

# Swaps

---

## Currency Swaps

Jonathan Kinlay

# Agenda

- Currency swap valuation
- Exposure analysis
- Convexity of a currency swap

# Demand for Currency Swaps

- Money market investors exploit high-yield currencies without forex exposure
- Asset managers enhance portfolio returns
- Liability managers reduce effective borrowing costs
- Central bank intervention

# Structures

- Fixed for fixed
- LIBOR currency A for LIBOR currency B
- Variants
  - Differential
  - Quanto
  - Third currency

# Valuation

- Based on:
  - Cash flows: spot LIBOR curve
  - Discounting: spot LIBOR curve
- Spot curves have different liquidity and risk premiums

# Currency vs. Interest Rate Swaps

## ➤ Notional principal

- Swapped at effective date at spot exchange rate  $S$
- Reswapped at maturity at initial spot rate  $S$

## ➤ Reset dates

- Interest payments swapped in relation to notional

# Exposure from Currency Swaps

- First, understand how currency swap works and is valued
  - Work through actual swap transaction to develop insight
- Second, apply valuation insights for sensitivity analysis
  - Change in spot rates?
  - Hedging currency swaps?

# JPY/USD Currency Swap

- ◆ Fixed for Floating Currency Swap
- ◆ Contract: Buyer's Perspective
  - Effective Date: Swaps USD for JPY at  $S_0 = \text{JPY/USD}$
  - Pays Fixed Interest for JPY (Semiannually)
  - Receives USD LIBOR (Semiannually)
  - Maturity Date: Swaps JPY for USD at  $1/S_0$

# JPY/USD Quotes

◆ Fixed-for-Floating (6-Month Resets)

◆ JPY/USD

◆     1           2           5           10

◆ 1.02/06 1.54/59 1.84/88 3.48/51

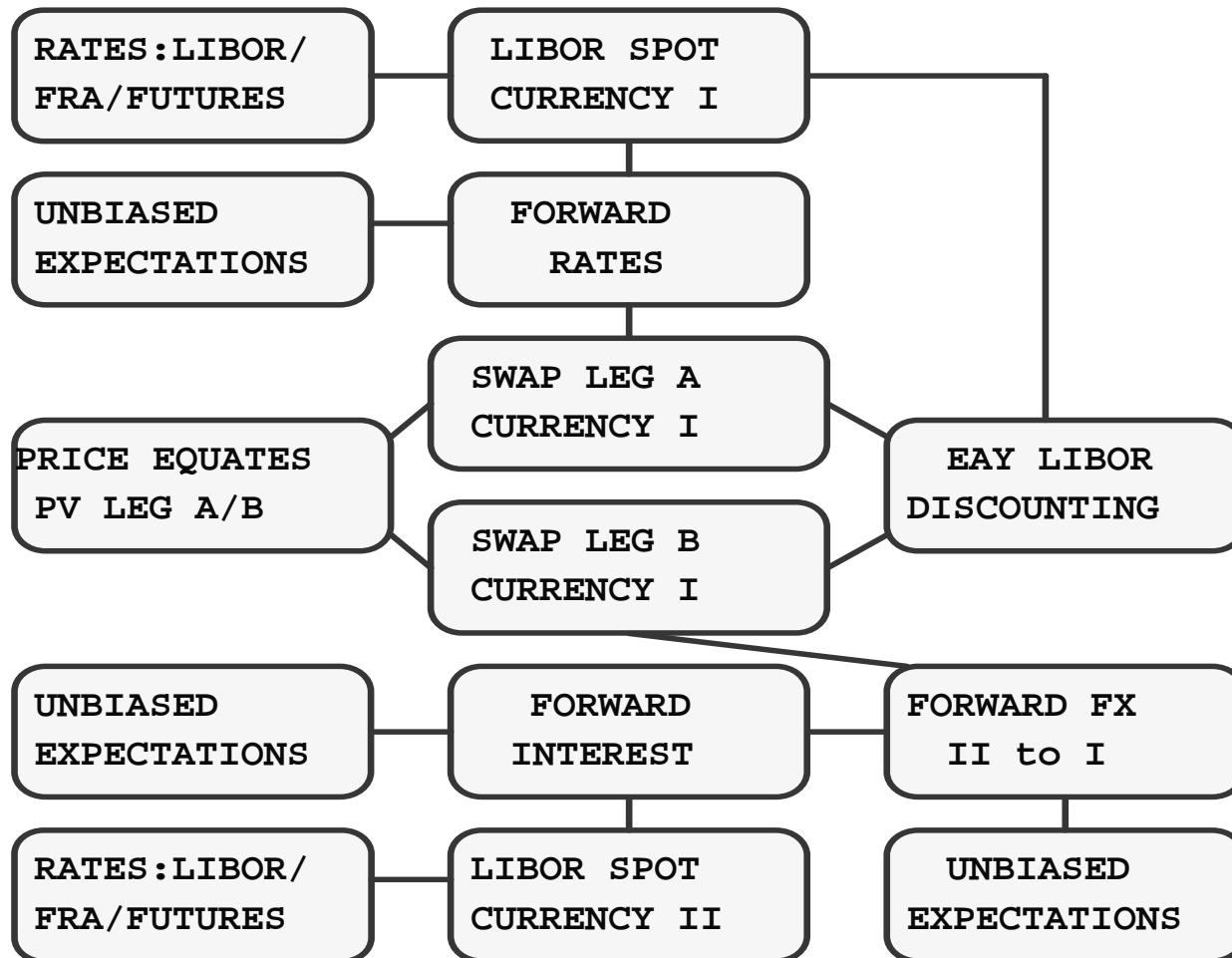
◆ Desk: Pays 1.54 Receives USD LIBOR

◆ Desk: Receives 1.59 Pays USD LIBOR

# JPY/USD Basis Quotes

- ◆ Floating-for-Floating (6-Month Resets)
- ◆ USD/JPY
- ◆ 1            2            5            10
- ◆ -9/-8    -10/-9   -12/-11   -12/-12
- ◆ e.g., 2-yr Desk: Pays JPY LIBOR -10  
Receives USD LIBOR
- ◆ Desk: Receives -9 Pays USD LIBOR

# Currency Swap Valuation



# USD/JPY Basis Swap

<b>Notional principal amount</b>	<b>USD10,000,000</b> <b>Yen977,500,000</b>
<b>Effective date</b>	<b>August 16, 1995</b>
<b>Day count between each reset date:</b>	
<b>February 16, 1996</b>	<b>184 days</b>
<b>August 16, 1996</b>	<b>182 days</b>
<b>Maturity date</b>	<b>August 16, 1996</b>
<b>Interest settlements are in arrears.</b>	
<b>Floating Side I (Leg):</b>	
<b>Reference Rate</b>	<b>6-Month Yen LIBOR - 8.95</b>
<b>Payment Frequency</b>	<b>Semiannual Resets</b>
<b>Day count</b>	<b>Actual/360</b>
<b>1st Coupon</b>	<b>0.848%</b>
<b>Floating Side (Leg):</b>	
<b>Reference Rate</b>	<b>6-Month USD LIBOR</b>
<b>Payment Frequency</b>	<b>Semiannual Resets</b>
<b>Day count</b>	<b>Actual/360</b>
<b>1st Coupon</b>	<b>6.0%</b>

# Forward LIBOR Rates

- Principal of equivalent return
  - Deposit @ LIBOR 6-month spot vs.
  - Roll over Two 3-month LIBOR deposits

$$(1 + \text{LIBOR}_{6m} \times \text{Actual Days} / 360) =$$

$$(1 + \text{LIBOR}_{3m} \times \text{Actual Days} / 360) \times$$

$$(1 + \text{LIBOR}_{\text{forward}} \times \text{Actual Days} / 360)$$

# Example: Forward LIBOR Rates


# Correcting LIBOR Spots: Effective Annual Yield

## ☞ Spot Curve Correction

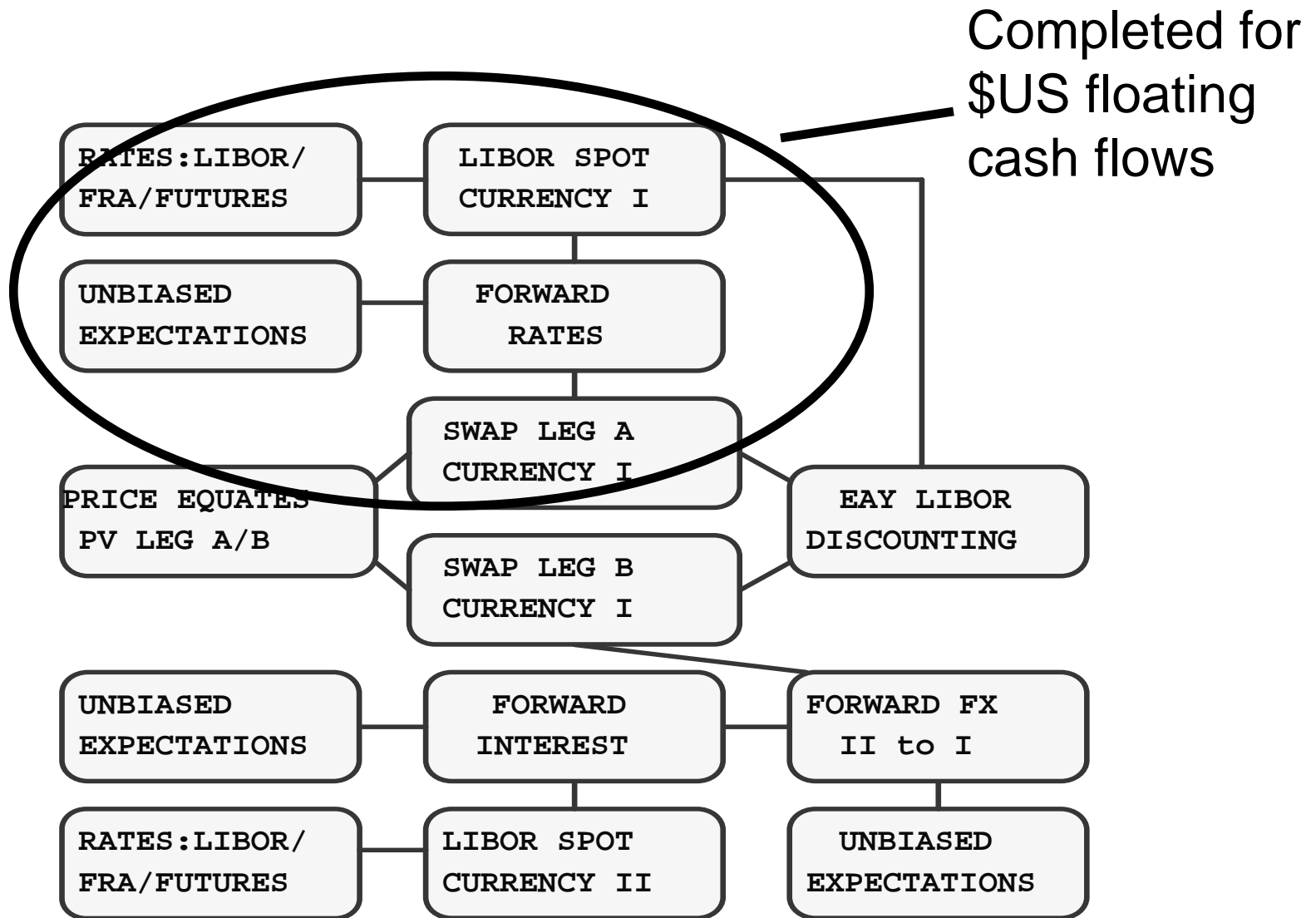
- Adjust for compounding over reset periods

$$1 + {}_0r_m^1 = \left(1 + {}_0r_m \times \frac{\sum \tau}{360}\right)^{\frac{360}{\sum \tau}}$$

$$1.06088 = \left(1 + 0.06 \times \frac{184}{360}\right)^{\frac{360}{184}}$$

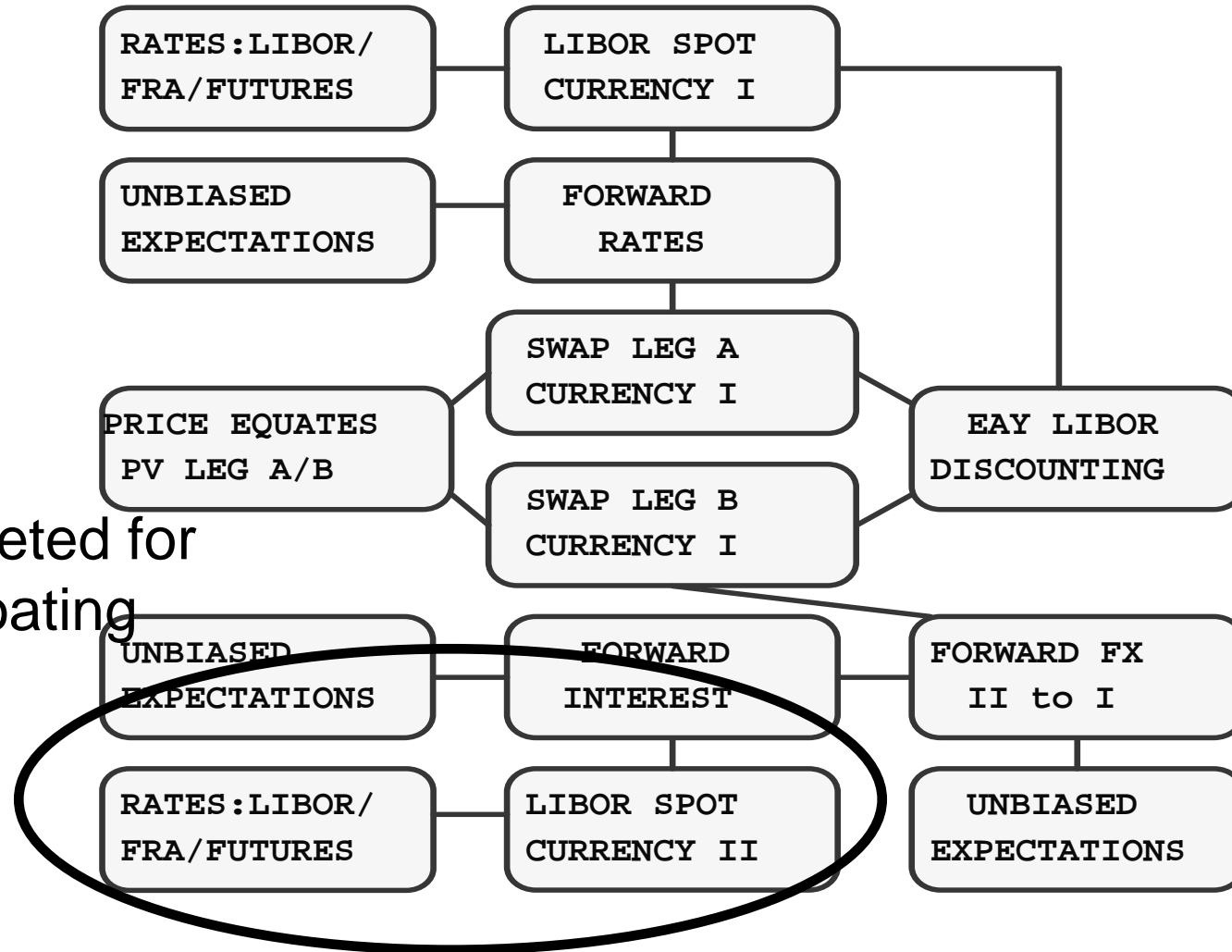
# USD Leg: PV


# Road Map



# JPY Cash Flow Projections


# Road Map



Completed for  
Yen floating

# Convert Projected Cash Flows: Notation

◆  $c/c^* = s$  or  $f$ :

- $c^*$  Deliverable Currency
- $s$ : Today's Spot Price of 1 unit of  $c^*$  in units of  $c$
- $f$ : Today's Forward Price of 1 unit of  $c^*$  in units of  $c$
- $r^*$  Annualized Risk Free Rate for Deliverable Currency ( $c^*$ )
- $r$  Annualized Risk Free Rate for Currency  $c$

# Covered Interest Parity (CIP)

- ◆ At time 0,  $s = \text{USD}/c^*$ , Deliverable  $c^*$
- ◆ Compare two investment alternatives:
  - i. Invest \$1 at  $r$
  - ii. Exchange \$1 at  $1/s$ , Invest in  $r^*$ , Re-exchange at  $f$ .
- ◆ Zero Arbitrage implies  $i. = ii.$
- ◆  $(1+r) = f(1+r^*)/s$

$$\frac{f}{s} = \frac{(1+r)}{(1+r^*)}$$

# Theorem: Difference Form

- ◆ Common Approximation for Interest Rates is the relationship  $\log(1 + r) \cong r$
- ◆ Re-express CIP Theorem by Taking Logs (Using Lowercase Notation for the Logs)
- ◆ CIP Theorem relates *forward rate discount* to difference in country spot 1-period interest rates (t=0 to 1).

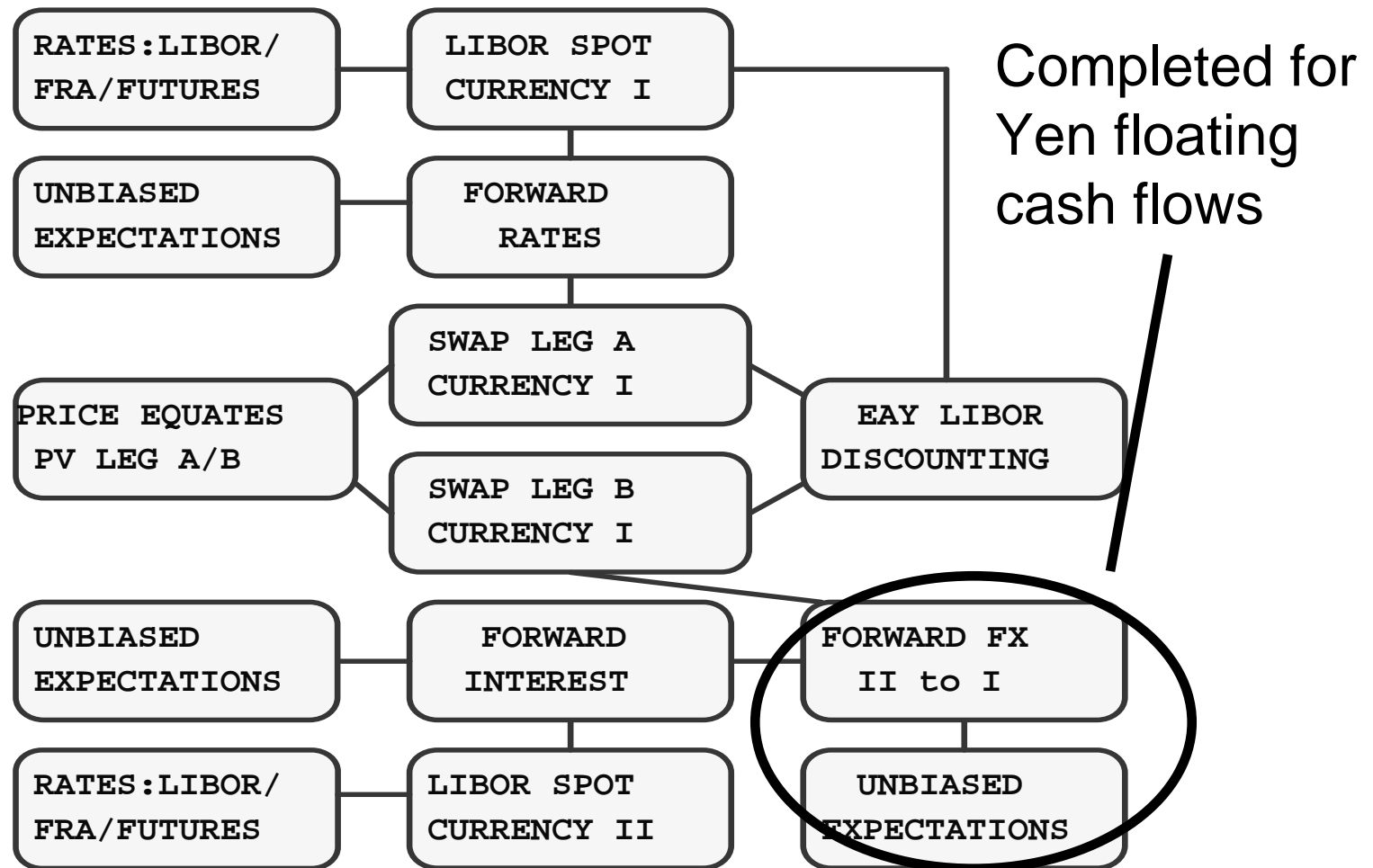
$$f_1 - S_0 = r_1 - r_1^*$$

# Currency Forwards: Quotes

- ◆ Quote: JPY/USD 97.40/45 =  $s$ ,  $r^* = \text{US}$
- ◆ 1M                      3M                      6M      (Aug 18, 95)
- ◆ 42.8/-42      -125/-124      -247/-245
- ◆ Quotes: Fwd Discount (possibly no sign)
  - Check using Covered Parity (Fix Deliverable)
  - USD LIBOR > JPY LIBOR ( $f - s = r - r^*$ )
- ◆ 3-Month Forward: 96.15/96.21
- ◆ Convert: Yen to \$US --- Divide \$1 by 96.15

# Yen Cash Flows in US\$

# Road Map



# Missing Component

- PV of USD LIBOR Leg = \$582,684
- PV of JPY LIBOR Leg = \$102,700
- Why the Significant Discrepancy?
  - We have not accounted for the effects from swapping the notional principal

# Appreciation Priced into Spot/Forward Rates

- Expected Exchange Rate Returns
  - Difference between nominal rates induce an expected return from a currency
  - Why? --- Inflation, (liquidity) risk premium
- USD LIBOR > JPY LIBOR
  - Buyer buys JPY sells USD, Maturity Reverses
  - Gives up higher Libor for a lower Libor - why?
  - Gains from appreciation in JPY/USD priced into forward price

# Forward Prices and Expected Appreciation

- Spot rate and forward rates
  - August 16, 1995 fx = 0.010230 (spot)
  - February 16, 1996 fx = 0.010493 (forward)
  - August 16, 1996 fx = 0.0107434 (forward)
- Forward rates imply appreciating yen
- Long currency swap benefits from appreciation by time swap is reversed
  - Why? - Swap re-exchanges at original spot

# Accounting for Expected Appreciation

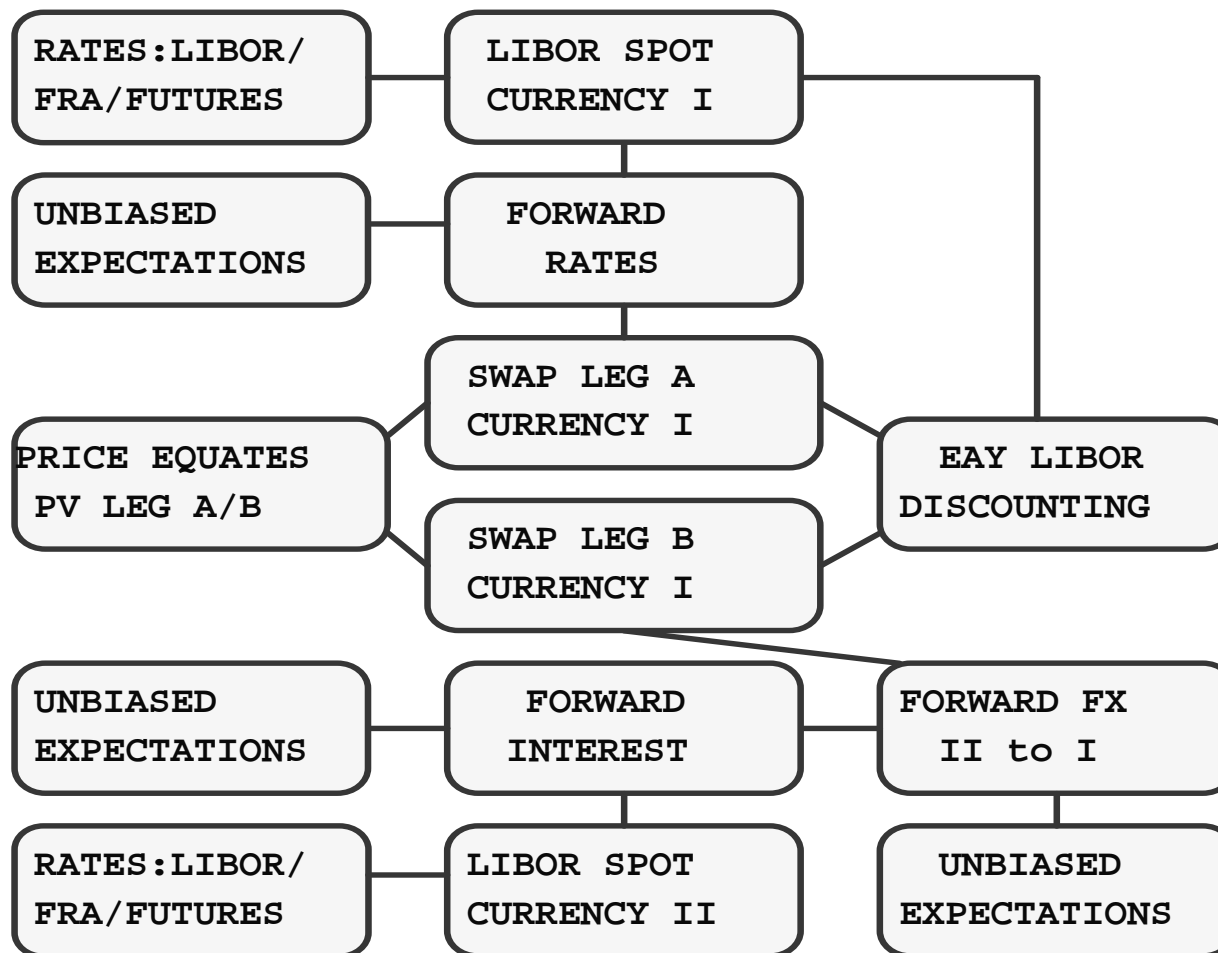

# Valuation Example

- ◆ Price -8.95 basis points
- ◆ PV of USD LIBOR Leg: \$582,685
- ◆ PV of JPY LIBOR Leg Interest Expense + E(Appreciation) in JPY/USD: \$582,685
- ◆ Quoted Price: USD/JPY 1 Year = -9/-8

Price equates PV  
of each leg

Interest expense =  
(projected Libor  
fwd rates + price)\*  
notional

# Currency Swap Valuation: Summary



# Forward Rate Approach

- Calculated PV of expected appreciation at each reset date
- Alternative: calculate PV of expected appreciation at time of maturity
  - Timing is accurate
  - BUT: ignores shape of forward curve
    - ◆ Forward curve captures correlation information
  - RESULT: pricing can be 5bp outside spread

# The Forward FX Curve

- Embodies information about correlation between forward rate discount and interest rate differential (CIP Theorem)
- Ignoring correlations in forward rate results in mispricing
  - Models provide insight into role of correlations

# Currency Swap Models

- Interest rate / exchange rate models
  - 1-factor models assuming that both LIBOR rates and fx rate follow a diffusion process
- Correlations influence pricing
  - Correlation between domestic and foreign rates
  - Correlation between foreign interest rate and exchange rate
    - ◆ Simulation indicates latter very significant

# Exposure Analysis

- Long Swap: Pay (Yen LIBOR - price)
- What if Yen appreciates more than implied by the forward rate curve?
- Long side *loses (twice)*:
  - Pays in Yen
  - Also, must re-exchange yen for USD at original spot rate
  - Current example: +1 basis point shift in exchange rate => price decreases

# Convexity of Currency Swap

## ➤ Definition: Positive Convexity

- Increase in Present Value from exchange rate decline  
EXCEEDS
- Decline in Present Value from exchange rate increase

➤ USD/Yen -1 bp: price increases

➤ USD/Yen +1 bp: price decreases

- Price increase > price decrease

# Long Currency Swap

- Pay Yen LIBOR - price, receive USD LIBOR
- Positive convexity in exchange rate
  - PV increases more with decline in USD/Yen

# Hedging Currency Swaps

- Sources of exposure
  - Domestic and foreign interest rates
  - Exchange rate
  - Hedge using Euro-future strips (domestic and foreign) plus currency forward contracts
    - ◆ Sufficient to capture effects of correlation
  - 1-Factor models imply simpler hedging
    - ◆ Problem: short rate hedge assumption

# Summary

- Currency swap valuation
- Exposure analysis
- Convexity of a currency swap