International Investments

Tuesdays 6:10-9:00 p.m.
Commerce 260306
Wednesdays 9:10 a.m.-12 noon
Commerce 260508

Handout #14
Derivative Security Markets
Currency and Interest Rate Futures

Course web pages:
http://finance2010.pageout.net
ID: California2010  Password: bluesky
ID: Oregon2010    Password: greenland
### Reading Assignments for this Week

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<td>Levich</td>
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<td>Luenberger</td>
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<td>Solnik</td>
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<td>Pages 433-483 Derivatives</td>
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<tr>
<td>Fabozzi</td>
<td>Chap 26</td>
<td>609-639 (esp. 622-6) Interest Rate Futures Contract</td>
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Midterm Exam: See University Calendar (November 16-20, 2009)

Coverage: Chapters 3, 4, 5, 6, 7, 8, 9, 10 + Ben Bernanke’s semi-annual testimony

It’s a closed-book exam. However, a two-sided formula sheet (11 x 8.5) is required; calculator/dictionary is okay; notebook is NOT okay.

75 minutes, 7 questions, 100 points total; five questions require calculation and two questions require (short) essay writing.
Final Exam See University Calendar (January 8-14, 2010)
A Three-hour Exam
Open-Book, Open Notes
Derivative Security Markets
Currency and Interest Rate Rate Futures

MS&E 247S International Investments
Yee-Tien Fu
Currency and Interest Rate Futures

A forward contract is an agreement struck today that binds two counterparties to an exchange at a later date.

Futures contracts call for both counterparties to post a “good-faith bond” that is held in escrow by a reputable and disinterested third party.

Futures exchanges require each counterparty to post a bond in the form of a margin requirement, but in an amount that varies from day to day as the futures contract loses or gains value.
Every futures contract traded on an organized exchange has the clearing house as one of the two counterparties.

The clearinghouse may be a separately chartered corporation or a division of the futures exchange.

In either case, the clearinghouse is the legal entity on one side of every futures contract, and it stands ready to meet the obligations of the futures contract vis-à-vis every customer of the exchange.
The essential feature of a forward contract is that no cash flows take place until the final maturity of the contract.

To enter into a futures contract, one must have an authorized futures trading account with a securities or brokerage firm. The broker requires that one posts (in advance of any trades) a good-faith deposit (known as margin) either in the form of cash, a bank letter of credit, or short-term US Treasury securities.
The initial margin is the amount of margin that must be on hand when the initial buy or sell order for the futures contract is placed.

Maintenance margin is defined as a portion (say, 75 percent) of the initial margin.

If my margin account falls below the maintenance margin value, my broker will issue a margin call and demand that I restore my margin account to the level of the initial margin before the end of the day. If not, the broker may elect to sell my futures contract and return any remaining proceeds of the margin account to me.
Prices and the Margin Account

Initial Margin

Maintenance Margin

$/DM Futures Price

Margin Calls

Margin Account

Time
The process of updating a margin account on a daily basis to reflect the market value of the underlying position is known as marking to market.

To some economists, marking to market is the defining feature of a futures market. Unlike a forward contract, a futures contract may “spin off” cash flows in and out the margin account on a daily basis.
Distinctions between Futures and Forwards

<table>
<thead>
<tr>
<th></th>
<th>Forwards</th>
<th>Futures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traded in</td>
<td>dispersed interbank market 24 hours a day. Lacks price transparency.</td>
<td>centralized exchanges during specified trading hours. Exhibits price transparency.</td>
</tr>
<tr>
<td>Transactions are</td>
<td>customized and flexible to meet customer preferences.</td>
<td>highly standardized to promote trading and liquidity.</td>
</tr>
</tbody>
</table>


## Distinctions between Futures and Forwards

<table>
<thead>
<tr>
<th><strong>Forwards</strong></th>
<th><strong>Futures</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Counterparty risk is <em>variable</em>.</td>
<td>Being one of the two parties, the <em>clearinghouse</em> standardizes the counterparty risk of all contracts.</td>
</tr>
<tr>
<td>No cash flows take place until the final <em>maturity</em> of the contract.</td>
<td>On a daily basis, cash may flow in or out of the margin account, which is <em>marked to market</em>.</td>
</tr>
</tbody>
</table>
Payoff Profiles for Futures and Forward Contracts

To better understand the risks and rewards of using futures and forward contracts, it is useful to trace the payoff profiles for these contracts.

A payoff profile is a graph of the value of a contract (or the profit and loss on a contract) plotted against the price of the underlying financial assets.
Currency Contracts

Consider someone with a long forward DM contract entered into at a price $F_{t,n} = $0.50/DM (buying DM1 forward at $0.50/DM).

$$V_1 = N \cdot (S_{t+n} - F_{t,n}) = DM1 \cdot (S_{t+n} - $0.50 / DM)$$

where $V_1$ is the value of the contract at maturity (the factor of proportionality), and $N$ is the notional principal of the contracts in DM.
Consider a short forward DM contract entered into at a price $F_{t,n} = \$0.48/DM$ (selling DM1 forward at $\$0.48/DM$).

\[ V_3 = -N \cdot (S_{t+n} - F_{t,n}) = -DM1 \cdot (S_{t+n} - \$0.48/DM) \]

where $V_3$ is the value of the contract at maturity, and $N$ is the notional principal of the contracts in DM.
Combinations of Currency Contracts

Let $V_5 = V_1 + V_3$. What does $V_5$ mean?

The combination of buying DM1 forward at $0.50/DM$ and selling DM1 forward at $0.48/DM$.

$V_5 = V_1 + V_3 = -$0.02$ and $V_5$ is flat or invariant w.r.t. the future spot rate.
Payoff Profiles for Currency Contracts

*Long DM1 at $0.50/DM and Short DM1 at $0.48/DM*

- $V_1$ = Long DM1 at $0.50/DM
  - Slope = +1
- $V_3$ = Short DM1 at $0.48/DM
  - Slope = -1
- $V_5 = V_1 + V_3$
  - i.e. hedged against exchange risk

Payoff in US$ per DM
Any single position, or portfolio of positions, whose value does not vary as a function of the spot exchange rate will be deemed hedged against exchange risk or not exposed to exchange risk.

Example: \[ \frac{\partial V_5}{\partial S_{t+n}} = 0 \]
Payoff Profiles for Currency Contracts

Long DM750,000 at $0.50/DM and Short DM500,000 at $0.48/DM

\[ V_2 = \text{Long DM750,000 at }$0.50/\text{DM} \]
\[ \text{Slope} = +750,000 \]

\[ V_4 = \text{Short DM500,000 at }$0.48/\text{DM} \]
\[ \text{Slope} = -500,000 \]

\[ V_6 = V_2 + V_4 \]
\[ \text{Slope} = +250,000 \]
### Table 11.3 Specifications for Selected Currency Futures Contracts

<table>
<thead>
<tr>
<th>Market</th>
<th>Currency</th>
<th>Contract Size</th>
<th>Minimum Price Change</th>
<th>Value of One Tick</th>
</tr>
</thead>
<tbody>
<tr>
<td>CME</td>
<td>€</td>
<td>€ 125,000</td>
<td>$ 0.0001</td>
<td>US$ 12.50</td>
</tr>
<tr>
<td></td>
<td>¥</td>
<td>¥ 12,500,000</td>
<td>$ 0.000001</td>
<td>US$ 12.50</td>
</tr>
<tr>
<td></td>
<td>C$</td>
<td>C$ 100,000</td>
<td>$ 0.0001</td>
<td>US$ 10.00</td>
</tr>
<tr>
<td></td>
<td>£</td>
<td>£ 62,500</td>
<td>$ 0.0002</td>
<td>US$ 12.50</td>
</tr>
<tr>
<td>NYBOT</td>
<td>US$ Index</td>
<td>$1,000 × index</td>
<td>0.01 index points</td>
<td>US$ 10.00</td>
</tr>
<tr>
<td></td>
<td>€/£ cross</td>
<td>€ 100,000</td>
<td>€ 0.0001</td>
<td>£ 10.00</td>
</tr>
<tr>
<td></td>
<td>€/¥ cross</td>
<td>€ 100,000</td>
<td>€ 0.01</td>
<td>¥ 1,000</td>
</tr>
<tr>
<td>TIFFE</td>
<td>US$</td>
<td>US$50,000</td>
<td>¥0.05</td>
<td>¥2,500</td>
</tr>
</tbody>
</table>

*aCME—Chicago Mercantile Exchange; NYBOT—New York Board of Trade; TIFFE—Tokyo International Financial Futures Exchange.*

*bCurrency futures generally have maturity months of March, June, September, and December. The expiration date for U.S.-traded futures is the second business day preceding the third Wednesday of the contract month (except for Canadian dollars, which expire on the business day immediately preceding the third Wednesday of the contract month). The settlement date for U.S.-traded futures is the third Wednesday of the contract month.*

*cThe US$ index is a trade-weighted average of the US$ against 10 major currencies, as computed by the Federal Reserve.*

*Source: Futures Industry Institute Factbook at <www.fiiweb.org/factbook>.*
Interest Rate Contracts

In a generic interest rate futures contract, the value of the contract at maturity is proportional to the interest differential between the futures price and the interest rate at maturity.

\[ V = N (S_{i,t+n} - F_{i,t,n}) \]

where \( F_{i,t,n} \) is the futures rate on interest rate \( i \) at time \( t \) that matures \( n \) periods later, and \( S_{i,t+n} \) is the spot interest rate on the maturity date of the futures contract.
Consider someone with a long position in the March 1998 Eurodollar futures contract, entered into at a price $F_{i,t,n} = 92.32$ (interest rate $= 100 - 92.32 = 7.68$ percent) which is the settlement price reported for June 27, 1994.

At maturity, the value of this contract is:

$$V_7 = N \left( S_{\text{euro-}$,t+n} - F_{i,t,n} \right) \times 0.01 \times (1/4)$$

where $N$ is the notional size of one Eurodollar futures contract on the CME, and $S_{\text{euro-}$,t+n$}$ is the spot Eurodollar rate on a 3-month deposit on the maturity date of the contract.

Multiplying by $0.01 \ (1/4)$ converts the spot/futures prices into percentage points (for a 3-month period).
The value of a short interest rate futures position in the March 1998 Eurodollar futures contract, entered into at the same settlement price \((F_{i,t,n} = 92.32\) on June 27, 1994) is:

\[
V_8 = -N (S_{\text{euro-}$,t+n} - F_{\text{euro-}$,t,n}) \times 0.01 \times \frac{1}{4}
\]

\[
V_7 + V_8 = 0 \Rightarrow \text{the short and long positions offset each other and produce zero payoff independent of the futures and spot interest rates.}
\]

Since you short-sell interest rate futures, what you get is \(F_{\text{euro-}$, t,n}\) and what will cost you is \(S_{\text{euro-}$, t+n}\)

Your net payoff is \(F_{\text{euro-}$, t,n} - S_{\text{euro-}$, t+n}\)
Payoff Profiles for Interest Rate Contracts

Long at 92.32 and Short at 92.32

Long at 92.32
Slope = +2,500

Short at 92.32
Slope = -2,500

Combination of Positions
Slope = 0
Hedging the Interest Rate Risk in Planned Investment and Planned Borrowing

A treasurer who plans to invest excess cash balances at a future date \((t+n)\) faces risk, because the interest rate \((i_{t+n})\) on this planned investment is uncertain. The treasurer, an investor, buys interest rate futures to lock in “better” future interest rate.

The treasurer’s interest earnings are \(N(100 - S_{i,t+n})\) where \(N\) is the investment amount (often assumed to be 1) and \(S_{i,t+n}\) is 100 minus the appropriate short-term interest rate.
A long interest rate futures position results in profits equal to \( N (S_{i,t+n} - F_{i,t,n}) \).

Let \( V_{10} \)

\[
= \text{Interest earnings} + \text{Gain/loss on Long futures}
\]

\[
= (100 - S_{i,t+n}) + (S_{i,t+n} - F_{i,t,n}) = 100 - F_{i,t,n}
\]

Thus, a long futures position is a complete hedge for a planned investment.
Consider a treasurer who plan to borrow money at a future date and face uncertain interest cost. The uncertain interest cost is \( N(100 - S_{i,t+n}) \). The value of the short interest rate futures is \( N(F_{i,t,n} - S_{i,t+n}) \). Borrower sells interest rate futures to lock in a “better” future interest rate.

The combined value of these two positions is:

\[
V_{11} = \text{Borrowing costs} - \text{Gain/Loss on Short Futures} = N(100 - S_{i,t+n}) - N(F_{i,t,n} - S_{i,t+n}) = N(100 - F_{i,t,n})
\]

Thus a short futures position is a complete hedge for a planned borrowing.
The market has adopted the following convention:

Eurocurrency interest rate futures price = 100.00 - Eurocurrency interest rate

Eurocurrency interest rates are quoted to the nearest basis point (or 1/100 of one percent)

The value of one basis point for each of these short-term options is determined by a general formula: contract size X 0.0001 X (number of months / 12).

For the Eurodollar option contract, this results in $1,000,000 X 0.0001 X 3/12 = $25.
Treasury bills are quoted in the cash market in terms of the annualized yield on a bank discount basis

\[ Y_d = \frac{D}{F \cdot \frac{360}{t}} \quad \text{or} \quad D = Y_d \cdot F \cdot \frac{t}{360} \]

\( Y_d \) = yield on a bank discount basis (expressed as a decimal)

\( D \) = dollar discount, or “Face value - Price of a bill maturing in \( t \) days”

\( F \) = face value

\( t \) = number of days remaining to maturity
In contrast, the Treasury bill futures contract is quoted on an index basis that is related to the yield on a bank discount basis:

\[ \text{Index price} = 100 - (Y_d \cdot 100) \]

E.g., if \( Y_d = 8\% \), \( \text{Index price} = 100 - 0.08 \cdot 100 = 92 \)

Given the price of the futures contract, the yield on a bank discount basis for the futures contract is:

\[ Y_d = (100 - \text{index price}) / 100 \]
Eurodollar CD Futures

Eurodollar certificates of deposits (CDs) are denominated in dollars but represent the liabilities of banks outside the United States.

The three-month Eurodollar CD is the underlying instrument for the Eurodollar CD futures contract.

The minimum price fluctuation (tick) for such contract is 0.01 (or 0.0001 in terms of LIBOR).

If LIBOR changes by 1 basis point (0.0001), then $1,000,000 \times 0.0001 \times 90/360 = $25.
Forward Interest Rates

Define \( i(0,1) \) as the one-period interest rate for a transaction that begins today \( (t=0) \), and define \( i(0,2) \) as the two-period interest rate. Define \( i(1,1) \) as a one-period forward interest rate beginning at \( t=1 \).

Consider two investments with ending values \( V \):

\[
V_A = [1 + i(0,2)]^2
\]

\[
V_B = [1 + i(0,1)] \times [1 + i(1,1)]
\]

Note that \( i(1,1) \) is uncertain and cannot be observed today!
An investor could lock in $i(1,1)$ by investing for two periods at $i(0,2)$ and borrowing for one period at $i(0,1)$. The implied value of the forward interest rate is:

$$i(1,1) = \frac{[1 + i(0,2)]^2}{[1 + i(0,1)]} - 1$$

What is $i(4,6)$? How to estimate it?

$i(4,6)$ is the implied two-period interest rate beginning four periods from now, it can be estimated as the solution to

$$[1 + i(0,6)]^6 = [1 + i(0,4)]^4[1 + i(4,6)]^2$$
Interest Rate Parity in a Perfect Capital Market

Equating the two:

\[ \$1 \times \frac{1.0}{S_t} \times (1 + i£) \times F_{t, 1} = \$1 \times (1 + i_\$) \]

Rearranging terms:

\[ \frac{F_{t, 1}}{S_t} = \frac{1 + i_\$}{1 + i£} \]

Subtracting 1 from each side:

\[ \frac{F_{t, 1} - S_t}{S_t} = \frac{i_\$ - i£}{1 + i£} \]
Term Structure of Forward Rates

Interest rate parity predicts that the forward exchange rate (in US$/FC) at time $t$ for delivery $n$ periods from now is:

$$ F_{t,n} = S_t \cdot \frac{1 + i_{\$,t}}{1 + i_{FC,t}} $$

where $S_t$ is the spot exchange rate (in US$/FC) and the two interest rates have the same maturity as the forward contract.
where \( F(0, n) \) is the forward rate at time 0 for maturity n periods, \( S \) is the spot rate in $/FC, and \( i_S(0, n) \) and \( i_{FC}(0, n) \) are interest rates at time 0 for maturity n periods.

Thus, the forward rates for 1, 3, 6, 12 months would reflect the relative yields on the US$ and FC for 1, 3, 6, 12 months, respectively.
Define $i(0,n)$ as the $n$-period interest rate for a transaction that begins today ($t=0$). Define $i(t,r)$ as a $r$-period forward interest rate rate beginning at time $t$.

For example:
Define $i(0,1)$ as the one-period interest rate for a transaction that begins today ($t=0$), and define $i(0,2)$ as the two-period interest rate for a transaction that begins today ($t=0$). Define $i(1,1)$ as a one-period forward interest rate rate beginning at $t=1$. 

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The Term Structure of Implied Forward Interest Rates

\[
1 + i(1,1) = \frac{[1 + i(0,2)]^2}{1 + i(0,1)}
\]

\[
1 + i(2,1) = \frac{[1 + i(0,3)]^3}{[1 + i(0,2)]^2}
\]

\[
1 + i(19,1) = \frac{[1 + i(0,20)]^{20}}{[1 + i(0,19)]^{19}}
\]
\[ 1 + i(1,1) = \frac{[1 + i(0,2)]^2}{1 + i(0,1)} \]

\[ [1 + i(0,2)]^2 = [1 + i(0,1)] \cdot [1 + i(1,1)] \]

\[ 1 + i(0,2) = \frac{2}{\sqrt{[1 + i(0,1)] \cdot [1 + i(1,1)]}} \]

\( i(0,1) \) is the one-period interest rate for a transaction that begins today \( (t=0) \), and \( i(0,2) \) is the two-period interest rate; \( i(1,1) \) as a one-period forward interest rate beginning at \( t=1 \).
$1 + i(2,1) = \frac{[1 + i(0,3)]^3}{[1 + i(0,2)]^2}$

$1 + i(0,3) = \sqrt[3]{[1 + i(0,2)]^2 [1 + i(2,1)]}$

$= \sqrt[3]{[1 + i(0,1)] \cdot [1 + i(1,1)] \cdot [1 + i(2,1)]}$

$i(0,1)$ is the one-period interest rate for a transaction that begins today ($t=0$), and $i(0,3)$ is the three-period interest rate; $i(2,1)$ as a one-period forward interest rate beginning at $t=2$. 
Interest rate term structure theories:

The pure expectations theory

\[ 1 + t_N y = \left[ (1 + t_N y_1) \times (1 + t_{N-1} r_1) \times \cdots \times (1 + t_1 r_1) \right]^N \]

where \( y \) indicates an observed rate and \( r \) an expected rate (= implied forward rate in this theory). The pre-subscript indicates time and the post-subscript maturity.
Interest rate term structure theories:

The pure expectations theory

The liquidity premium theory

\[= \left[ (1 + r_1^{t+1}) \times (1 + r_1^{t+1} + L_2) \times \cdots \times (1 + r_1^{t+N-1} + L_N) \right]^N \]

where \( L_N > L_{N-1} > 0 \) (i.e., the liquidity premiums are strictly positive and increase monotonically).

The preferred habitat theory

\[= \left[ (1 + r_1^{t+1}) \times (1 + r_1^{t+1} + a_2) \times \cdots \times (1 + r_1^{t+N-1} + a_N) \right]^N \]

where \( a_N \) can be either >, < or = 0.
Synthetic Interest Rate Futures

A synthetic nondollar interest rate futures contract can be constructed using available futures contracts, specifically by using Eurodollar interest rate futures in conjunction with currency futures contracts.

This technique permits us to construct interest rate futures contracts denominated in Euro-¥, Euro-DM, Euro-£, and any other Euro-denomination that has an active currency futures market.
Synthetic Interest Rate Futures

This replicating portfolio approach is general and could be applied to construct synthetic Eurocurrency interest rate futures of any maturity.

However, to simplify the exposition, we assume that the maturity of the nondollar borrowing period matches the maturity of the Eurodollar interest rate futures contract.
Assume that today (time $t_0$) a treasurer plans to borrow foreign currency (FC) at time $t_1$ to be repaid at time $t_2$. At time $t_0$, the FC interest rate at $t_1$ is uncertain. It is this risk that the treasurer wants to hedge.
\[ S_{t_0} = \text{spot exchange rate in US$/FC at time } t_0 \]
\[ F_{t_1} = \text{forward exchange rate at } t_0 \text{ for delivery at time } t_1 \]
\[ F_{t_2} = \text{forward exchange rate at } t_0 \text{ for delivery at time } t_2 \]
\[ i\$,t_0,t_1 = \text{US$ interest rate for the period } t_0 \text{ to } t_1 \]
\[ i\$,t_0,t_2 = \text{US$ interest rate for the period } t_0 \text{ to } t_2 \]
\[ i_{FC,t_0,t_1} = \text{FC interest rate for the period } t_0 \text{ to } t_1 \]
\[ i_{FC,t_0,t_2} = \text{FC interest rate for the period } t_0 \text{ to } t_2 \]
From the interest rate parity condition, we know that the rate for a forward transaction on \( t_1 \) is given by:

\[
1 \cdot (1 + i_{\text{S}, t_0, t_1}) = 1 \cdot \frac{1}{S_{t_0}} \cdot (1 + i_{\text{FC}, t_0, t_1}) \cdot F_{t_1}
\]

\[
\frac{F_{t_1}}{S_{t_0}} = \frac{1 + i_{\text{S}, t_0, t_1}}{1 + i_{\text{FC}, t_0, t_1}} \quad \text{(11A.1)}
\]
The rate for a forward transaction on $t_2$ is given by:

$$1 \cdot (1 + i_{$,t_0,t_2} ) = 1 \cdot \frac{1}{S_{t_0}} \cdot (1 + i_{FC,t_0,t_2} ) \cdot F_{t_2}$$

$$\frac{F_{t_2}}{S_{t_0}} = \frac{1 + i_{$,t_0,t_2}}{1 + i_{FC,t_0,t_2}}$$

$$= \frac{(1 + i_{$,t_0,t_1} ) \cdot (1 + i_{$,t_1,t_2} )}{(1 + i_{FC,t_0,t_1} ) \cdot (1 + i_{FC,t_1,t_2} )} \quad (11A.3)$$

where $i_{$,t_1,t_2}$ and $i_{$,t_1,t_2}$ are implied forward interest rates at time $t_0$ for the period $t_1$ to $t_2$. 
(11A.1) and (11A.3) =>

\[ 1 + i_{FC,t_1,t_2} = \frac{F_{t_1}}{F_{t_2}} \cdot (1 + i_{\$t_1,t_2}) \quad (11A.4) \]

Equation (11A.4) predicts that the implied forward interest rate on FC is uniquely related to the implied forward interest rate on US$ and the term structure of forward exchange rates.
In Figure 11A.1

line segment AB (sale of a FC interest rate futures contract) which can be replicated by line segments AD (sale of a currency futures contract for date $t_2$), DC (sale of a US$ interest rate futures contract), CB (purchase of a currency futures contract for date $t_1$)
Figure 11A.1  Synthetic Eurocurrency Interest Rate Pricing

Synthetic Eurocurrency Interest Rate Pricing

- Currency Dimension
  - FC
  - US$

- Time Dimension
  - Today
  - Near future
  - Distant future

Symbols:
- \( i_{FC,t_0,t_1} \)
- \( i_{FC,t_1,t_2} \)
- \( S_{t_0} \)
- \( F_{t_1} \)
- \( F_{t_2} \)
- \( i_{US,t_0,t_1} \)
- \( i_{US,t_1,t_2} \)

- \( t_0 \) Today
- \( t_1 \) Near future
- \( t_2 \) Distant future
A Specific Example

A treasurer plans to borrow £1 million in the Eurocurrency market for three months beginning March 15, 1998. Assume that today (Dec 15, 1997) the treasurer could hedge the cost of borrowing with a forward rate agreement (FRA) obtained from a bank.
Alternatively, the treasurer could implement the synthetic approach by

(1) selling the March 1998 Eurodollar futures (segment DC) to borrow Euro-$ for \([t_1, t_2]\); and

(2) covering the exchange risk by buying the near-term March 1998 currency futures (segment CB) and

(3) selling the far-term June 1998 currency futures (segment AD).
Applying equation (11A.4), we can assess the theoretical Euro-£ borrowing rate implied by these futures transactions as follows:

Assume:

\[
AD = 1.555 \text{ £/£}, \quad DC = [1 + 0.06 \times (90/360)] = 1.015, \\
CB = 1.567 \text{ £/£}
\]

So \([1 + i_£ (90/360)] = 1.015 \times (1.567/1.555) = 1.022833\]

Therefore, our estimate of \(i_£\) is 9.13 percent, which represents the effective £ borrowing rate over the March 15 - June 15, 1998, interval, using the synthetic approach.
Figure 11A.2  Example of Synthetic Euro-£ Hedge

(1) Sell March 1998 Euro-$ Futures at 94.00 (6.00% yield)

(2) Buy March 1998 Sterling Futures at 1.567 $/£

(3) Sell June 1998 Sterling Futures at 1.555 $/£
Rollover Pricing of a Eurocredit  Teltrex International can borrow $3,000,000 at LIBOR plus a lending margin of .75 percent per annum on a three-month rollover basis from Barclays in London. Suppose that three-month LIBOR is currently $5\frac{1}{2}$ percent. Further suppose that over the second three-month interval LIBOR falls to $5\frac{1}{2}$ percent. How much will Teltrex pay in interest to Barclays over the six-month period for the Eurodollar loan?

Solution: $3,000,000 \times (.0553125 + .0075)/4 + 3,000,000 \times (.05125 + .0075)/4 = 47,109.38 + 44,062.50 = 91,171.88$
A major risk Eurobanks face in accepting Eurodeposits and in extending Eurocredits is interest rate risk resulting from a mismatch in the maturities of the deposits and credits. For example, if deposit maturities are longer than credit maturities, and interest rates fall, the credit rates will be adjusted downward while the bank is still paying a higher rate on deposits. Conversely, if deposit maturities are shorter than credit maturities, and interest rates rise, deposit rates will be adjusted upwards while the bank is still receiving a lower rate on credits. Only when deposit and credit maturities are perfectly matched will the rollover feature of Eurocredits allow the bank to earn the desired deposit-loan rate spread.
A forward rate agreement (FRA) is an interbank contract that allows the Eurobank to hedge the interest rate risk in mismatched deposits and credits. The size of the market is enormous. At June 2004, the notional value of FRAs outstanding was $13,144 billion. An FRA involves two parties, a buyer and a seller, where:

1. the buyer agrees to pay the seller the increased interest cost on a notional amount if interest rates fall below an agreement rate, or
2. the seller agrees to pay the buyer the increased interest cost if interest rates increase above the agreement rate.
Exhibit 11.6 graphs the payoff profile of a FRA. $SR$ denotes the settlement rate and $AR$ denotes the agreement rate.

**EXHIBIT 11.6**
Forward Rate Agreement Payoff Profile

![Diagram showing the payoff profile of a FRA with axes labeled SR and Profit (%), and points indicating Long position (Buy) and Short position (Sell).]
FRAs are structured to capture the maturity mismatch in standard-length Eurodeposits and credits. For example, the FRA might be on a six-month interest rate for a six-month period beginning three months from today and ending nine months from today; this would be a “three against nine” FRA. The following time line depicts this FRA example.

<table>
<thead>
<tr>
<th>Start</th>
<th>Agreement Period (3 Months)</th>
<th>Cash Settlement</th>
<th>FRA Period (6 Months)</th>
<th>End</th>
</tr>
</thead>
</table>

The payment amount under an FRA is calculated as the absolute value of:

\[
\frac{\text{Notional Amount} \times (SR - AR) \times \text{days/360}}{1 + (SR \times \text{days/360})}
\]

where \text{days} denotes the length of the FRA period.
Three against Six Forward Rate Agreement  As an example, consider a bank that has made a three-month Eurodollar loan of $3,000,000 against an offsetting six-month Eurodollar deposit. The bank’s concern is that three-month LIBOR will fall below expectations and the Eurocredit is rolled over at the new lower base rate, making the six-month deposit unprofitable. To protect itself, the bank could sell a $3,000,000 “three against six” FRA. The FRA will be priced such that the agreement rate is the expected three-month dollar LIBOR in three months.

Assume AR is 6 percent and the actual number of days in the three-month FRA period is 91. Thus, the bank expects to receive $45,500 (= $3,000,000 × .06 × 91/360) as the base amount of interest when the Eurodollar loan is rolled over for a second three-month period. If SR (i.e., three-month market LIBOR) is 5½ percent, the bank will receive only $38,864.58 in base interest, or a shortfall of $6,635.42.
Since $SR$ is less than $AR$, the bank will profit from the FRA it sold. It will receive from the buyer in three months a cash settlement at the beginning of the 91-day FRA period equaling the present value of the absolute value of \[ [\$3,000,000 \times (.05125 - .06) \times 91/360] = \$6,635.42. \] This absolute present value is:

\[
\frac{\$3,000,000 \times (.05125 - .06) \times 91/360}{1 + (.05125 \times 91/360)}
\]

\[
= \frac{\$6,635.42}{1.01295}
\]

\[= \$6,550.59\]

The sum, $\$6,550.59$, equals the present value as of the beginning of the 91-day FRA period of the shortfall of $\$6,635.42$ from the expected Eurodollar loan proceeds that are needed to meet the interest on the Eurodollar deposit. Had $SR$ been greater than $AR$, the bank would have paid the buyer the present value of the excess amount of interest above what was expected from rolling over the Eurodollar credit. In this event, the bank would have effectively received the agreement rate on its three-month Eurodollar loan, which would have made the loan a profitable transaction.
Balance Of Payments Account

Records the flow of payments between residents of a country and the rest of the world in a given year.

Every transaction is recorded twice, once as a debit (-), once as a credit (+). So the sum of all the items on the balance of payments account should equal zero.

There are three major accounts on the balance of payments: the current account (records transactions in goods and services), the capital account (records one time changes in the stock of assets), and the financial account (records transactions in assets).
Balance Of Payments Account

The double entry system often makes one entry on the current account and an offsetting entry on the financial account, or it may make two entries on one of the two accounts.
Balance Of Payments Account

- A simple way of understanding how transactions are recorded is to think of debits as arising when money flows out of US or in foreign currencies, and credits when money flows into the US in dollars.

- Credits result from purchases by foreigners; they give rise to inflows or sources of foreign exchange. Debits result from purchases by domestic residents (could be either private individuals or government officials); they give rise to outflows or uses of foreign exchange.
CURRENT ACCOUNT

(a) ‘TRADE BALANCE’
(goods, services, transfers)

DEBIT (-)
Imports
import of a Japanese car; foreign aid to Israel

CREDIT (+)
Exports
exports of PC’s; money transfers from abroad to local students

(b) ‘DEBT SERVICE’

Payments of dividends & interest to foreigners
Receipts from dividends, interest payments on overseas investments by US citizens
- another Balance of Payment (BOP) account
- asset (real & financial) transactions
- payment flows from current account transactions
- the way they are recorded on the US BOP account is US assets abroad (net), Foreign assets in the US (net)
- don’t interpret these terms as ‘physically’ being abroad, e.g., a US bank in New York acquiring DM increases the item ‘US assets abroad’
- anything that is capital inflow is a credit, anything that is a capital outflow ("capital export") is a debit
<table>
<thead>
<tr>
<th>DEBIT (-)</th>
<th>CREDIT (+)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CAPITAL EXPORT (-)</td>
<td>CAPITAL IMPORT (+)</td>
</tr>
</tbody>
</table>

| US assets abroad | foreign assets in the US |
| US citizens buy Japanese stocks/bonds | Japanese firm buys Sears tower |

| foreign assets in the US | US assets abroad |
| US citizens sell US stocks | US firm sells stake in British firm |
Official Settlement Account

Under this account, foreign asset transactions of the US & foreign central banks are recorded. Holdings of foreign currency denominated assets by central banks are called International or Official Reserves.

The same rule applies; i.e. an increase in official reserves of the Federal Reserve is recorded as an increase in US assets abroad which is a debit.
Official Settlement Account

$\uparrow$Official reserves US $\downarrow$Official reserves US
$\downarrow$reserves foreign $\uparrow$reserves foreign
central banks central banks

Now we can compute 3 sub-balances, but then

current account + capital account + official settlements = 0

deficit/surplus deficit/surplus surplus/deficit
The balance on the BOP account is often referred to as the sum of the current account and the financial account balances or equivalently the negative of the official settlements balance.

So an increase in official reserves is then seen as a BOP surplus.

This makes sense in a system of fixed exchange rates. When a currency is in excess demand, the central bank has to supply these dollars in order to clear the market and keep the currency rate fixed.
A currency is in excess demand when the financial account plus the current account balance exceed 0 when purchases of US goods (‘exports’) and assets (‘capital import’) by foreigners exceed Americans’ purchases of foreign goods & assets (‘capital export’).
Price of the $ = FC/$

= extra supply of $ by central bank

get foreign currencies in return
i.e. build up foreign reserves
With flexible exchange rates the official settlements balance should equal zero as there is no need to intervene to make market clear. In practice, even in the post-Bretton Woods system of flexible exchange rates, central banks intervene, which is why the current system is sometimes called a “managed” or “dirty” float.

Reference: Professor Bekaert’s class notes
Alternative Investment Risk and Return Characteristics

Rate of Return vs. Risk

Risk

T-Bills

U.S. Government Bonds

Foreign Government Bonds

U.S. Corporate Bonds

Foreign Corporate Bonds

U.S. Common Stocks

Foreign Common Stock

Real Estate (Personal Home)

Commercial Real Estate

Warrants and Options

Art and Antiques

Futures

Coins and Stamps

Reilly/Brown: Investment Analysis & Portfolio Management, 7E, Exhibit 3.17
Assignment from Chapter 11
Exercises 1, 2, 3, 4.

Chapter 11, Exercise 1
a. $.626/DM
b. $4,000,000
c. $8,820,512

Chapter 11, Exercise 2
a. 2.5%

Chapter 11, Exercise 3
a. 10.75
b. 99.25
c. 4.25

Chapter 11, Exercise 4
11.1. Consider the following:

Spot Rate: $ 0.65/DM
German 1-yr interest rate: 9%
US 1-yr interest rate: 5%

a. Calculate the theoretical price of a one year futures contract.
b. What would you do if the futures price was quoted at $0.65/DM in the market place? Where would you borrow? Lend? Calculate the gain on a $100 million arbitrage transaction.
c. What would you do if the future price was quoted at $0.60/DM in the market place? Where would you borrow? Lend? Calculate the gain on a $100 million arbitrage transaction.
HINTS:

a. \[ F = S \frac{(1 + r_S)}{(1 + r_{FC})} = \frac{.65 \times (1.05)}{1.09} = \$0.626/DM \]

b. Borrow $ at 5%; Exchange into DM at spot rate; Invest in DM at 9%; Sell forward at $.65/DM. Earn interest differential on nominal amount with no loss or gain on currency. Gain = …

c. Borrow DM at 9%; Exchange into $ at spot rate; Invest in the US at 5%; Buy forward at $.60/DM. Gain on currency more than offsets negative interest rate differential. Gain = …
11.2. Consider the following prices:

Spot Rate: Yen 100/$
1-yr US interest rate 5%
Futures price Yen 97.62/$

a. What value of the one-year Japanese interest rate will remove arbitrage incentives conditional on the spot rate, futures price, and US interest rate?

b. If the yen interest rate is higher than the one found above, what would you do to take advantage of arbitrage opportunities?

c. If the yen interest rate is lower than the one found above, what would you do to take advantage of arbitrage opportunities?
HINTS:

a. The exchange rate is expressed in FC/$. Adjust formula to calculate the futures price to take this into consideration.
\[ F = S \times \frac{(1 + i_{\text{yen}})}{(1 + i_\$)} \]
\[ i_{\text{yen}} = \left( \frac{F}{S} \right) \times (1 + i_\$) - 1 \]

b. Borrow US$ at $i_\$; Buy yen at spot rate; Invest in yen securities at $i_{\text{yen}}$; Sell yen forward for US$.

c. Borrow in yen at $i_{\text{yen}}$; Sell yen at spot rate for US$; Invest in the US$ securities at $i_\$; Buy yen forward.
11.3. Suppose the interest rate futures contract for delivery in three months is currently selling at 110. The deliverable bond for that particular contract is a 25-year bond, currently traded at 100 with a coupon rate of 10%. The current 3-month rate is 7%.

a. Is there any arbitrage opportunity? If yes, what would you do and what would be your potential gain from an arbitrage transaction?

b. What is the theoretical price of the futures contract?

c. Suppose the price was 95 instead of 110. What would you do to take advantage of arbitrage opportunities?
HINTS:

a. Yes, there is an arbitrage opportunity. Here is how:
   Sell Futures contracts at 110; Purchase the bond at 100
   Borrow 100 at 7%.
   Profit = Proceeds - Outlays
   Profit = (Price of Bond + Accrued Interest) - (Principal
   Repayment + Interest Payment);

b. The correct price is determined so that there are no arbitrage
   opportunities.

c. Buy the futures at 95; Sell Bond at 100; Lend at 7% for 3
   months.
   Profit = (Principal + Interest Payment) - (Price of Bond +
   Accrued Interest);
   Profit = …
11.4. The Portfolio Manager of the WXYZ pension fund wants to protect herself against a decline in future interest rates. The fund’s planned short-term investments are placed in 3-month Eurodollar deposits at the LIBID rate. The current LIBID-LIBOR spread in the interbank market is 7.375-7.500%, and the current price of a CME futures contract (which settles on the basis of three-month Eurodollar LIBOR) is 92.50 reflecting a 7.500% interest rate.

a. How could the WXYZ fund use the futures market to hedge itself? What is the minimum interest that the firm locks in?

b. Suppose that at maturity, Eurodollar rates have fallen to 6.375-6.500% in the interbank market. Evaluate the hedge. What deposit rate has the fund secured?

Suppose that at maturity, Eurodollar rates have increased to 8.375-8.625% in the interbank market. Assume that the LIBID-LIBOR spread has widened because of greater interest rate and macroeconomic uncertainty. Now, evaluate the hedge. What deposit rate has the fund secured?
**HINTS:**

a. The fund manager should use the money to buy the CME futures contract at 92.50 to lock in the 7.50% interest rate.

b. In this case, the hedge caused a net gain and the locked-in deposit rate of 7.5% is higher than the Eurodollar deposit rate of 6.375% at maturity.

c. In this case, the hedge caused a net loss and the locked-in deposit rate of 7.5% is lower than the Eurodollar deposit rate of 8.375% at maturity.