##### Solutions to End-of-Chapter Questions and Problems: Chapter Twenty Three

1. How does using options differ from using forward or futures contracts?

Both options and futures contracts are useful in managing risk. Other than the pure mechanics, the primary difference between these contracts lies in the requirement of what must be done on or before maturity. Futures and forward contracts require that the buyer or seller of the contracts must execute some transaction. The buyer of an option has the choice to execute the option or to let it expire without execution. The writer of an option must perform a transaction only if the buyer chooses to execute the option.

1. What is a call option?

A call option is a contract that allows the owner to buy some underlying asset at a prespecified price on or before a specified maturity date.

1. What must happen to interest rates for the purchaser of a call option on a bond to make money? How does the writer of the call option make money?

A call option on a bond allows the owner to buy a bond at a specific price. For the owner of the option to make money, he/she should be able to immediately sell the bond at a higher price. Thus, for the bond price to increase, interest rates must decrease between the time the option is purchased and the time it is executed. The writer of the call option makes a premium from the sale of the option. If the option is not exercised, the writer maximizes profit in the amount of the premium. If the option is exercised, the writer stands to lose a portion or the entire premium and may lose additional money if the price on the underlying asset moves sufficiently far.

1. What is a put option?

A put option is a contract that allows the owner to sell some underlying asset at a prespecified price on or before a specified maturity date.

1. What must happen to interest rates for the purchaser of a put option on a bond to make money? How does the writer of the put option make money?

The put option on a bond allows the owner to sell a bond at a specific price. For the owner of the option to make money, he/she should be able to buy the bond at a lower price immediately prior to exercising the option. Thus, for the bond price to decrease, interest rates must increase between the time the option is purchased and the time it is executed. The writer of the put option makes a premium from the sale of the option. If the option is not exercised, the writer maximizes profit in the amount of the premium. If the option is exercised, the writer stands to lose a portion or the entire premium, and may lose additional money if the price on the underlying asset moves sufficiently far.

6. Consider the following:

a. What are the two ways to use call and put options on T-bonds to generate positive cash flows when interest rates decline? Verify your answer with a diagram.

The FI can either (a) buy a call option, or (b) sell a put option on interest rate instruments, such as T-bonds, to generate positive cash flows in the event that interest rates decline. In the case of a call option, positive cash flows will increase as long as interest rates continue to decrease. See Figure 23-1 in the text as an example of positive cash flows minus the premium paid for the option. Although not labeled in this diagram, interest rates are decreasing as you move from left to right on the x-axis. Thus, bond prices are increasing.

The sale of a put option generates positive cash flows from the premium received. Figure 23-4 shows that the profit will decrease as the price of the bond falls. Of course, this can only happen if interest rates are increasing. Again, although not labeled in this diagram, interest rates are increasing as you move from right to left on the x-axis.

b. Under what balance sheet conditions would an FI use options on T-bonds to hedge its assets and/or liabilities against interest rate declines?

An FI would use call options on T-bonds to hedge an underlying cash position that decreases in value as interest rates decline. This would be true if, in the case of a macrohedge, the FI's duration gap is negative and the repricing gap is positive. In the case of a microhedge, the FI can hedge a single fixed-rate liability against interest rate declines.

c. Is it more appropriate for FIs to hedge against a decline in interest rates with long calls or short puts?

An FI is better off purchasing calls as opposed to writing puts for two reasons. First, regulatory restrictions limit an FI's ability to write naked short options. Second, since the potential positive cash inflow on the short put option is limited to the size of the put premium, there may be insufficient cash inflows in the event of interest rate declines to offset losses in the underlying cash position.

7. In each of the following cases, identify what risk the manager of an FI faces and whether the risk should be hedged by buying a put or a call option.

a. A commercial bank plans to issue CDs in three months.

The bank faces the risk that interest rates will increase. The bank should buy a put option. If rates rise, the CDs can be issued only at a lower price. But, the increase in interest rates also lowers the price of the security underlying the put option. Thus, the bank can purchase the underlying security and the gain from the option exercise will offset the loss in value from the lower issue value of the CDs the bank experiences in the spot market.

b. An insurance company plans to buy bonds in two months.

The insurance company (IC) is concerned that interest rates will fall, and thus the price of the bonds will rise. The IC should buy call options on bonds. As rates fall, the underlying bond prices increase, but can be bought for less than the market price by exercising the call option. The bonds purchased with the options can be sold immediately for a gain that can be applied against the increase in the price of the bonds bought by the IC in the spot market and held on the balance sheet. Alternatively, the bonds bought through the exercise of the call option can be kept and placed in the IC’s portfolio if they are the desired type of asset.

c. A thrift plans to sell Treasury securities next month.

The thrift will incur a loss on the sale if rates rise and the value of the bonds falls. The thrift should buy a put option on Treasury securities that allows the sale of the bonds at or near the current price.

d. A U.S. bank lends to a French company with the loan payable in euros.

The U.S. bank will incur a loss on the loan if the dollar appreciates (euros depreciate). Thus, the bank should buy a put to sell euros at or near the current exchange rate.

e. A mutual fund plans to sell its holding of stock in a British company.

The mutual fund will incur a loss on the sale if the dollar appreciates (£s depreciate). Thus, the fund should buy a put to sell £s at or near the current exchange rate.

f. A finance company has assets with a duration of six years and liabilities with a duration of 13 years.

The FI is concerned that interest rates will fall, causing the value of the liabilities to rise more than the value of the assets which would cause the value of the equity to decrease. Thus, the finance company should buy a call option on bonds.

8. Consider an FI that wishes to use bond options to hedge the interest rate risk in the bond portfolio.

a. How does writing call options hedge the risk when interest rates decrease?

In the case where the FI is long in the bond on the balance sheet, writing a call option will provide extra cash flow in the form of a premium. But, falling interest rates will cause the value of the bond to increase, and eventually the option will be exercised at a loss to the writer. However, the loss is offset by the increase in value of the long bond. Thus, the initial goal of maintaining the interest rate return on the long bond can be realized.

b. Will writing call options fully hedge the risk when interest rates increase? Explain.

Writing call options provides a premium that can be used to offset losses in the bond portfolio caused by rising rates up to the amount of the premium. Any additional losses beyond the value of the option premium are not protected.

c. How does buying put options reduce the losses on the bond portfolio when interest rates rise?

When interest rates increase, the value of the bond portfolio falls. But the put option allows for the sale of the bonds at or near the original price. Thus, the profit potential from the exercise of the put option increases as interest rates continue to increase, although it is tempered by the amount of premium that was paid for the put option.

d. Diagram the purchase of a bond call option against the combination of a bond investment and the purchase of a bond put option.

The profit of a bond call option is given in Figure 23-1. If the price of the bond falls below the exercise price, the purchaser of the call loses the premium. As the price of the bond increases beyond the exercise price, the purchaser recovers the premium and then realizes a net profit. Figures 23-7 and 23-8 give the individual and net profit of holding a bond long and the purchase of a put option. The put option produces a profit if bond prices drop. This profit will offset the loss on the long bond caused by the decrease in the bond value. If bond prices increase, the option will not be exercised and the investor will realize a gain from the increase in the bonds value. Thus, the call option or the combination of long bond and put option give the same results.

9. What are the regulatory reasons why FIs seldom write options?

Regulators often prohibit the writing of options because of the unlimited loss potential.

1. What are the problems of using the Black-Scholes option pricing model to value bond options? What is meant by the term *pull-to-par*?

First, the Black-Scholes model assumes unrealistically that short-term interest rates are constant. Second, the model assumes that the variance of returns on the bond is constant over time. In fact, the variance may increase in the initial life of a bond, but it must decrease during the final stages of the bond’s life because the bond must trade at par at maturity. The decrease in variance of returns over the final portion of a bond’s life is called the pull-to-par.

11. An FI has purchased a two-year, $1,000 par value zero-coupon bond for $867.43. The FI will hold the bond to maturity unless it needs to sell the bond at the end of one year for liquidity purposes. The current one-year interest rate is 7 percent and the one-year rate in one year is forecast to be either 8.04 percent or 7.44 percent with equal likelihood. The FI wishes to buy a put option to protect itself against a capital loss if the bond needs to be sold in one year.

a. What is the yield on the bond at the time of purchase?

PV0 = FVxPVIFn=2,i=? => $867.43 = $1,000 x PVIFn=2,i=? => i = 7.37 percent

b. What is the market-determined, implied one-year rate one year before maturity?

E(r1) = (0.5 x 8.04) + (0.5 x 7.44) = 7.74

c. What is the expected sale price if the bond has to be sold at the end of one year?

E(P1) = $1,000/(1.0774) = $928.16

d. Diagram the bond prices over the two-year horizon.



e. If the FI buys a put option with an exercise price equal to your answer in part (c), what will be its value at the end of one year?

Put Option Value of Weighted

Exercise Bond Price Put Option Probability Value

$928.16 - $925.58 = $2.58 x 0.5 = $1.29

$928.16 - $930.75 = $0.00 x 0.5 = $0.00

Total value = $1.29

f. What should be the premium on the put option today?

PV = $1.29/1.07 = $1.2056

g. Diagram the value for the put option on the two-year, zero-coupon bond.



h. What would have been the premium on the option if the one-year interest rates at the end of one year were expected to be 8.14 percent and 7.34 percent?

The bond prices for the respective interest rates are $924.73 and $931.62. The expected one-year rate and the expected one-year bond price are the same. Further, the call price of the option is the same.

Put Option Value of Weighted

Exercise Bond Price Put Option Probability Value

$928.16 - $924.73 = $3.43 x 0.5 = $1.716

$928.16 - $931.62 = $0.00 x 0.5 = $0.000

Total value = $1.716

PV = $1.716/1.07 = $1.60

12. A pension fund manager anticipates the purchase of a 20-year, 8 percent coupon Treasury bond at the end of two years. Interest rates are assumed to change only once every year at year-end, with an equal probability of a 1 percent increase or a 1 percent decrease. The Treasury bond, when purchased in two years, will pay interest semiannually. Currently, the Treasury bond is selling at par.

a. What is the pension fund manager's interest rate risk exposure?

The pension fund manager is exposed to interest rate declines (price increases).

b. How can the pension fund manager use options to hedge this interest rate risk exposure?

This interest rate risk exposure can be hedged by buying call options on either financial securities or financial futures.

c. What prices are possible on the 20-year T-bonds at the end of year 1 and year 2?

Currently, the bond is priced at par, $1,000 per $1,000 face value. At the end of the first year, either of two interest rates will occur.

(a) Interest rates will increase 1 percent to 9 percent (50 percent probability of either occurrence). The 20-year 8 percent coupon Treasury bond's price will fall to $907.9921 per $1,000 face value.

(b) Interest rates will decrease 1 percent to 7 percent (50 percent probability of occurrence). The 20-year 8 percent coupon Treasury bond's price will increase to $1,106.7754 per $1,000 face value.

At the end of two years, one of three different interest rate scenarios will occur.

(a) Interest rates will increase another 1 percent to 10 percent (25 percent probability of occurrence). The 20 year 8 percent coupon Treasury bond's price will fall to $828.4091 per $1,000 face value.

(b) Interest rates will decrease 1 percent to 8 percent or increase 1 percent to 8 percent (50 percent probability of occurrence). The 20-year 8 percent coupon Treasury bond's price will return to $1,000 per $1,000 face value.

(c) Interest rates will decrease another 1 percent to 6 percent (25 percent probability of occurrence). The 20-year 8% coupon Treasury bond's price will increase to $1,231.1477 per $1,000 face value.

d. Diagram the prices over the two-year period.



e. If options on $100,000, 20-year, 8 percent coupon Treasury bonds (both puts and calls) have a strike price of 101, what are the possible (intrinsic) values of the option position at the end of year 1 and year 2?

The call option's intrinsic value at the end of one year will be either:

(a) Zero if the price of a $100,000 20-year Treasury bond is $90,799.21 (in the scenario that interest rates rise to 9 percent); or

(b) $110,677.54 ‑ $101,000 (strike price) = $9,677.54 if the price of a $100,000 20-year Treasury bond is $110,677.54 (in the scenario that interest rates fall to 7 percent).

The call option's intrinsic value at the end of two years will be either:

(a) Zero if the price of a $100,000 20-year Treasury bond is $82,840.91 (in the scenario that interest rates rise to 10 percent); or

(b) Zero if the price of a $100,000 20-year Treasury bond is $100,000 (in the scenario that interest rates stay at 8 percent); or

(c ) $123,114.77 ‑ $101,000 (strike price) = $22,114.77 if the price of a $100,000 20-year Treasury bond is $123,114.77 (in the scenario that interest rates fall to 6 percent).

f. Diagram the possible option values.



g. What is the option premium? (Use an 8 percent discount factor.)

PV = ($9,677.54 x 0.5)/1.08 + ($22,114.17 x 0.5 x 0.25)/(1.08)2 = $6,850.32

13. Why are options on interest rate futures contracts preferred to options on cash instruments in hedging interest rate risk?

Futures options are preferred to options on the underlying bond because they are more liquid, have less credit risk, are homogeneous, and have the benefit of mark-to-market features common in futures contracts. At the same time, futures options offer the same asymmetric payoff functions of regular puts and calls.

14. Consider Figure 23-13. What are the prices paid for the following futures options:

a. March T-bond calls at $153. => 5 33/64% x $100,000 = $5,515.625 per $100,000 contract.

b. March 10-year T-note puts at $151.50. => 19 26/64% x $100,000

= $19,406.25 per $100,000 contract.

c. December Eurodollar puts at 99.50 percent.

Because the underlying security on options on Eurodollar futures is a 90 day Eurodollar CD, each 1 basis point is equal to $25 ($1m x 0.0001 x 90/360) => 50 bpts x $25

= $1,250 per $1,000,000 contract.

15. Consider Figure 23-13 again. What happens to the price of the following?

a. A call when the exercise price increases. => The call value decreases.

b. A call when the time until expiration increases. => The call value increases.

c. A put when the exercise price increases. => The put value increases.

d. A put when the time to expiration increases. => The put value increases.

16. An FI manager writes a call option on a T-bond futures contract with an exercise price of 11400 at a quoted price of 0-55.

a. What type of opportunities or obligations does the manager have?

The manager is obligated to sell the interest rate futures contract to the call option buyer at the price of $114,000 per $100,000 contract, if the buyer chooses to exercise the option. If the writer does not own the bond at the time of exercise, the bond must be purchased in the market. The call writer receives a premium of $859.375 from the sale of the option.

b. In what direction must interest rates move to encourage the call buyer to exercise the option?

Interest rates must decrease so the market price of the underlying bond increases.

17. What is the delta of an option (δ)?

The delta of an option measures the change in the option value for a $1 change in the value of the underlying asset. The delta of a call option will always be between 0 and 1.0, and the delta of a put option will always be between –1.0 and 0.

18. An FI has a $100 million portfolio of six-year Eurodollar bonds that have an 8 percent coupon. The bonds are trading at par and have a duration of five years. The FI wishes to hedge the portfolio with T-bond options that have a delta of -0.625. The underlying long-term Treasury bonds for the option have a duration of 10.1 years and trade at a market value of $96,157 per $100,000 of par value. Each put option has a premium of $3.25 per $100 of face value.

a. How many bond put options are necessary to hedge the bond portfolio?



b. If interest rates increase 100 basis points, what is the expected gain or loss on the put option hedge?

A $100,000 20-year, eight percent bond selling at $96,157 implies a yield of 8.4 percent.

ΔP = Np x Δp = 824 x (-0.625) x (-10.1) x $96,157 x 0.01/1.084 = $4,614,028 gain

c. What is the expected change in market value on the bond portfolio?

ΔB = -5 x $100,000,000 x 0.01/1.08 = -$4,629,630

d. What is the total cost of placing the hedge?

The price quote of $3.25 is per $100 of face value. Therefore, the cost of one put contract is $3,250, and the cost of the hedge = 824 contracts x $3,250 per contract = $2,678,000.

e. Diagram the payoff possibilities.

The diagram of this portfolio position and the corresponding hedge is given in Figures 23-7 and 23-8.

f. How far must interest rates move before the payoff on the hedge will exactly offset the cost of placing the hedge?

ΔP = 824 x 3,250 = 824 x (-0.625) x (-10.1) x $96,157 x ΔR /1.084

Solving for the change in interest rates gives

ΔR = ($3,250 x 1.084)/(0.625 x 10.1 x $96,157) = 0.005804 or 0.58 percent.

g. How far must interest rates move before the gain on the bond portfolio will exactly offset the cost of placing the hedge?

ΔB = 3,250 x 824 = -5 x $100,000,000 x ΔR /1.08

Again solving for ΔR = ($3,250 x 824 x 1.08)/(5 x $100,000,000) = -.0057845 or -0.58 percent.

h. Summarize the gain, loss, and cost conditions of the hedge on the bond portfolio in terms of changes in interest rates.

If rates increase 0.58 percent, the portfolio will decrease in value approximately equal to the gain on the hedge. This position corresponds to the intersection of the profit function from the put and the X-axis in Figure 23-7. The FI is out the cost of the hedge, which also will be the case for any other increase in interest rates. In effect, the cost of the hedge is the insurance premium to assure the yield on the portfolio at the time the hedge is placed.

If rates decrease approximately 0.58 percent, the gain on the portfolio will offset the cost of the hedge, and the put option will not be exercised. This position is shown by the intersection of the X-axis and the net profit function in Figure 23-8. Any decrease in rates beyond 0.58 percent will generate positive profits for the portfolio in excess of the cost of the hedge.

19. Corporate Bank has $840 million of assets with a duration of 12 years and liabilities worth $720 million with a duration of seven years. Assets and liabilities are yielding 7.56 percent. The bank is concerned about preserving the value of its equity in the event of an increase in interest rates and is contemplating a macrohedge with interest rate options. The call and put options have a delta (δ) of 0.4 and –0.4, respectively. The price of an underlying T-bond is 104.53125 (104 68/128), its duration is 8.17 years, and its yield to maturity is 7.56 percent.

a. What type of option should Corporate Bank use for the macrohedge?

The duration gap for the bank is [12 – (720/840)7] = 6. Therefore, the bank is concerned that interest rates may increase, and it should purchase put options. As rates rise, the value of the bonds underlying the put options will fall, but they will be puttable at the higher put option exercise price.

b. How many options should be purchased?

The bonds underlying the put options have a market value of $104,531.25. Thus,



c. What is the effect on the economic value of the equity if interest rates rise 50 basis points?

The change in equity value is:

ΔE = –DGAPxAx(ΔR/(1+R)) = -6($840,000,000)(.005/1.0756) = -$23,428,784.

d. What will be the effect on the hedge if interest rates rise 50 basis points?

ΔP = Np(‌‌‌|δ| x D x B x ΔR/(1+R)) = 14,754 x 0.4 x 8.17 x $104,531.25 x 0.005/1.0756 = $23,429,185 gain

e. What will be the cost of the hedge if each option has a premium of $0.875 per

$100 of face value?

A price quote of $0.875 is per $100 face value of the put contract. Therefore, the cost per contract is $875, and the cost of the hedge is $875x14,754 = $12,909,750.

f. Diagram the economic conditions of the hedge.

The diagram of this portfolio position and the corresponding hedge is given in Figures 23-7 and 23-8. In this particular case, the profit function for the net long position of the bank (DGAP = 6) should be considered as the profit function of the bond in Figure 23-7.

g. How much must interest rates move against the hedge for the increased value of the bank to offset the cost of the hedge?

Let ΔE = $12,909,750, and solve the equation in part (c) above for ΔR. Then,

ΔR = $12,909,750x1.0756/($840,000,000x(-6)) = -0.002755 or -0.2755 percent.

h. How much must interest rates move in favor of the hedge, or against the balance sheet, before the payoff from the hedge will exactly cover the cost of the hedge?

Use the equation in part (d) above and solve for ΔR. Then,

ΔR = ($12,909,750 x 1.0756)/[14,754 x 0.4 x 8.17 x $104,531.25] = 0.002755 or 0.2755 percent.

i. Formulate a management decision rule regarding the implementation of the hedge.

If rates increase 0.2755 percent, the equity will decrease in value approximately equal to the gain on the hedge. This position corresponds to the intersection of the profit function from the put and the X-axis in Figure 23-7. The FI is out the cost of the hedge, which also will be the case for any other increase in interest rates. In effect, the cost of the hedge is the insurance premium to assure the value of the equity at the time the hedge is placed.

If rates decrease approximately 0.2755 percent, the gain on the equity value will offset the cost of the hedge, and the put option will not be exercised. This position is shown by the intersection of the X-axis and the net profit function in Figure 23-8. Any increase in rates beyond 0.2755 percent will generate positive increases in value for the equity in excess of the cost of the hedge.

20. An FI has a $200 million asset portfolio that has an average duration of 6.5 years. The average duration of its $160 million in liabilities is 4.5 years. Assets and liabilities are yielding 10 percent. The FI uses put options on T-bonds to hedge against unexpected interest rate increases. The average delta (δ) of the put options has been estimated at -0.3 and the average duration of the T-bonds is seven years. The current market value of the T-bonds is $96,000.

a. What is the modified duration of the T-bonds if the current level of interest rates is 10 percent?

*MD* = *D*/(1+0.10) = 7/1.10 = 6.3636 years

b. How many put option contracts should the FI purchase to hedge its exposure against rising interest rates? The face value of the T-bonds is $100,000.

 = [6.5 - 4.5(0.80)] x $200,000,000/[(-0.3) x (-7.0) x (96,000)]

= 2,876.98 or 2,877 contracts

c. If interest rates increase 50 basis points, what will be the change in value of the equity of the FI?

The change in equity value is:

ΔE = –DGAP x A x (ΔR/(1+R)) = -2.9($200,000,000)(0.005/1.10) = -$2,636,364

d. What will be the change in value of the T-bond option hedge position?

ΔP = Np(|δ| x D x B x ΔR/(1=R)) = 2,877 x 0.3 x 7 x $96,000 x 0.005/(1.10) = $2,636,378 gain

e. If put options on T-bonds are selling at a premium of $1.25 per face value of $100, what is the total cost of hedging using options on T-bonds?

Premium on the put options = 2,877 x $1.25 x 1,000 = $3,596,250.

f. Diagram the spot market conditions of the equity and the option hedge.

The diagram of this portfolio position and the corresponding hedge is given in Figures 23-7 and 23-8. In this particular case, the profit function for the net long position of the bank (DGAP = 2.9) should be considered as the profit function of the bond in Figure 23-7.

g. What must be the change in interest rates before the change in value of the balance sheet (equity) will offset the cost of placing the hedge?

Let ΔE = $3,596,250, and solve the equation in part (c) above for ΔR. Then,

ΔR = $3,596,250 x 1.10/($200,000,000 x -2.9) = -0.00682 or -0.68 percent.

h. How much must interest rates change before the profit on the hedge will exactly cover the cost of placing the hedge?

Use the equation in part (d) above and solve for ΔR. Then

ΔR = $3,596,250/[2,877 x (-0.3) x (-6.3636) x $96,000] = 0.00682 or 0.68 percent.

i. Given your answer in part (g), what will be the net gain or loss to the FI?

If rates decrease by 0.68 percent, the increase in value of the equity will exactly offset the cost of placing the hedge. The options will be allowed to expire unused since the price of the bonds will be higher in the market place than the exercise price of the option.

21. A mutual fund plans to purchase $10 million of 20-year T-bonds in two months. The bonds are yielding 7.68 percent. These bonds have a duration of 11 years. The mutual fund is concerned about interest rates changing over the next two months and is considering a hedge with a two-month option on a T-bond futures contract. Two-month calls with a strike price of 105 are priced at 1-25, and puts of the same maturity and exercise price are quoted at 2-09. The delta of the call is 0.5 and the delta of the put is -0.7. The current price of a deliverable T-bond is $103.2500 per $100 of face value, its duration is nine years, and its yield to maturity is 7.68 percent.

a. What type of option should the mutual fund purchase?

The mutual fund is concerned about interest rates falling which would imply that bond prices would increase. Therefore, the FI should buy call options to guarantee a certain purchase price.

b. How many options should it purchase?



c. What is the cost of these options?

The quote for T-bond options is 1-25, or 1 25/64 = $1.390625 per $100 face value. This converts to $1,390.625 per $100,000 option contract. The total cost of the hedge is 237 x $1,390.625 = $329,578.125.

d. If rates change +/-50 basis points, what will be the impact on the price of the desired T-bonds?

For a rate increase, the ΔB = -11 x $10,000,000 x (0.005)/1.0768 = -$510,773. If rates decrease, the value of the bonds will increase by $510,773.

e. What will be the effect on the value of the hedge if rates change +/- 50 basis points?

If rates decrease, the value of the underlying bonds, and thus the option value, increases.

ΔC = Nc(δ x (-D) x B x ΔR/(1+R)) = 237 x 0.5 x (-9) x $103,250x(-0.005/(1.0768)) = $511,312. This occurs because the FI can buy the bonds at the exercise price and sell them at the higher market price. If rates rise, the options will expire without value because the bonds will be priced lower in the market.

f. Diagram the effects of the hedge and the spot market value of the desired T-bonds.

The profit profile of the call option hedge is given in Figure 23-1, and the profile of a long bond is shown in Figure 23-5. The profit profile of the call option is less than the bond by the amount of the premium, but the call option profile illustrates less opportunity for loss.

g. What must be the change in interest rates to cause the change in value of the purchased T-bonds to exactly offset the cost of placing the hedge?

The premium on a $100,000 option is $1,390.625 and the mutual fund purchased 237 option contracts. The yield in the market on the deliverable bond is 7.68 percent. Therefore, from the equation used in part (d), we can solve for ΔR = [1,390.625 x 237 x 1.0768]/[11 x $10,000,000] = 0.003226 or 0.3226 percent. If rates increase 0.3226 percent, the present value of the existing $10,000,000 bond in the market place will decrease by $1,390.625 x 237, or $329,578.125. The savings on the bond purchase will offset the premium on the call option.

22. An FI must make a single payment of 500,000 Swiss francs in six months at the maturity of a CD. The FI’s in-house analyst expects the spot price of the franc to remain stable at the current $0.80/SF. But as a precaution, the analyst is concerned that it could rise as high as $0.85/SF or fall as low as $0.75/SF. Because of this uncertainty, the analyst recommends that the FI hedge the CD payment using either options or futures. Six-month call and put options on the Swiss franc with an exercise price of $0.80/SF are trading at 4 cents and 2 cents per SF, respectively. A six-month futures contract on the Swiss franc is trading at $0.80/SF.

a. Should the analyst be worried about the dollar depreciating or appreciating?

The analyst should be worried about the dollar depreciating.

b. If the FI decides to hedge using options, should the FI buy put or call options to hedge the CD payment? Why?

The analyst should buy call options on Swiss francs, because if the dollar depreciates to $0.85/SF, the call options will be in-the-money.

c. If futures are used to hedge, should the FI buy or sell Swiss franc futures to hedge the payment? Why?

The FI should buy futures, because if the dollar depreciates to $0.85/SF, the cash flows will be positive on the futures position.

d. What will be the net payment on the CD if the selected call or put options are used to hedge the payment? Assume the following three scenarios: the spot price in six months will be $0.75, $0.80 or $0.85/SF. Also assume that the options will be exercised.

Using call options, the net payments are:

Future spot prices $0.75 $0.80 $0.85

Premium on call options (0.04 x 500,000) -$ 20,000 -$ 20,000 -$20,000 Gain/loss on exercise 0 0 +$25,000

Purchase of spot -$375,000 -$400,000 -$425,000

Net payment -$395,000 -$420,000 -$420,000

e. What will be the net payment if futures had been used to hedge the CD payment? Use the same three scenarios as in part (d).

Using futures, the net payments are:

Future Spot prices $0.75 $0.80 $0.85

Gain/loss on futures -$ 25,000 0 $ 25,000

Purchase of spot -$375,000 -$400,000 -$425,000

Net payment -$400,000 -$400,000 -$400,000

f. Which method of hedging is preferable after the fact?

Ex-post it appears that hedging with futures will result in the lowest payments in dollars, at least until the spot reaches $0.76/SF, at which time both net payments will be similar. If the dollar appreciates beyond $0.76/SF, i.e. to $0.74/SF or $0.72/SF, then the option hedge result in lower payments. Once again, this is an ex-post conclusion. Ex-ante, it depends on your projections of the expected future spot rates.

1. An American insurance company issued $10 million of one-year, zero-coupon GICs (guaranteed investment contracts) denominated in Swiss francs at a rate of 5 percent. The insurance company holds no SF‑denominated assets and has neither bought nor sold francs in the foreign exchange market.

a. What is the insurance company's net exposure in Swiss francs?

The net exposure is (0 ‑ $10 million) + (0 ‑ 0) = ‑$10 million (FX assets - FX liabilities plus FX bought minus FX sold).

b. What is the insurance company's risk exposure to foreign exchange rate fluctuations?

The insurance company has SF liabilities (i.e., it is short in the Swiss franc) and is exposed to an appreciation of the Swiss franc.

c. How can the insurance company use futures to hedge the risk exposure in part (b)? How can it use options to hedge?

The insurance company can hedge its risk exposure by entering a long hedge by: (a) buying Swiss franc futures and/or (b) buying Swiss franc call options.

d. If the strike price on SF options is $0.6667/SF and the spot exchange rate is $0.6452/SF, what is the intrinsic value (on expiration) of a call option on Swiss francs? What is the intrinsic value (on expiration) of a Swiss franc put option? (Note: Swiss franc futures options traded on the Chicago Mercantile Exchange are set at SF125,000 per contract.)

Since the strike price is US$0.6667/SF and the spot exchange rate is $0.6452/SF, the put option is in the money, but the call is not. The intrinsic value of the put option is $0.6667 ‑ $0.6452 = $0.0215 per Swiss franc. Since each Swiss franc option is worth SF125,000, each put option's intrinsic value upon expiration is (125,000)($0.0215) = $2,687.50.

e. If the June delivery call option premium is 0.32 cents per franc and the June delivery put option is 10.7 cents per franc, what is the dollar premium cost per contract? Assume that today's date is April 15.

The call option premium is ($0.0032)(125,000) = $400. The put option premium is ($0.107)(125,000) = $13,375.

f. Why is the call option premium lower than the put option premium?

The put option premium is higher because it is in-the-money and the call option is not. However, since there is time until expiration, both options' values exceed their intrinsic values.

24. An FI has made a loan commitment of SF10 million that is likely to be taken down in six months. The current spot exchange rate is $0.60/SF.

a. Is the FI exposed to the dollar depreciating or the dollar appreciating? Why?

The FI is exposed to the dollar depreciating, because it would require more dollars to purchase the SF10 million if the loan is drawn down in six months as expected.

b. If the FI decides to hedge using SF futures, should it buy or sell SF futures?

The FI should buy SF futures if it decides to hedge against a depreciation of the dollar.

c. If the spot rate six months from today is $0.64/SF, what dollar amount is needed in six months if the loan is drawn down?

If the FI had remained unhedged, it would require $0.64 x SF10,000,000 = $6.4 million to make the SF-denominated loan.

d. A six-month SF futures contract is available for $0.61/SF. What is the net amount needed at the end of six months if the FI has hedged using the SF10 million of futures contract? Assume futures prices are equal to spot prices at the time of payment, that is, at maturity.

If the FI has hedged using futures, it will gain ($0.64 - $0.61) x SF10 million = $300,000 on its futures position. Its net payment will be $6.1 million.

e. If the FI decides to use options to hedge, should it purchase call or put options?

It should purchase call options if it has to hedge against the likely draw down.

f. Call and put options with an exercise price of $0.61/SF are selling for $0.02 and $0.03 per SF, respectively. What would be the net amount needed by the FI at the end of six months if it had used options instead of futures to hedge this exposure?

Premium on call options = $0.02 x SF10m = $200,000. Purchase at spot = $0.64 x SF10 million = $6.4 million. Gain on options = $0.03 x SF10 million = $300,000. Its net payment will be $6.3 million.

1. What is a credit spread call option?

A credit spread call option has a payoff that increases as the yield spread against some specified benchmark bond increases above the exercise spread. The increased payoff compensates the lender for decreases in value caused by an increase in the credit risk of the borrower.

1. What is a digital default option?

This option pays a stated amount in the event of a loan default. If the loan is repaid in its entirety, the option expires unexercised.

1. How do the cash flows to the lender for a credit spread call option hedge differ from the cash flows for a digital default option spread?

In both cases, the maximum loss to the call option purchaser is the amount of the premium paid for the option. The digital default option has a one-time, lump-sum cash payment at the time the loan defaults. The payoff for the credit spread option increases as the default risk increases. See Figures 23-17 and 23-18 for a visual illustration of the payoff profiles.

28. What is a catastrophe call spread option? How do the cash flows of this option affect the buyer of the option?

For a premium the purchaser of this option receives a hedge against a range of loss ratios that may occur, where the loss ratio is the amount of losses divided by the insurance premiums. For loss ratios below the minimum in the option, the option expires out-of-the-money. For loss ratios between the minimum and the maximum stated ratios, the option holder receives an increasing payoff as the loss ratio increases. For loss ratios in excess of the maximum ratio in the option, the holder of the option receives a maximum payoff equal to the maximum ratio in the option coverage. Thus, there is a cap or ceiling to the amount of payoff or benefit that can be received from this option.

29. What are caps? Under what circumstances would the buyer of a cap receive a payoff?

A cap is a call option on interest rates. If market interest rates rise above some stated amount, the writer of the option pays to the holder the excess interest on some amount of money. For this insurance, the buyer of the option pays a premium. This option would be a valuable interest rate risk management vehicle for an FI that is borrowing money in the variable rate market.

30. What are floors? Under what circumstances would the buyer of a floor receive a payoff?

A floor is a put option on interest rates. The buyer receives a minimum interest rate should market rates fall below some minimum level. This option would be a valuable interest rate risk management vehicle for an FI that is lending money in the variable rate market.

31. What are collars? Under what circumstances would an FI use a collar?

A collar is a combination of a cap and a floor. An FI that is borrowing money in the variable rate market and lending money at variable rates might find it useful to buy a cap and to buy a floor if they perceive interest rates to be extremely volatile. The closer are the exercise prices of the two options, the greater will be the premiums paid on the options.

32. How is buying a cap similar to buying a call option on interest rates?

If interest rates increase above the exercise rate, the buyer of the cap has the right to call or purchase money at the exercise interest rate rather than paying the higher rate in the market. If interest rates decrease, the buyer of the cap is not obligated to take a loss by calling the cap.

33. Under what balance sheet circumstances would it be desirable to sell a floor to help finance a cap? When would it be desirable to sell a cap to help finance a floor?

An FI that is funding fixed-rate assets with floating-rate liabilities may find it valuable to buy a cap for the purpose of protecting against increases in interest rates on the funding side of the balance sheet. This cap may be funded in part by selling a floor if the FI is confident that interest rates will not decrease below the floor exercise price. It would be desirable to sell a cap and to buy a floor if interest rates are volatile downward and the FI has a positive duration gap.

34. Use the following information to price a three-year collar by purchasing an in-the-money cap and writing an out-of-the-money floor. Assume a binomial options pricing model with an equal probability of interest rates increasing 2 percent or decreasing 2 percent per year. Current rates are 7 percent, the cap rate is 7 percent, and the floor rate is 4 percent. The notional value is $1 million. All interest payments are annual payments as a percent of notional value, and all payments are made at the end of year 2 and the end of year 3.

7% Cap Valuation

***t* = 1 *t* = 2 (beg.) *t* = 2 (end) *t* = 3 (beg.) *t* = 3 (end)**

11% (0.25) $40,000

9% (0.50) $20,000

**7% spot**  7% (0.50) $0

5% (0.50) $0

3% 0.25) $0

Cap price = 0.50 ($20,000)/(1.07)(1.09)+0.25($40,000)/(1.07)(1.09)(1.11) = $16,298.56

Note: If interest rates are 9%, the cap is in-the-money with an interest rate differential (over the cap rate) of 2%. Two percent of $1 million face value equals $20,000.

4% Floor Valuation

***t* = 1 *t* = 2 (beg.) *t* = 2(end) *t* = 3(beg.) *t* = 3(end)**

11% (0.25) $0

9% (0.50) $0

**7% spot** 7% (0.50) $0

5% (0.50) $0

3% (0.25) $10,000

Floor price = 0.25 ($10,000)/(1.07)(1.05)(1.03) = $2,160.37

The cost of the collar = cap price - floor price = $16,298.56 - $2,160.37 = $14,138.19

35. Use the following information to price a three-year collar by purchasing an out-of-the-money cap and writing an in-the-money floor. Assume a binomial options pricing model with an equal probability of interest rates increasing 2 percent or decreasing 2 percent per year. Current rates are 4 percent, the cap rate is 7 percent, and the floor rate is 4 percent. The notional value is $1 million. All interest payments are annual payments as a percent of notional value, and all payments are made at the end of year 2 and the end of year 3.

7% Cap Valuation

***t* = 1 *t* = 2 (beg.) *t* = 2 (end) *t* = 3 (beg.) *t* = 3 (end)**

8% (0.25) $10,000

6% (0.50) $0

4**% spot**  4% (0.50) $0

2% (0.50) $0

0% (0.25) $0

Cap price = 0.25 ($10,000)/ (1.04)(1.06)(1.08)=$2,099.80

4% Floor Valuation

***t* = 1 *t* = 2 (beg.) *t* = 2 (end) *t* = 3 (beg.) *t* = 3 (end)**

8% (0.25) $0

6% (0.50) $0

**4% spot** 4% (0.50) $0

2% (0.50) $20,000

0% (0.25) $40,000

Floor price = 0.50 ($20,000)/(1.04)(1.02) +0.25($40,000)/(1.04)(1.02)(1.00) = $18,853.70

The cost of the collar = cap price - floor price = $2,099.80 - $18,853.70 = -$16,753.90

36. Contrast the total cash flows associated with the collar position in question 34 against the collar in question 35. Do the goals of FIs that utilize the collar in question 34 differ from those that put on the collar in question 35? If so, how?

The collar in problem 34 is used as an interest rate hedge. The collar in problem 35 is a source of fee income for the bank. The collar in problem 34 purchases a lot of insurance against increasing interest rates. For that reason it is expensive. The collar in problem 35 purchases very little insurance against increasing interest rates. For that reason it is a less expensive hedge than the collar in problem 34.

37. An FI has purchased a $200 million cap of 9 percent at a premium of 0.65 percent of face value. A $200 million floor of 4 percent is also available at a premium of 0.69 percent of face value.

a. If interest rates rise to 10 percent, what is the amount received by the FI? What are the net savings after deducting the premium?

Premium for purchasing the cap = 0.0065 x $200 million = $1,300,000. If interest rates rise to 10 percent, cap purchasers receive $200 million x 0.01 = $2,000,000. The net savings is $700,000.

b. If the FI also purchases a floor, what are the net savings if interest rates rise to 11 percent? What are the net savings if interest rates fall to 3 percent?

If the FI also purchases the floor: Premium = 0.0069 x $200 million = $1,380,000, and the total premium = $1,380,000 + $1,300,000 = $2,680,000.

If interest rates rise to 11 percent, the cap purchaser receives 0.02 x $200m = $4,000,000, and the net savings = $4,000,000 - $2,680,000 = $1,320,000.

If interest rates fall to 3 percent, the floor purchaser receives 0.01 x $200 million = $2,000,000, and the net savings = $2,000,000 - $2,680,000 = -$680,000.

c. If, instead, the FI sells (writes) the floor, what are the net savings if interest rates rise to 11 percent? What if they fall to 3 percent?

If the FI sells the floor, it receives net $1,380,000 minus the cost of the cap of $1,300,000 = +$80,000.

If interest rates rise to 11 percent, cap purchasers receive 0.02 x $200m = $4,000,000. The net the net savings = $4,000,000 + $80,000 = $4,080,000.

If interest rates fall to 3 percent, floor purchasers receive 0.01 x $200 million = $2,000,000. The net savings to the FI = $-2,000,000 + 80,000 = -$1,920,000.

d. What amount of floors should the FI sell in order to compensate for its purchases of caps, given the above premiums?

The FI needs to sell: NVf x 0.0069 = $1,300,000, or NVf = $188,405,795 worth of 4 percent floors.

38. What credit risk exposure is involved with buying caps, floors, and collars for hedging purposes?

These hedging vehicles are over-the-counter contracts that have counterparty credit risk not present with exchange-traded futures and options contracts. Because contracts often are long-term in nature, a default at the end of any one year may mean that the FI (a) loses the benefits expected at that time, (b) must incur additional costs of arranging additional coverage for the remaining years of the original contract, and (c) may pay less favorable premiums because of changes in the market.

**Integrated Mini Case: Hedging Interest Rate Risk with Futures versus Options**

On January 4, 2015, an FI has the following balance sheet (rates = 10 percent)

Assets Liabilities/Equity

A 200m DA = 6 years L 170m DL = 4 years

E 30m

DGAP = [6 – (170/200)4] = 2.6 years > 0

## The FI manager thinks rates will increase by 0.75 percent in the next three months. If this happens, the equity value will change by:



The FI manager will hedge this interest rate risk with either futures contracts or option contracts.

If the FI uses futures, it will select June T-bonds to hedge. The duration on the T-bonds underlying the contract is 14.5 years, and the T-bonds are selling at a price of $114.34375 per $100, or $114,343.75. T-bond futures rates, currently 9 percent, are expected to increase by 1.25 percent over the next three months.

If the FI uses options, it will buy puts on 15-year T-bonds with a June maturity, an exercise price of 113, and an option premium of 1 percent. The spot price on the T-bond underlying the option is $135.71875 per $100 of face value. The duration on the T-bonds underlying the options is 14.5 years, and the delta of the put options is -0.75. Managers expect these T-bond rates to increase by 1.24 percent from 7.875 percent in the next three months.

If by April 4, 2015, balance sheet rates increase by 0.8 percent, futures rates by 1.4 percent, and T-bond rates underlying the option contract by 1.3 percent, would the FI have been better off using the futures contract or the option contract as its hedge instrument?

For the hedge with futures contracts:

  contracts

On April 4, 2015, as the FI gets out of the futures hedge:

Loss on balance sheet Gain off balance sheet (futures)

 

 

The net gain is $3,970,909 - $3,781,818 = $189,091

For a hedge with option contracts:

,  contracts

On April 4, 2015, as the FI gets out of the option hedge:

Loss on balance sheet Gain off balance sheet (options)

 =  =

-$3,781,818 $3,717,009

The net gain is $3,621,701 - $3,717,009 = -$64,809

In this case, the FI would be better off hedging with futures contracts rather than option contracts.

If by April 4, 2015, balance sheet rates actually fall by 0.75 percent, futures rates fall by 1.05 percent, and T-bond rates underlying the option contract fall by 1.24 percent, would the FI have been better off using the futures contract or the option contract as its hedge instrument?

For the hedge with futures contracts:

  contracts

On April 4, 2015, as the FI gets out of the futures hedge:

Loss on balance sheet Gain off balance sheet (futures)

 

 

The net gain is $3,545,454 - $2,978,182 = $567,272

For a hedge with option contracts:

,  contracts

On April 4, 2015, as the FI gets out of the option hedge, the value of the T-bond underlying the put option has increased. The FI does not have to exercise these options if the loss on exercise is greater than the option premium. Thus:

Loss on balance sheet Gain off balance sheet (options)

 Exercise: =

= $3,545,454 -$3,545,454

No exercise: ΔO=208.9786545×100,000×(-1 36/64%)

= -$326,529

The FI will not exercise the options, taking the loss. Rather, it will let the options expire unused. Thus, the net gain is $3,545,454 - $326,529 = $3,218,925

In this case, the FI would be much better off hedging with option contracts rather than futures contracts.