

CHAPTER 7 FUTURES AND OPTIONS ON FOREIGN EXCHANGE
SUGGESTED ANSWERS AND SOLUTIONS TO END-OF-CHAPTER
QUESTIONS AND PROBLEMS

QUESTIONS

1. Explain the basic differences between the operation of a currency forward market and a futures market.

Answer: The forward market is an OTC market where the forward contract for purchase or sale of foreign currency is tailor-made between the client and its international bank. No money changes hands until the maturity date of the contract when delivery and receipt are typically made. A futures contract is an exchange-traded instrument with standardized features specifying contract size and delivery date. Futures contracts are marked-to-market daily to reflect changes in the settlement price. Delivery is seldom made in a futures market. Rather a reversing trade is made to close out a long or short position.

2. In order for a derivatives market to function most efficiently, two types of economic agents are needed: hedgers and speculators. Explain.

Answer: Two types of market participants are necessary for the efficient operation of a derivatives market: **speculators** and **hedgers**. A speculator attempts to profit from a change in the futures price. To do this, the speculator will take a long or short position in a futures contract depending upon his expectations of future price movement. A hedger, on-the-other-hand, desires to avoid price variation by locking in a purchase price of the underlying asset through a long position in a futures contract or a sales price through a short position. In effect, the hedger passes off the risk of price variation to the speculator who is better able, or at least more willing, to bear this risk.

3. Why are most futures positions closed out through a reversing trade rather than held to delivery?

Answer: In forward markets, approximately 90 percent of all contracts that are initially established result in the short making delivery to the long of the asset underlying the contract. This is natural because the terms of forward contracts are tailor-made between the long and short. By contrast, only about one percent of currency futures contracts result in delivery. While futures contracts are useful for speculation and hedging, their

standardized delivery dates make them unlikely to correspond to the actual future dates when foreign exchange transactions will occur. Thus, they are generally closed out in a reversing trade. In fact, the commission that buyers and sellers pay to transact in the futures market is a single amount that covers the round-trip transactions of initiating and closing out the position.

4. How can the FX futures market be used for price discovery?

Answer: To the extent that FX forward prices are an unbiased predictor of future spot exchange rates, the market anticipates whether one currency will appreciate or depreciate versus another. Because FX futures contracts trade in an expiration cycle, different contracts expire at different periodic dates into the future. The pattern of the prices of these contracts provides information as to the market's current belief about the relative future value of one currency versus another at the scheduled expiration dates of the contracts. One will generally see a steadily appreciating or depreciating pattern; however, it may be mixed at times. Thus, the futures market is useful for *price discovery*, i.e., obtaining the market's forecast of the spot exchange rate at different future dates.

5. What is the major difference in the obligation of one with a long position in a futures (or forward) contract in comparison to an options contract?

Answer: A futures (or forward) contract is a vehicle for buying or selling a stated amount of foreign exchange at a stated price per unit at a specified time in the future. If the long holds the contract to the delivery date, he pays the effective contractual futures (or forward) price, regardless of whether it is an advantageous price in comparison to the spot price at the delivery date. By contrast, an option is a contract giving the long the right to buy or sell a given quantity of an asset at a specified price at some time in the future, but not enforcing any obligation on him if the spot price is more favorable than the exercise price. Because the option owner does not have to exercise the option if it is to his disadvantage, the option has a price, or premium, whereas no price is paid at inception to enter into a futures (or forward) contract.

6. What is meant by the terminology that an option is in-, at-, or out-of-the-money?

Answer: A call (put) option with $S_t > E$ ($E > S_t$) is referred to as trading in-the-money. If $S_t \cong E$ the option is trading at-the-money. If $S_t < E$ ($E < S_t$) the call (put) option is trading *out-of-the-money*.

7. List the arguments (variables) of which an FX call or put option model price is a function. How does the call and put premium change with respect to a change in the arguments?

Answer: Both call and put options are functions of only six variables: S , E , r_i , r_s , T and σ . When all else remains the same, the price of a European FX call (put) option will increase:

1. the larger (smaller) is S ,
2. the smaller (larger) is E ,
3. the smaller (larger) is r_i ,
4. the larger (smaller) is r_s ,
5. the larger (smaller) r_s is relative to r_i , and
6. the greater is σ .

When r_s and r_i are not too much different in size, a European FX call and put will increase in price when the option term-to-maturity increases. However, when r_s is very much larger than r_i , a European FX call will increase in price, but the put premium will decrease, when the option term-to-maturity increases. The opposite is true when r_i is very much greater than r_s . For American FX options the analysis is less complicated. Since a longer term American option can be exercised on any date that a shorter term option can be exercised, or a some later date, it follows that the all else remaining the same, the longer term American option will sell at a price at least as large as the shorter term option.

PROBLEMS

1. Assume today's settlement price on a CME EUR futures contract is \$1.3140/EUR. You have a short position in one contract. Your performance bond account currently has a balance of \$1,700. The next three days' settlement prices are \$1.3126, \$1.3133, and \$1.3049. Calculate the changes in the performance bond account from daily marking-to-market and the balance of the performance bond account after the third day.

Solution: $\$1,700 + [(\$1.3140 - \$1.3126) + (\$1.3126 - \$1.3133) + (\$1.3133 - \$1.3049)] \times \text{EUR}125,000 = \$2,837.50$,
where EUR125,000 is the contractual size of one EUR contract.

2. Do problem 1 again assuming you have a long position in the futures contract.

Solution: $\$1,700 + [(\$1.3126 - \$1.3140) + (\$1.3133 - \$1.3126) + (\$1.3049 - \$1.3133)] \times \text{EUR}125,000 = \562.50 ,
where EUR125,000 is the contractual size of one EUR contract.

With only \$562.50 in your performance bond account, you would experience a margin call requesting that additional funds be added to your performance bond account to bring the balance back up to the initial performance bond level.

3. Using the quotations in Exhibit 7.3, calculate the face value of the open interest in the March 2008 Swiss franc futures contract.

Solution: $66,265 \text{ contracts} \times \text{SF}125,000 = \text{SF}8,283,125,000$.
where SF125,000 is the contractual size of one SF contract.

4. Using the quotations in Exhibit 7.3, note that the March 2008 Mexican peso futures contract has a price of \$0.90975 per 10MXN. You believe the spot price in March will be \$0.97500 per 10MXN. What speculative position would you enter into to attempt to profit from your beliefs? Calculate your anticipated profits, assuming you take a position in three contracts. What is the size of your profit (loss) if the futures price is indeed an unbiased predictor of the future spot price and this price materializes?

Solution: If you expect the Mexican peso to rise from \$0.90975 to \$0.97500 per 10 MXN, you would take a long position in futures since the futures price of \$0.90975 is less than your expected spot price.

Your anticipated profit from a long position in three contracts is: $3 \times (\$0.97500 - \$0.90975) \times \text{MP}500,000 = \$9,787.50$, where MXN500,000 is the contractual size of one MXN contract.

If the futures price is an unbiased predictor of the expected spot price, the expected spot price is the futures price of \$0.90975 per 10 MXN. If this spot price materializes, you will not have any profits or losses from your short position in three futures contracts: $3 \times (\$0.90975 - \$0.90975) \times \text{MP}500,000 = 0$.

5. Do problem 4 again assuming you believe the March 2008 spot price will be \$0.77500 per 10 MXN.

Solution: If you expect the Mexican peso to depreciate from \$0.90975 to \$0.77500 per 10 MXN, you would take a short position in futures since the futures price of \$0.90975 is greater than your expected spot price.

Your anticipated profit from a short position in three contracts is: $3 \times (\$0.90975 - \$0.77500) \times \text{MP}500,000 = \$20,212.50$.

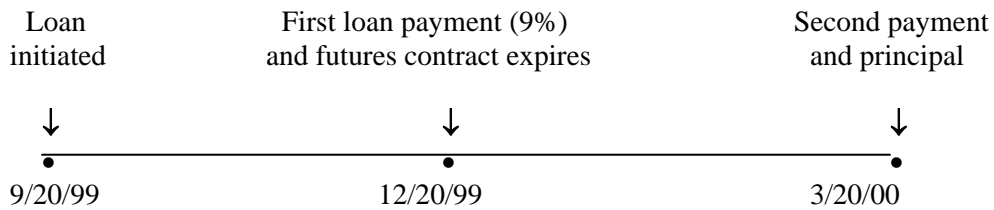
If the futures price is an unbiased predictor of the future spot price and this price materializes, you will not profit or lose from your long futures position.

6. George Johnson is considering a possible six-month \$100 million LIBOR-based, floating-rate bank loan to fund a project at terms shown in the table below. Johnson fears a possible rise in the LIBOR rate by December and wants to use the December Eurodollar futures contract to hedge this risk. The contract expires December 20, 1999, has a US\$ 1 million contract size, and a discount yield of 7.3 percent.

Johnson will ignore the cash flow implications of marking to market, initial margin requirements, and any timing mismatch between exchange-traded futures contract cash flows and the interest payments due in March.

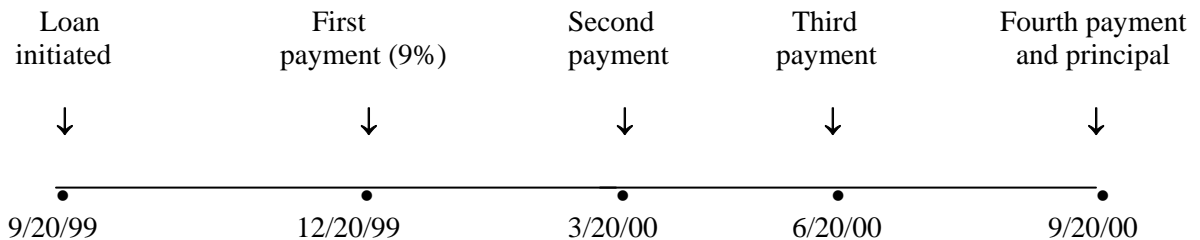
Loan Terms

September 20, 1999	December 20, 1999	March 20, 2000
<ul style="list-style-type: none"> • Borrow \$100 million at September 20 LIBOR + 200 basis points (bps) • September 20 LIBOR = 7% 	<ul style="list-style-type: none"> • Pay interest for first three months • Roll loan over at December 20 LIBOR + 200 bps 	<ul style="list-style-type: none"> • Pay back principal plus interest



a. Formulate Johnson's September 20 floating-to-fixed-rate strategy using the Eurodollar future contracts discussed in the text above. Show that this strategy would result in a fixed-rate loan, assuming an increase in the LIBOR rate to 7.8 percent by December 20, which remains at 7.8 percent through March 20. Show all calculations.

Johnson is considering a 12-month loan as an alternative. This approach will result in two additional uncertain cash flows, as follows:



b. Describe the strip hedge that Johnson could use and explain how it hedges the 12-month loan (specify number of contracts). No calculations are needed.

CFA Guideline Answer

a. The basis point value (BPV) of a Eurodollar futures contract can be found by substituting the contract specifications into the following money market relationship:

$$\begin{aligned}\text{BPV}_{\text{FUT}} = \text{Change in Value} &= (\text{face value}) \times (\text{days to maturity} / 360) \times (\text{change in yield}) \\ &= (\$1 \text{ million}) \times (90 / 360) \times (.0001) \\ &= \$25\end{aligned}$$

The number of contract, N, can be found by:

$$\begin{aligned}N &= (\text{BPV}_{\text{spot}}) / (\text{BPV}_{\text{futures}}) \\ &= (\$2,500) / (\$25) \\ &= 100\end{aligned}$$

OR

$$\begin{aligned}N &= (\text{value of spot position}) / (\text{face value of each futures contract}) \\ &= (\$100 \text{ million}) / (\$1 \text{ million}) \\ &= 100\end{aligned}$$

OR

$$\begin{aligned}N &= (\text{value of spot position}) / (\text{value of futures position}) \\ &= (\$100,000,000) / (\$981,750) \\ &\text{where value of futures position} = \$1,000,000 \times [1 - (0.073 / 4)] \\ &\approx 102 \text{ contracts}\end{aligned}$$

Therefore on September 20, Johnson would sell 100 (or 102) December Eurodollar futures contracts at the 7.3 percent yield. The implied LIBOR rate in December is 7.3 percent as indicated by the December Eurofutures discount yield of 7.3 percent. Thus a borrowing rate of 9.3 percent (7.3 percent + 200 basis points) can be locked in if the hedge is correctly implemented.

A rise in the rate to 7.8 percent represents a 50 basis point (bp) increase over the implied LIBOR rate. For a 50 basis point increase in LIBOR, the cash flow on the short futures position is:

$$\begin{aligned}&= (\$25 \text{ per basis point per contract}) \times 50 \text{ bp} \times 100 \text{ contracts} \\ &= \$125,000.\end{aligned}$$

However, the cash flow on the floating rate liability is:

$$\begin{aligned}&= -0.098 \times (\$100,000,000 / 4) \\ &= -\$2,450,000.\end{aligned}$$

Combining the cash flow from the hedge with the cash flow from the loan results in a net outflow of \$2,325,000, which translates into an annual rate of 9.3 percent:

$$= (\$2,325,000 \times 4) / \$100,000,000 = 0.093$$

This is precisely the implied borrowing rate that Johnson locked in on September 20. Regardless of the LIBOR rate on December 20, the net cash outflow will be \$2,325,000, which translates into an annualized rate of 9.3 percent. Consequently, the floating rate liability has been converted to a fixed rate liability in the sense that the interest rate uncertainty associated with the March 20 payment (using the December 20 contract) has been removed as of September 20.

b. In a strip hedge, Johnson would sell 100 December futures (for the March payment), 100 March futures (for the June payment), and 100 June futures (for the September payment). The objective is to hedge each interest rate payment separately using the appropriate number of contracts. The problem is the same as in Part A except here three cash flows are subject to rising rates and a strip of futures is used to hedge this interest rate risk. This problem is simplified somewhat because the cash flow mismatch between the futures and the loan payment is ignored. Therefore, in order to hedge each cash flow, Johnson simply sells 100 contracts for each payment. The strip hedge transforms the floating rate loan into a strip of fixed rate payments. As was done in Part A, the fixed rates are found by adding 200 basis points to the implied forward LIBOR rate indicated by the discount yield of the three different Eurodollar futures contracts. The fixed payments will be equal when the LIBOR term structure is flat for the first year.

7. Jacob Bower has a liability that:

- has a principal balance of \$100 million on June 30, 1998,
- accrues interest quarterly starting on June 30, 1998,
- pays interest quarterly,
- has a one-year term to maturity, and
- calculates interest due based on 90-day LIBOR (the London Interbank Offered Rate).

Bower wishes to hedge his remaining interest payments against changes in interest rates.

Bower has correctly calculated that he needs to sell (short) 300 Eurodollar futures contracts to accomplish the hedge. He is considering the alternative hedging strategies outlined in the following table.

**Initial Position (6/30/98) in
90-Day LIBOR Eurodollar Contracts**

<i>Contract Month</i>	<i>Strategy A (contracts)</i>	<i>Strategy B (contracts)</i>
September 1998	300	100
December 1998	0	100
March 1999	0	100

- a. Explain why strategy B is a more effective hedge than strategy A when the yield curve undergoes an instantaneous nonparallel shift.

- b. Discuss an interest rate scenario in which strategy A would be superior to strategy B.

CFA Guideline Answer

a. Strategy B's Superiority

Strategy B is a strip hedge that is constructed by selling (shorting) 100 futures contracts maturing in each of the next three quarters. With the strip hedge in place, each quarter of the coming year is hedged against shifts in interest rates for that quarter. The reason Strategy B will be a more effective hedge than Strategy A for Jacob Bower is that Strategy B is likely to work well whether a parallel shift or a nonparallel shift occurs over the one-year term of Bower's liability. That is, regardless of what happens to the term structure, Strategy B structures the futures hedge so that the rates reflected by the Eurodollar futures cash price match the applicable rates for the underlying liability—the 90-day LIBOR-based rate on Bower's liability. The same is not true for Strategy A. Because Jacob Bower's liability carries a floating interest rate that resets quarterly, he needs a strategy that provides a series of three-month hedges. Strategy A will need to be restructured when the three-month September contract expires. In particular, if the yield curve twists upward (futures yields rise more for distant expirations than for near expirations), Strategy A will produce inferior hedge results.

b. Scenario in Which Strategy A is Superior

Strategy A is a stack hedge strategy that initially involves selling (shorting) 300 September contracts. Strategy A is rarely better than Strategy B as a hedging or risk-reduction strategy. Only from the perspective of favorable cash flows is Strategy A better than Strategy B. Such cash flows occur only in certain interest rate scenarios. For example Strategy A will work as well as Strategy B for Bower's liability if interest rates (instantaneously) change in parallel fashion. Another interest rate scenario where Strategy A outperforms Strategy B is one in which the yield curve rises but with a twist so that futures yields rise more for near expirations than for distant expirations. Upon expiration of the September contract, Bower will have to roll out his hedge by selling 200 December contracts to hedge the remaining interest payments. This action will have the effect that the cash flow from Strategy A will be larger than the cash flow from Strategy B because the appreciation on the 300 short September futures contracts will be larger than the cumulative appreciation in the 300 contracts shorted in Strategy B (i.e., 100 September, 100 December, and 100 March). Consequently, the cash flow from Strategy A will more than offset the increase in the interest payment on the liability, whereas the cash flow from Strategy B will exactly offset the increase in the interest payment on the liability.

8. Assume that the Japanese yen is trading at a spot price of 92.04 cents per 100 yen. Further assume that the premium of an American call (put) option with a striking price of 93 is 2.10 (2.20) cents. Calculate the intrinsic value and the time value of the call and put options.

Solution: Premium - Intrinsic Value = Time Value

Call: $2.10 - \text{Max}[92.04 - 93.00 = -.96, 0] = 2.10$ cents per 100 yen

Put: $2.20 - \text{Max}[93.00 - 92.04 = .96, 0] = 1.24$ cents per 100 yen

9. Assume spot Swiss franc is \$0.7000 and the six-month forward rate is \$0.6950. What is the minimum price that a six-month American call option with a striking price of \$0.6800 should sell for in a rational market? Assume the annualized six-month Eurodollar rate is 3 ½ percent.

Solution:

Note to Instructor: A complete solution to this problem relies on the boundary expressions presented in footnote 3 of the text of Chapter 7.

$$C_a \geq \text{Max}[(70 - 68), (69.50 - 68)/(1.0175), 0]$$

$$\geq \text{Max}[2, 1.47, 0] = 2 \text{ cents}$$

10. Do problem 9 again assuming an American put option instead of a call option.

$$\text{Solution: } P_a \geq \text{Max}[(68 - 70), (68 - 69.50)/(1.0175), 0]$$

$$\geq \text{Max}[-2, -1.47, 0] = 0 \text{ cents}$$

11. Use the European option-pricing models developed in the chapter to value the call of problem 9 and the put of problem 10. Assume the annualized volatility of the Swiss franc is 14.2 percent. This problem can be solved using the FXOPM.xls spreadsheet.

Solution:

$$d_1 = [\ln(69.50/68) + .5(.142)^2(.50)]/(.142)\sqrt{.50} = .2675$$

$$d_2 = d_1 - .142\sqrt{.50} = .2675 - .1004 = .1671$$

$$N(d_1) = .6055$$

$$N(d_2) = .5664$$

$$N(-d_1) = .3945$$

$$N(-d_2) = .4336$$

$$C_e = [69.50(.6055) - 68(.5664)]e^{-(.035)(.50)} = 3.51 \text{ cents}$$

$$P_e = [68(.4336) - 69.50(.3945)]e^{-(.035)(.50)} = 2.03 \text{ cents}$$

12. Use the binomial option-pricing model developed in the chapter to value the call of problem 9.

The volatility of the Swiss franc is 14.2 percent.

Solution: The spot rate at T will be either $77.39\text{¢} = 70.00\text{¢}(1.1056)$ or $63.32\text{¢} = 70.00\text{¢}(.9045)$, where $u = e^{.142\sqrt{.50}} = 1.1056$ and $d = 1/u = .9045$. At the exercise price of $E = 68$, the option will only be exercised at time T if the Swiss franc appreciates; its exercise value would be $C_{uT} = 9.39\text{¢} = 77.39\text{¢} - 68$. If the Swiss franc depreciates it would not be rational to exercise the option; its value would be $C_{dT} = 0$.

The hedge ratio is $h = (9.39 - 0)/(77.39 - 63.32) = .6674$.

Thus, the call premium is:

$$C_0 = \text{Max}\{[69.50(.6674) - 68((70/68)(.6674 - 1) + 1)]/(1.0175), 70 - 68\}$$

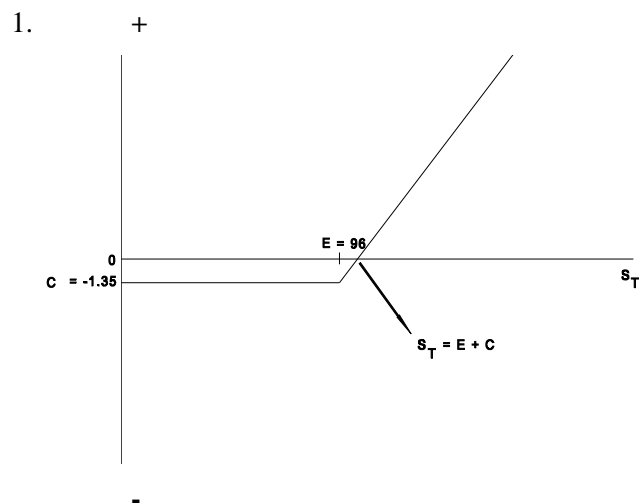
$$= \text{Max}[1.64, 2] = 2 \text{ cents per SF.}$$

MINI CASE: THE OPTIONS SPECULATOR

A speculator is considering the purchase of five three-month Japanese yen call options with a striking price of 96 cents per 100 yen. The premium is 1.35 cents per 100 yen. The spot price is 95.28 cents per 100 yen and the 90-day forward rate is 95.71 cents. The speculator believes the yen will appreciate to \$1.00 per 100 yen over the next three months. As the speculator's assistant, you have been asked to prepare the following:

1. Graph the call option cash flow schedule.
2. Determine the speculator's profit if the yen appreciates to \$1.00/100 yen.
3. Determine the speculator's profit if the yen only appreciates to the forward rate.
4. Determine the future spot price at which the speculator will only break even.

Suggested Solution to the Options Speculator:



2. $(5 \times \text{¥}6,250,000) \times [(100 - 96) - 1.35]/10000 = \$8,281.25$.

3. Since the option expires out-of-the-money, the speculator will let the option expire worthless. He will only lose the option premium.

4. $S_T = E + C = 96 + 1.35 = 97.35$ cents per 100 yen.