

and D. Wilford, *Managing Financial Risk* (McGraw-Hill, 1998); and S. Sundaresan, *Fixed Income Markets and Their Derivatives* (Academic Press, 2009).

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For an in-depth treatment of the use of forwards, futures, and options for risk management, see the following text: R. McDonald, *Derivatives Markets* (Pearson, 2012).

These two articles integrate risk management and the overall strategy of the firm: K. Froot, D. Scharfstein, and J. Stein, "A Framework for Risk Management," *Harvard Business Review* 72 (November–December 1994): 59–71; and P. Tufano, "How Financial Engineering Can Advance Corporate Strategy," *Harvard Business Review* (January–February 1996).

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## Problems

All problems are available in MyFinanceLab.

### Insurance

1. The William Companies (WMB) owns and operates natural gas pipelines that deliver 12% of the natural gas consumed in the United States. WMB is concerned that a major hurricane could disrupt its Gulfstream pipeline, which runs 691 miles through the Gulf of Mexico. In the event


of a disruption, the firm anticipates a loss of profits of \$65 million. Suppose the likelihood of a disruption is 3% per year, and the beta associated with such a loss is  $-0.25$ . If the risk-free interest rate is 5% and the expected return of the market is 10%, what is the actuarially fair insurance premium?

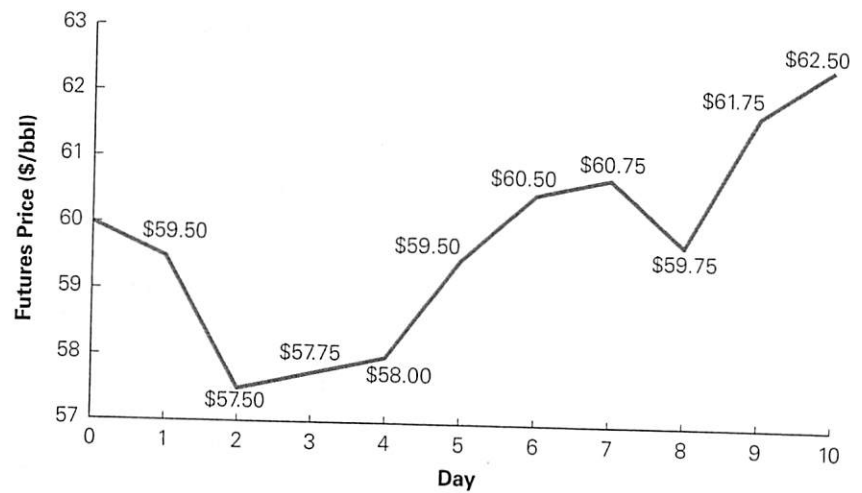
2. Genentech's main facility is located in South San Francisco. Suppose that Genentech would experience a direct loss of \$450 million in the event of a major earthquake that disrupted its operations. The chance of such an earthquake is 2% per year, with a beta of  $-0.5$ .
  - a. If the risk-free interest rate is 5% and the expected return of the market is 10%, what is the actuarially fair insurance premium required to cover Genentech's loss?
  - b. Suppose the insurance company raises the premium by an additional 15% over the amount calculated in part (a) to cover its administrative and overhead costs. What amount of financial distress or issuance costs would Genentech have to suffer if it were not insured to justify purchasing the insurance?
3. Your firm imports manufactured goods from China. You are worried that U.S.–China trade negotiations could break down next year, leading to a moratorium on imports. In the event of a moratorium, your firm expects its operating profits to decline substantially and its marginal tax rate to fall from its current level of 40% to 10%.

An insurance firm has agreed to write a trade insurance policy that will pay \$500,000 in the event of an import moratorium. The chance of a moratorium is estimated to be 10%, with a beta of  $-1.5$ . Suppose the risk-free interest rate is 5% and the expected return of the market is 10%.

- a. What is the actuarially fair premium for this insurance?
  - b. What is the NPV of purchasing this insurance for your firm? What is the source of this gain?
4. Your firm faces a 9% chance of a potential loss of \$10 million next year. If your firm implements new policies, it can reduce the chance of this loss to 4%, but these new policies have an upfront cost of \$100,000. Suppose the beta of the loss is 0, and the risk-free interest rate is 5%.
    - a. If the firm is uninsured, what is the NPV of implementing the new policies?
    - b. If the firm is fully insured, what is the NPV of implementing the new policies?
    - c. Given your answer to part (b), what is the actuarially fair cost of full insurance?
    - d. What is the minimum-size deductible that would leave your firm with an incentive to implement the new policies?
    - e. What is the actuarially fair price of an insurance policy with the deductible in part (d)?

### Commodity Price Risk

5. BHP Billiton is the world's largest mining firm. BHP expects to produce 2 billion pounds of copper next year, with a production cost of \$0.90 per pound.
  - a. What will be BHP's operating profit from copper next year if the price of copper is \$1.25, \$1.50, or \$1.75 per pound, and the firm plans to sell all of its copper next year at the going price?
  - b. What will be BHP's operating profit from copper next year if the firm enters into a contract to supply copper to end users at an average price of \$1.45 per pound?
  - c. What will be BHP's operating profit from copper next year if copper prices are described as in part (a), and the firm enters into supply contracts as in part (b) for only 50% of its total output?
  - d. Describe situations for which each of the strategies in parts (a), (b), and (c) might be optimal.
6.  Your utility company will need to buy 100,000 barrels of oil in 10 days' time, and it is worried about fuel costs. Suppose you go long 100 oil futures contracts, each for 1000 barrels of oil, at the current futures price of \$60 per barrel. Suppose futures prices change each day as follows:



- What is the mark-to-market profit or loss (in dollars) that you will have on each date?
  - What is your total profit or loss after 10 days? Have you been protected against a rise in oil prices?
  - What is the largest cumulative loss you will experience over the 10-day period? In what case might this be a problem?
7. Suppose Starbucks consumes 100 million pounds of coffee beans per year. As the price of coffee rises, Starbucks expects to pass along 60% of the cost to its customers through higher prices per cup of coffee. To hedge its profits from fluctuations in coffee prices, Starbucks should lock in the price of how many pounds of coffee beans using supply contracts?

### Exchange Rate Risk



8. Your start-up company has negotiated a contract to provide a database installation for a manufacturing company in Poland. That firm has agreed to pay you \$100,000 in three months' time when the installation will occur. However, it insists on paying in Polish zloty (PLN). You don't want to lose the deal (the company is your first client!), but are worried about the exchange rate risk. In particular, you are worried the zloty could depreciate relative to the dollar. You contact Fortis Bank in Poland to see if you can lock in an exchange rate for the zloty in advance.
- You find the following table posted on the bank's Web site, showing zloty per dollar, per euro, and per British pound:

	1 week	2 weeks	1 month	2 months	3 months
USD					
purchase	3.1433	3.1429	3.1419	3.1390	3.1361
sale	3.1764	3.1761	3.1755	3.1735	3.1712
EUR					
purchase	3.7804	3.7814	3.7836	3.7871	3.7906
sale	3.8214	3.8226	3.8254	3.8298	3.8342
GBP					
purchase	5.5131	5.5131	5.5112	5.5078	5.5048
sale	5.5750	5.5750	5.5735	5.5705	5.5681

What exchange rate could you lock in for the zloty in three months? How many zloty should you demand in the contract to receive \$100,000?


- b. Given the bank forward rates in part (a), were short-term interest rates higher or lower in Poland than in the United States at the time? How did Polish rates compare to euro or pound rates? Explain.
9. You are a broker for frozen seafood products for Choyce Products. You just signed a deal with a Belgian distributor. Under the terms of the contract, in one year you will deliver 4000 kilograms of frozen king crab for 100,000 euros. Your cost for obtaining the king crab is \$110,000. All cash flows occur in exactly one year.
- Plot your profits in one year from the contract as a function of the exchange rate in one year, for exchange rates from \$0.75/€ to \$1.50/€. Label this line "Unhedged Profits."
  - Suppose the one-year forward exchange rate is \$1.25/€, and that you enter into a forward contract to sell the euros you will receive at this rate. In the figure from part (a), plot your combined profits from the crab contract and the forward contract as a function of the exchange rate in one year. Label this line "Forward Hedge."
  - Suppose that instead of using a forward contract, you consider using options. A one-year call option to buy euros at a strike price of \$1.25/€ is trading for \$0.10/€. Similarly a one-year put option to sell euros at a strike price of \$1.25/€ is trading for \$0.10/€. To hedge the risk of your profits, should you buy or sell the call or the put?
  - In the figure from parts (a) and (b), plot your "all in" profits using the option hedge (combined profits of crab contract, option contract, and option price) as a function of the exchange rate in one year. Label this line "Option Hedge." (Note: You can ignore the effect of interest on the option price.)
  - Suppose that by the end of the year, a trade war erupts, leading to a European embargo on U.S. food products. As a result, your deal is cancelled, and you don't receive the euros or incur the costs of procuring the crab. However, you still have the profits (or losses) associated with your forward or options contract. In a new figure, plot the profits associated with the forward hedge and the options hedge (labeling each line). When there is a risk of cancellation, which type of hedge has the least downside risk? Explain briefly.
10. Suppose the current exchange rate is \$1.80/£, the interest rate in the United States is 5.25%, the interest rate in the United Kingdom is 4%, and the volatility of the \$/£ exchange rate is 10%. Use the Black-Scholes formula to determine the price of a six-month European call option on the British pound with a strike price of \$1.80/£.

### Interest Rate Risk

11. Assume each of the following securities has the same yield-to-maturity: a five-year, zero-coupon bond; a nine-year, zero-coupon bond; a five-year annuity; and a nine-year annuity. Rank these securities from lowest to highest duration.
12. You have been hired as a risk manager for Acorn Savings and Loan. Currently, Acorn's balance sheet is as follows (in millions of dollars):

Assets		Liabilities	
Cash Reserves	50	Checking and Savings	80
Auto Loans	100	Certificates of Deposit	100
Mortgages	150	Long-Term Financing	100
Total Assets	300	Total Liabilities	280
		Owner's Equity	20
		Total Liabilities and Equity	300

When you analyze the duration of loans, you find that the duration of the auto loans is two years, while the mortgages have a duration of seven years. Both the cash reserves and the checking and savings accounts have a zero duration. The CDs have a duration of two years and the long-term financing has a 10-year duration.

- a. What is the duration of Acorn's equity?
- b. Suppose Acorn experiences a rash of mortgage prepayments, reducing the size of the mortgage portfolio from \$150 million to \$100 million, and increasing cash reserves to \$100 million. What is the duration of Acorn's equity now? If interest rates are currently 4% but fall to 3%, estimate the approximate change in the value of Acorn's equity.
- c. Suppose that after the prepayments in part (b), but before a change in interest rates, Acorn considers managing its risk by selling mortgages and/or buying 10-year Treasury STRIPS (zero-coupon bonds). How many should the firm buy or sell to eliminate its current interest rate risk?
-  13. The Citrix Fund has invested in a portfolio of government bonds that has a current market value of \$44.8 million. The duration of this portfolio of bonds is 13.5 years. The fund has borrowed to purchase these bonds, and the current value of its liabilities (i.e., the current value of the bonds it has issued) is \$39.2 million. The duration of these liabilities is four years. The equity in the Citrix Fund (or its net worth) is obviously \$5.6 million. The market-value balance sheet below summarizes this information:

Assets		Liabilities (Debt) and Equity	
Portfolio of Government Bonds (duration = 13.5)	\$44,800,000	Short- and Long-Term Debt (duration = 4.0)	\$39,200,000
		Equity	\$5,600,000
Total	\$44,800,000	Total	\$44,800,000

Assume that the current yield curve is flat at 5.5%. You have been hired by the board of directors to evaluate the risk of this fund.

- a. Consider the effect of a surprise increase in interest rates, such that the yields rise by 50 basis points (i.e., the yield curve is now flat at 6%). What would happen to the value of the assets in the Citrix Fund? What would happen to the value of the liabilities? What can you conclude about the change in the value of the equity under these conditions?
- b. What is the initial duration of the Citrix Fund (i.e., the duration of the equity)?
- c. As a result of your analysis, the board of directors fires the current manager of the fund. You are hired and given the objective of minimizing the fund's exposure to interest rate fluctuations. You are instructed to do so by liquidating a portion of the fund's assets and reinvesting the proceeds in short-term Treasury bills and notes with an average duration of two years. How many dollars do you need to liquidate and reinvest to minimize the fund's interest rate sensitivity?
- d. Rather than immunizing the fund using the strategy in part (c), you consider using a swap contract. If the duration of a 10-year, fixed-coupon bond is seven years, what is the notational amount of the swap you should enter into? Should you receive or pay the fixed-rate portion of the swap?
14. Your firm needs to raise \$100 million in funds. You can borrow short term at a spread of 1% over LIBOR. Alternatively, you can issue 10-year, fixed-rate bonds at a spread of 2.50% over 10-year Treasuries, which currently yield 7.60%. Current 10-year interest rate swaps are quoted at the LIBOR rate versus the 8% fixed rate.

Management believes that the firm is currently "underrated" and that its credit rating is likely to improve in the next year or two. Nevertheless, the managers are not comfortable with the interest rate risk associated with using short-term debt.

- a. Suggest a strategy for borrowing the \$100 million. What is your effective borrowing rate?
- b. Suppose the firm's credit rating does improve three years later. It can now borrow at a spread of 0.50% over Treasuries, which now yield 9.10% for a seven-year maturity. Also, seven-year interest rate swaps are quoted at LIBOR versus 9.50%. How would you lock in your new credit quality for the next seven years? What is your effective borrowing rate now?