CHAPTER 1

Solutions to Exercises

Solution to Exercise 1.

As Figure 1.3 shows, a long position in a bond at time t_1 and a forward loan starting at t_1 can be used to replicate the payoffs of an interest rate swap.

Solution to Exercise 2.

Eurodollars are time deposits denominated in U.S. dollars at banks outside the United States. The euro-prefix is used to refer to any currency held in a country where it is not the official currency, for example, Euroyen or Euroeuro. The euro-prefix has therefore no connection with the euro currency or the eurozone. The Eurodollar term was first used for U.S. dollars in European banks, but it expanded over the years to its present definition—a U.S. dollar-denominated deposit in Tokyo or Beijing would be likewise deemed a Eurodollar deposit.

Solution to Exercise 3.

Figure 1.4 shows, a long position in an equity at time t_1 and a forward loan starting at t_1 can be used to replicate the payoffs of an equity swap. Eurodollar are deposits denominated in U.S. dollars at a bank outside the United States

Solution to Exercise 4.

As Figure 1.8 shows, a a foreign currency loan can be synthetically created by borrowing in local currency, converting the local currency into foreign currency in the spot market and entering forward agreement to sell the foreign currency in the future and buying local currency. The euro-prefix refers to any currency held in a country where it is not the official currency: for example, euroyen or even euroeuro.

Solution Case Study: Japanese Loans and Forwards

1. Follow Figures 1-7 and 1-8 from the text.

2. Japanese banks borrow in yen, and buy spot dollars from their Western counterparties. So, the Western banks are left holding the yen for the time of the loan (three months, in this case). The main point is here. In an FX transaction, in this case buying Yen, the purchased currency may have to be kept overnight in a Yen denominated account. The FX is by definition not euroYen, so these accounts have to be in a bank Japan. Some of these will be Japanese banks.

3. A nostro account is one that a bank holds with a "foreign bank". (In this case London banks hold Nostro accounts with Japanese Banks inTokyo, for example).[1] Nostro accounts are usually in the currency of the foreign country. Suppose an American bank called Bank A buys Euros from an European bank Bank B. These Euros cannot "leave" Europe. They will be sent to a European bank, say Bank of Europe, to be kept in a Deposit account for the use of Bank A. This would be a nostro account of Bank A. Bank A will have similar nostro accounts in Japan, Australia, etc... to trade Dollar against Yen or Australian dollar. This allows for easy cash management because the currency doesn't need to be converted. Incidentally, nostro is derived from the Latin term "ours".[2] The Western banks may not be willing to hold the Yen in their

[1] Nostro accounts are mostly commonly used for currency settlement, where a bank or other financial institution needs to hold balances in a currency other than its home accounting unit.
[2] For more details, see http://en.wikipedia.org/wiki/Nostro_and_vostro_accounts.

nostro accounts because this requires them to hold capital against the yen for regulatory purposes. Japanese banks being more risky, risk managers may also be against holding "too much" in a Nostro account in Japan. Note that banks operate in an environment where others have credit lines against each other. The "Headquarters" may not want a currency desk to have exposure to Japanese Banks beyond a certain limit. This may force Western banks to dump the excess Yens at a negative interest rate.

4. By not holding the yen, the Western banks could potentially lose significant sums if the bank where the Nostro account is held defaults. For this reason they may prefer to dump the yen deposits and earn negative yield because they can be more than compensated with their earnings from the spot-forward trade.

5. The Covered Interest Rate Parity (CIRP) relationship, derived in Chapter 6, is the appropriate formula. The CIRP states that the forward-spot spread is equal to the interest rate differential:

$$F(t,T)/S(t)= (1+i(t,T))/(1+i^*(t,T)),$$

where S(t) is, for example, the spot USD/EUR rate expressed a the amount of USD that 1 EUR can buy. An increase in S(t) over time means that the EUR appreciates relative to the USD as more USD can be bought with 1 EUR. The interest rate i(t,T) is the USD interst rate from time t to time T. The interest rate i*(t,T) is the EUR interest rate from t to T. For CIRP to hold any positive (negative) interest rate differential must be offset by the currency loss (gain). For example, if $i(t,T) > i^*(t,T)$ then (under certain simplying assumptions) an arbitrage could potentially be available by borrowing in EUR at the rate $i^*(t,T)$, converting the EUR into USD and investing at the rate USD interest rate $i(t,T)$ and locking in the rate at which the USD are converted back into EUR in the future to pay back the EUR loan. This arbitrage would exist unless $F(t,T) > S(t)$.

CHAPTER 2

Solutions to Exercises

Solution to Exercise 1.

The amount of margin exchanges require to be deposited when a trade is initiated is called initial margin and the minimum amount of margin the customer must maintain in his or her account at all times for each open position is called maintenance or variation margin. The initial margin requirement is the amount required to be collateralized in order to open a position.

Solution to Exercise 2.

Futures are exchange traded and centrally cleared while some OTC derivatives are not centrally cleared. Without central clearing, the bilateral trading partners can decide whether collateral is demanded, negotiate on the value of the collateral required and specify the frequency of the collateral payments as well as the variation of the collateral requirements and margin calls.

Solution to Exercise 3.

Centrally cleared derivatives are cleared through a central counter party. As instruments to reduce risk, CCPs demand collaterals in the form of margin requirements as well as contributions to CCP insurance pools.

Solution to Exercise 4.

Open interest refers to the total number of derivative contracts, like futures and options, that have not been settled in the immediately previous time period for a specific underlying security.

Solution to Exercise 5.

(a) One could take a market arbitrage position as follows: buy Honeywell shares and sell General Electric shares. If the merger takes place, the Honeywell shares will convert to GE shares - that is, these shares will become similar and now one can sell the expensive shares and make a profit.

(b) You do not need to deposit funds to take this position.

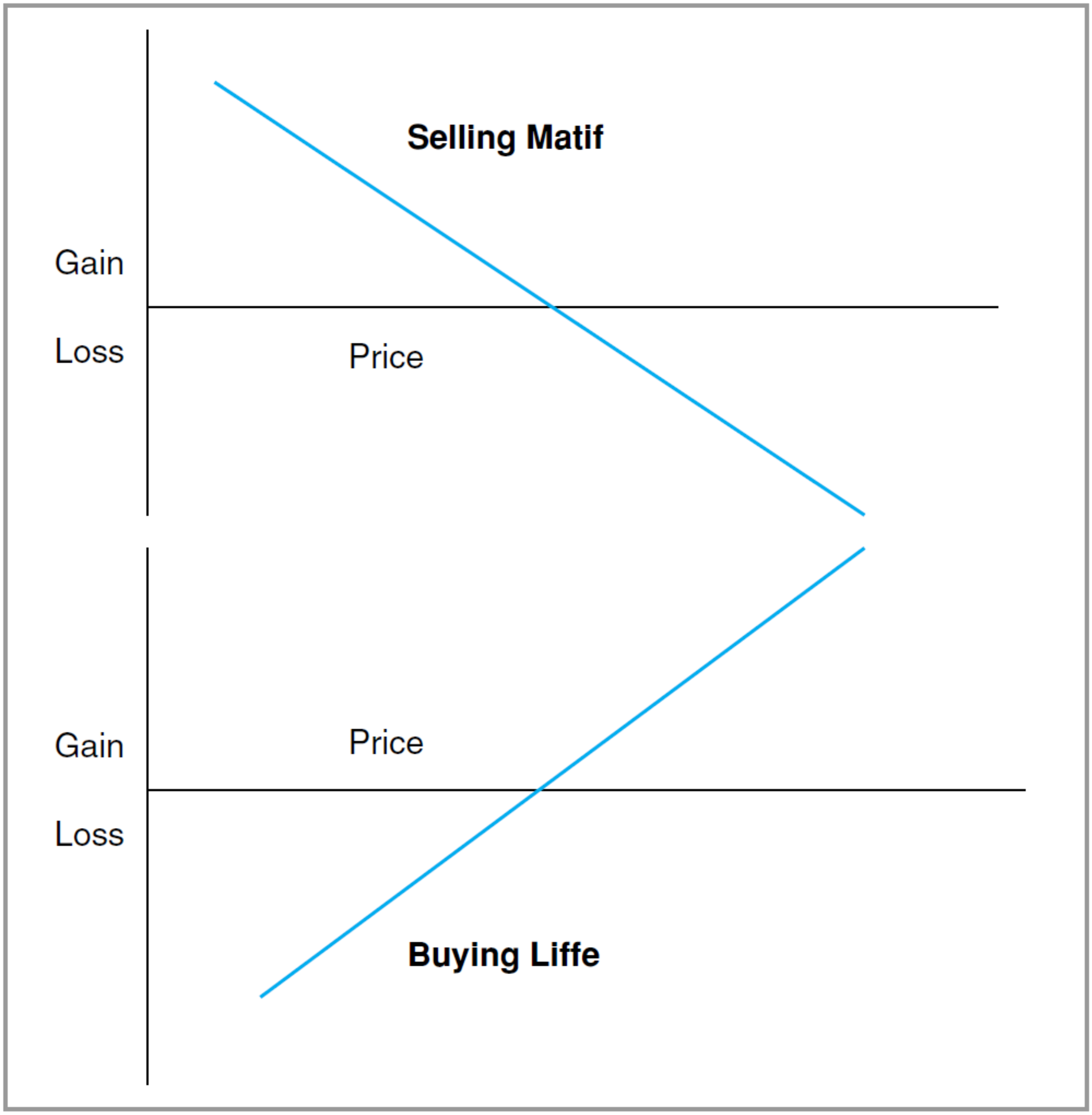
(c) You could borrow funds for this position. You would need to if you do not have any GE shares. If you had them then you could engineer this short position through short selling them.

(d) This is different from the academic sense of the word arbitrage. That involves zero risk and infinite gain. Here we do face a risk (see below) and our gains might be very high - but not infinite!

(e) You would be taking the risk that the merger indeed goes through successfully.

Solution to Exercise 6.

(a) The dealers are selling the Matif contract and buying the Liffe. (See figure below)



(b) The horizontal axis would have price and the vertical axis would show gain and loss.

(c) Since both Euribor and Euro BBA Libor are both European based rates, the profit would simply be scaled down - if all European interest rates would be dramatically lowered.

CHAPTER 3

Solution to Exercise 3.1

(a) The cash flows of this coupon bond can be separated into 8 separate payments. The first 7 of these will pay $4 at *ti*, *i* = 1, .., 7. The last payment will be of size $104. This can be used to create the synthetic:

$$Coupon\ Bond = \sum_{i=1}^{7} 4B(t_0, t_i) + 104B(t_0, t_8)$$

where the $B(t_0, t_i)$ are the time t_0 value of the default-free discount bonds maturing at t_i. These bonds pay $1 at maturity. Hence the price of the coupon bond should equal the value on the right hand side plus a profit margin.

(b) In this question the B_i are measured at annual frequencies. However, the underlying cash flows are semi-annual. Hence some sort of interpolation of B_i is needed. Using a linear interpolation, and then applying the above equality twice we can get the bid-ask prices. For example, the Bid price of the coupon bond can be calculated as:

$$Bid = 4(.95 + .90 + .885 + .87 + .845 + .82 + .81) + 104(.80) = 107.52$$

According to this the coupon bond sells at a premium. This is not very surprising since, the 8% coupon is significantly higher than the annual rate implied by the term structure.

(c) Here one can use either the interpolated data or the original term structure, depending on how one interprets the numbers in 1x2 FRA. Taking these as the FRA rate on an 12-month loan that will be made in one year we get the equation:

$$1 + f(t_0, t_2, t_4) = \frac{B(t_0, t_2)}{B(t_0, t_4)}$$

Replacing from the term structure we obtain:

$$f(t_0, t_2, t_4)^{Bid} = \frac{0.9}{0.88} - 1 = 2.27\%$$

Solution to Exercise 3.2

(a) These are just the differences of the two prices. So, the mark to market losses are given by $\{Q_1 - Q_0, Q_2 - Q_1, Q_3 - Q_2, Q_4 - Q_3, Q_5 - Q_4\}$. Of course, negative losses are gains.

(b) You just calculate the interest accrued after multiplying by 1/360 for every day and,

(c) then adding the gains and losses.

Solution to Exercise 3.3

(a) Treasurer has risks for three months starting in three months. So a 3×6 FRA is needed.

(b) To get the break even rate we need:

$$\left(1 + 0.0673\left(\frac{1}{4}\right)\right)\left(1 + f\left(\frac{1}{4}\right)\right) = \left(1 + 0.0787\left(\frac{1}{2}\right)\right)$$

(c) Lowest offered rate. (6.87%)

(d) (FRA settlement) (0.0687 − 0.0609)(38 million)(1/4)

Solution to Exercise 3.4

(a) The futures price has moved by 34 ticks. (It moved from $Q_{t_0} = \$94.90$ to $Q_{t_0} = \$94.56$.

(b) The current implied forward rate is given by

$$\tilde{F}_{t_0} = \frac{100 - 94.90}{100} = 0.0510$$

which means the buyer of the contract needs to deposit

$$100\left(1-\frac{0.0510}{4}\right)=98.725$$

dollars per \$100 dollars on expiry (which is in three months in this case)

(c) In three months the futures price moves to $Qt1$ = \$94.56 giving a implied forward rate of

$$\tilde{F}_{t_{10}}=\frac{100-94.56}{100}=0.0544$$

and a settlement of

$$100\left(1-\frac{0.0544}{4}\right)= 98.64$$

So the buyer of the original contract receives a compensation as if she were making a deposit of \$98.725 and receiving a loan of \$98.64, making a loss of

$$98.64 - 98.725 = -0.085 \text{ per \$100 dollars} \Rightarrow \text{Loss of \$595000}$$

since the sum involved is \$7 million.

Solution to Exercise 3.5

(a) The trader will buy (sell) the LIBOR-based FRA, and sell (buy) TIBOR-based FRA. This way the market risk inherent in the LIBOR positions will be eliminated to a large degree. However, TIBOR and LIBOR fixings occur at different times, so there still some risk in this position.

(b) Use two cash flow diagrams, one for LIBOR FRA the other for the TIBOR FRA. In one case the trader is paying fixed and receiving floating. The other cash flow diagram will display the reserve situation. In this setting, the two fixed rates are known and their difference will remain fixed. The trader will have exposure to the difference between the floating rates.

(c) If LIBOR panel is made of better-rated banks, then the LIBOR fixings will be lower everything else being the same. This means that the spread between LIBOR and TIBOR will widen. According to this, traders need to *buy* the spread if they decide to take such a speculative position.

Solution to Exercise 3.6

(a) This can be done by taking a cash loan at time t_0, pay the Libor rate L_{t_0}, and buy a FRA strip made of two sequential FRA contracts – a (3×6) FRA and a (6×9) FRA. The cash flow diagrams are left as an exercise.

(b) Let *N* be the sum to be borrowed. To find the fixed borrowing cost, simply add the costs incurred by:

- The (3 × 6) FRA, since 3.4 > 3.2, so the floating rate is higher.
- The (6 × 9) FRA, since 3.7 > 3.2, so the floating rate is higher.
- The cost from the three month fixed rate loan.

Solution to Exercise 3.7

To rank the instruments we need to recall the conventions from Chapter 3. We review Section 3.5 from Chapter 3, and Table 3-1 in particular.

(a) According to the formula given there, we first calculate present day values of these instruments.

• **30-day US T-bill: Day count convention:** ACT/360. Yield is quoted at discount rate, so we have

$$B(t,T) = 100 - R^T \left(\frac{T-t}{360}\right) 100 = 100 - 5.5 \left(\frac{30}{365}\right) = 99.54167$$

• **30-day UK T-bill:** Day count convention: ACT/365. Yield is quoted at discount rate, so we have

$$B(t,T) = 100 - R^T \left(\frac{T-t}{365}\right) 100 = 100 - 5.4 \left(\frac{30}{365}\right) = 99.5561$$

• **30-day ECP:** Day count convention: ACT/360. Yield is quoted at the money market yield, so we have

$$B(t,T) = \frac{100}{\left(1 + R^T \left(\frac{T-t}{360}\right)\right)} = \frac{100}{\left(1 + 0.052 \left(\frac{T-t}{360}\right)\right)} = 99.56854$$

• **30-day interbank deposit USD:** Day count convention: ACT/360. Yield is quoted at the money market yield, so we have

$$B(t,T) = \frac{100}{\left(1 + R^T \left(\frac{T-t}{360}\right)\right)} = \frac{100}{\left(1 + 0.055 \left(\frac{T-t}{360}\right)\right)} = 99.54376$$

• **30-day US CP:** Day count convention: ACT/360. Yield is quoted at the discount rate, so we have

$$B(t,T) = 100 - R^T \left(\frac{T-t}{360}\right) 100 = 100 - 5.6 \left(\frac{30}{360}\right) = 99.53973$$

Yields on these instruments = *100−B(t, T),* so to arrange these instruments in increasing order of their yields, we simply arrange them in decreasing order of their present day values.

(b) Since we are dealing with an ECP (Euro), the day count convention used is ACT/360. So there are 62 days till maturity. Also, we have to use the money market yield rate to compute the present day value. (We have again used conventions from Chapter 3, Table 3-1).

$$B(t,T) = 100 - R^T\left(\frac{T-t}{360}\right)100 = 100 - 3.2\left(\frac{30}{360}\right) = 99.45644$$

is the present day of a bond that would yield 100 USD. So, we have to make a payment of 99.45644× 10, 000, 000/100= 9945644 US Dollars for this ECP.

Solution to Exercise 3.8

a) If the settlement occurs on the date of loan initiation

$$\frac{(L_{t_3} - F_{t_0})\delta N}{1 + L_{t_3}\delta} = \frac{(0.0402 - 0.0438) * 1/4 * 300{,}000}{1 + 0.0402 * 1/4} = -\$3{,}252.27$$

b) If the settlement occurs on the date of loan repayment

$$(L_{t_3} - F_{t_0})\delta N = (0.0402 - 0.0438) * 1/4 * 300{,}000 = -\$3{,}284.96$$

Solution to Exercise 3.9

a) The 3-month implied forward rate is $F_{t_0} = \frac{100-93.83}{100} = 0.0617$

b) At the end of three month this contract involves a delivery of

$100 \times \left(1 - 0.0617 \times \frac{1}{4}\right) = 98.45$ dollars per contract.

Total repayment amount $= 5\ millions * 98.45 = \$492.25\ millions$

Solution to Exercise 3.10

Using the formula $1 + F\left(t_0, t_i, t_j\right) = \frac{B(t_0,t_i)}{B\left(t_0,t_j\right)}$ we will calculate the implied forward rate

3 x 6 FRA rate $F(t_0, t_1, t_2) = \frac{B(t_0,t_1)}{B(t_0,t_2)} - 1 = \frac{98.79}{97.21} - 1 = 0.01625$

6 x 9 FRA rate $F(t_0, t_2, t_3) = \frac{B(t_0,t_2)}{B(t_0,t_3)} - 1 = \frac{97.21}{95.84} - 1 = 0.0143$

3 x 9 FRA rate $F(t_0, t_1, t_3) = \frac{B(t_0,t_1)}{B(t_0,t_3)} - 1 = \frac{98.79}{95.84} - 1 = 0.0307$

6 x 12 FRA rate $F(t_0, t_2, t_4) = \frac{B(t_0,t_2)}{B(t_0,t_4)} - 1 = \frac{97.21}{93.21} - 1 = 0.0429$

Solution to Exercise 3.11

We abbreviated the value of the 2-year and the 10-year bond in the barbell portfolio by V_2 and V_{10}. We can write the condition that the barbell portfolio should have the same value as the bullet as

$$V_2 + V_{10} = \$990{,}468.75 \qquad (1)$$

The requirement that the duration of the barbell portfolio an the bullet should be the same can be written as

$$\frac{V_2}{\$990{,}468.75} \times 1.943 + \frac{V_{10}}{\$990{,}468.75} \times 8.701 = 4.748 \qquad (2)$$

Solving equations (1) and (2) leads to the solutions V_2 =579361.6 and V_{10} = 411107.2 or in other words 58.5% of the portfolio is to be invested in the 2 year and 41.5% to be invested in the 10 year bond.

We can also use these weights to calculate the convexity of the barbell portfolio:

$$Convexity\ of\ barbell = 58.5\% \times 0.048 + 41.5\% \times 0.859 = 0.384565 \quad (3)$$

The barbell portfolio has greater convexity than the bullet which is 0.254. The reason for this is that duration increases linearly with maturity while conversity increases with the square root of maturity as shown in Chapter 3. We can deduce from this fact that if a combination of short and long durations (which are related to maturities), equals the duration of the bullet portfolio, that same combination of the two convexities (which can be viewed as maturities squared) must be greater than the convexity of the bullet.

From the point of view of the fund manager in the example, the barbell portfolio is attractive since it has the same duration but a higher convexity. In other words, for the same amount of duration risk, the barbell portfolio has greater convexity, which implies that its value will increase more than the value of the bullet when rates rise or fall.

However, the disadvantage of the barbell portfolio lies in its lower yield which is

$$0.457\% \times 58.5\% + 2.598\% \times 41.5\% = 13.457\% \quad (4)$$

Therefore there is a tradeoff. The barbell portfolio can be expected to perform worse than the bullet portfolio if yields remain unchanged or near current levels. However, if yields were to move significantly, the barbell portfolio can be expected to outperform. Therefore the choice depends on the fund managers view about interest rate volatility. A fund manager with a view that rates will be particularly volatility will prefer the barbell portfolio while a manager with a view that rates will not be particularly volatility will prefer the bullet portfolio.