEAR*€*)

+ (2 x ρ*z12,US* x DEARz12 x DEAR*US*)+ (2 x ρ*€,US* x DEAR*€* x DEARUS)]

= [(20,260)2 + (33,367)2 + (22,894)2 + (72,187)2 + 2(0.75)(20,260)( 33,367)

+ 2(-0.2)(20,260)(22,894) + 2(0.4)(20,260)(72,187) + 2(-0.3)(33,367)(22,894)

+ 2(0.45)(33,367)(72,187) + 2(0.25)(22,894)(72,187)]

= $108,597