Derivatives & Risk Management

• Previous lecture set:
  – Interest-Rate Derivatives:
    • Introduction
    • FRAs, Eurodollar Futures & T-bills futures

• This lecture set – Parts II & III
  – Interest-Rate Derivatives
    • Swaps

Part III: Swaps
Swaps

- Fundamentals
  - what, how, why?
  - what’s in it for investment banks?
- Interest rates swaps
  - market microstructure and quotes
- Currency Swaps
  - basis-point equivalence

Swap Fundamentals

- Basic idea
  - agree to exchange interest payments of different kinds
    » different interest computations
    » different currencies
  - during a given time period
  - with interest payments computed on notional amount
- Notional amount
  - never exchanges hands in single-currency IR swaps
- Reference interest rate
  - LIBOR = reference floating rate in most cases
Interest Rates Swaps

• Types
  • coupon swap
    » fixed vs. floating
  • floating-floating swap = basis-rate swap
    » different reference “reset” rate

• Typical setup (“plain vanilla IR swap”)
  • coupon swap
    – floating leg = LIBOR + premium
  • fixed rate <-> floating rate (works for assets or liabilities)

Interest Rates Swaps 2

• Plain-vanilla Interest Rate Swap
  • Contract by which
    » **Buyer** (long) is committed to pay **fixed** rate \( R \)
      (similar to FRA: buyer locks in borrowing rate)
    » **Seller** (short) is committed to pay **variable** \( r \) (e.g., LIBOR)
  • on notional amount \( M \)
    » no exchange of principal (*can we swap outstanding bonds?*)
  • at future dates set in advance
    » \( t + \Delta t, t + 2 \Delta t, t + 3\Delta t, t+ 4 \Delta t, \ldots \)
    » most common swap : 6-month LIBOR (\( \Delta t=6 \) months)
Interest Rates Swaps 3: Example (i)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Borrowing conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fix</td>
<td>Var</td>
</tr>
<tr>
<td>A</td>
<td>Fix</td>
</tr>
<tr>
<td>B</td>
<td>Var</td>
</tr>
</tbody>
</table>

* indicates borrower’s preference

Prelude to the swap: each borrows where its (dis)advantage is largest (smallest)

Interest Rates Swaps 3: Example (ii)

<table>
<thead>
<tr>
<th>Objective</th>
<th>Borrowing conditions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fix</td>
<td>Var</td>
</tr>
<tr>
<td>A</td>
<td>Fix</td>
</tr>
<tr>
<td>B</td>
<td>Var</td>
</tr>
</tbody>
</table>

Prelude to the swap: each borrows where its (dis)advantage is largest (smallest)
Interest Rates Swaps 3: Example (iii)

Objective | Borrowing conditions
---|---
| Fix | Var
A | Fix | 5%* | Libor+1%
B | Var | 4% | Libor+0.5%*

Swap: transforms the nature of the liabilities

Swap: solution when the parties equally split gains from swapping (*QSD*)
### Interest Rates Swaps 3: Example

<table>
<thead>
<tr>
<th>Objective</th>
<th>Borrowing conditions</th>
<th>Fix</th>
<th>Var</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Fix</td>
<td>5%*</td>
<td>Libor+1%</td>
</tr>
<tr>
<td>B</td>
<td>Var</td>
<td>4%</td>
<td>Libor+0.5%*</td>
</tr>
</tbody>
</table>

Swap (*indicates preference):

- **A**
  - Libor+1%
  - 3.75%

- **B**
  - Libor
  - 4%

- **Inflow** Libor 3.75%
- **Outflow** (Libor+1%) (4%)

- **Net outflow** (4.75%) (Libor+.25%)
- **Saving** 0.25% 0.25%

*A free lunch?*

### Swap Fundamentals 2

- **Market microstructure**
  - *early on: brokered market*
    - origin: credit risk discrepancies
      - familiarity, risk perceptions, regulation, ...
      - fund availability, subsidies, excessive use of MKT, ...
    - credit risk?
  - *nowadays: dealer market*
    - minimize transaction costs, balance sheet management
    - quotes
      - what’s in it for intermediaries?
    - regulatory mandate: CCP clearing of std swaps *(Mar. 3, 2013)*
Interest Rates Swaps 4: Quotes

• Floating leg
  • LIBOR

• Fixed leg
  • Quote by reference to Treasury benchmark yields

• **Years** | **T-Bond benchmark yield** | **Spread (bp)**
--- | --- | ---
• 2 | 3.22 % | 48-58
• 3 | 3.25 % | 60-70
• 4 | ... | ...

Interest Rates Swaps 5: Example with FI

<table>
<thead>
<tr>
<th>Objective</th>
<th>Borrowing conditions</th>
<th>Fix</th>
<th>Var</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Fix</td>
<td>5%*</td>
<td>Libor + 1%</td>
</tr>
<tr>
<td>B</td>
<td>Var</td>
<td>4%</td>
<td>Libor+0.5%*</td>
</tr>
</tbody>
</table>

Swap:

- **Gains for each company**
  - A
    - Outflow: 3.80% Libor+1% 4%
    - Inflow: 3.70% Libor
  - B
    - Outflow: 3.80% Libor 4%
    - Inflow: 3.70% Libor+0.3%

- Saving: 0.20% 0.20%

What’s in it for the FI?
Interest Rates Swaps 6: QSD

• Quality Spread Differential:
  • represents the potential gains from the swap
  • is shared between the counterparties (+ the swap bank)

• Sharing the QSD
  • in our numerical example:
    – parties split equally, and bank gets its B-A spread
    – company A is less credit-worthy than bank B yet gets an equal share of the QSD
  • no reason why the gains should be shared equally

Interest Rates Swaps 7

• Key terminology:
  • “Notional Amount”
  • “Indices”
    » LIBOR, Treasury,… = different reference rates
  • “Fixed-Rate Payer”
    » = Variable-Rate Receiver = swap buyer = long
  • “Variable-Rate Payer”
    » = Fixed-Rate Receiver = swap seller = short
Interest Rates Swaps 8: Valuation

• Valuation
  
  • Floating leg:
    – Value of upcoming cash-flow till next reset
      » small number
  
  • Fixed leg:
    – Value of a fixed-rate bond
      » can fluctuate significantly with the yield curve
  
  • Which leg’s value is riskier?

Interest Rates Swaps 9: Risks

• Risks for the counterparties
  
  – Credit Risk
    • the counterparty or the swap bank defaults (big deal?)
  
  – Interest Rate Risk
    • in a coupon swap
      » fixed leg is unhedged and its value changes
    • in a basis-rate swap
      » basis changes
  
  – Mismatch Risk
    • need a counterparty for the right amount & horizon.
Interest Rates Swaps 10

• Risks for the swap bank
  – Interest Rate Risk
    • Interest rates might move against the swap bank
      – after it has only gotten half of a swap on the books
      – or if it has an unhedged position.
  – Credit Risk
    • This is the major risk faced by a swap dealer
      – the risk that a counter party will default on its end of the swap.
  – Mismatch Risk
    • It’s hard to find a counterparty that wants to borrow the right amount of money for the right amount of time.

Currency Swaps

• Interest rate swap vs. currency swap
  • number of currencies involved
  • Currency swaps were first, but IR swaps now dominate

• Typical setup
  • dollar: \textit{semi-annual, LIBOR + premium}
  • foreign currency: \textit{annual, fixed}

• Examples
Currency Swaps 2: Quotes

- Usual convention:
  - Floating leg: LIBOR (pay or receive)
  - Fixed leg: annual fixed in foreign currency

- Example
  
<table>
<thead>
<tr>
<th>Years</th>
<th>SF/$ annual</th>
<th>C$/S annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2.50-2.63</td>
<td>5.25-5.38</td>
</tr>
<tr>
<td>3</td>
<td>3.13-3.25</td>
<td>5.63-5.75</td>
</tr>
<tr>
<td>4</td>
<td>...</td>
<td>...</td>
</tr>
</tbody>
</table>

Currency Swaps 3

- Rationales for currency swaps
  
  - Financial market imperfections (why?)
    - Home-market effect
    - Differences in risk perception
    - Regulation of issuers and investors
    - Subsidized financing
    - Availability of funds/excessive uses of a market
    - Transactions costs for bond deals

- Change the nature of assets or liabilities
Currency Swaps 4

• Investment bank perspective
  • financial advising
  • pricing
    – big picture: swap rates are by reference to bond yields
    – cash-flow matching
    – basis-point equivalence
      » numerical example

Currency Swaps 5: Valuation

• Valuation
  • Nested sequence of FX forward contracts
  • Alternatively, value as difference between two bonds
Currency Swaps 6: Risks

• Risks
  – In addition to the risks from IR swaps:
  – 1. the principal repayment matters
     • FX rate changes affect more than mere interest
  – 2. there is sovereign risk
     • Risk that a country will impose exchange rate restrictions that will interfere with performance on the swap

Swap Fundamentals 3: Variations

• Currency Swaps
  • Fixed annual in FX for US$ @ LIBOR, but also…
  • fixed for fixed
  • fixed for floating
  • floating for floating
  • amortizing

• Interest Rate Swaps
  • Fixed for floating ("plain vanilla IR swap"), but also…
  • zero-for floating
  • floating for floating
Concluding Remarks

• Astounding growth of the swap market
  • from about 4 trillion US dollars in 1991
  • to a peak of 710 trillion US dollars by end-2013
  • down to (still) 493 trillion US dollars by end-2015

• Swaps are an important source of revenue (and risk) for banks

• Swaps are here to stay
  • A QSD is needed for a swap – transactions costs associated with foreign bond and eurobond deals
  • Regulatory questions? (clearing, SEFs, futurization)

Currency Swaps vs. Long-Dated FX Forwards

• Observation
  • long-dated forward
  • “=“ zero-coupon swap

• Consequence
  • dual-currency bonds
  • market efficiency and arbitrage

• NOT EXAM MATERIAL
Currency Swaps vs. Long-Dated FX Forwards 2

**Situation.**

Your company, H.J. Heinz, would like

- to issue 5-year zero-coupon bonds in SF,
- for a total face value of SF 50m,
- at a maximum effective interest rate in SF of 5%.

Heinz does not want to issue SF-denominated bonds in Switzerland: it would rather go to the Euromarkets. Unfortunately, the Swiss authorities have in effect prohibited the issuing of SF Eurobonds.

---

Swaps vs. Long-Dated Forwards 3

Heinz does not want to irritate the Swiss authorities by breaking the "ban" on SF-Eurobond, yet wants to achieve its cash-flow goals in SF. As a financial analyst at H.J. Heinz, you have the following pieces of information.

5-year annualized borrowing rate, dollar-denominated Eurobonds: 10%

5-year annualized borrowing rate, SF-denominated bonds (issued in Switzerland): 5%

SF/$ spot rate: 1.5SF/1$

<table>
<thead>
<tr>
<th></th>
<th>possible</th>
<th>wanted</th>
</tr>
</thead>
<tbody>
<tr>
<td>t=0</td>
<td>+$26,117,539</td>
<td>+SF 39,176,308</td>
</tr>
<tr>
<td>t=5</td>
<td>-$42,062,557</td>
<td>-SF 50,000,000</td>
</tr>
</tbody>
</table>
Key element to achieving Heinz’s goals.

You must find a combination of financial instruments that together reproduce the pattern of cash-flows that Heinz would obtain if it were able to float SF Eurobonds. Hence, the preliminary step required to find a solution to Heinz’s problem, is to determine the cash-flows that the company desires.

They are as follows:

\[
\begin{align*}
    t=0 \text{ (now)} &: \text{ cash-in of SF } 39,176,308 = \text{ SF } 50m/(1.05)^5 \\
    t=5 \text{ (in 5 years)} &: \text{ cash-out of SF } 50m
\end{align*}
\]

Solution 1: Heinz sells dollar Eurobonds and sells SF for $ forward.

Heinz wants to obtain at least SF 39,176,308 now in exchange for a repayment of SF 50m in 5 years. Given the "ban" on SF-denominated Eurobonds, Heinz would be better off:

- floating 5-year $-denominated zero-coupon Eurobonds,
- converting the proceeds at the current spot rate,
- and bundling the Eurobonds thus floated with $/SF forward contracts at the appropriate forward rate given by interest rate parity.

At maturity, Heinz would then:

- redeem the dollar bonds at their face value,
- using the SF 50m sold forward to do so.
Swaps vs. Long-Dated Forwards 6

The table below sums up the pattern of cash-flows over time.

<table>
<thead>
<tr>
<th>t=0</th>
<th>$ Eurobonds</th>
<th>spot SF purchase</th>
<th>forward SF sale</th>
<th>total cash-flow</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+$ 26,117,539</td>
<td>-$ 26,117,539</td>
<td>+SF 39,176,308</td>
<td>+SF 39,176,308</td>
</tr>
<tr>
<td>t=5</td>
<td>-$ 42,062,557</td>
<td>+$ 42,062,557</td>
<td>-SF 50,000,000</td>
<td>-SF 50,000,000</td>
</tr>
</tbody>
</table>

Swaps vs. Long-Dated Forwards 7

At the current spot rate, SF 39,176,308 = $ 26,117,539.

Suppose that Heinz were to float $-denominated zero-coupon Eurobonds that would yield proceeds of $ 26,117,539. Given that the 5-year borrowing rate for dollar-denominated Eurobonds is 10%, Heinz would have to float $-denominated zero-coupon Eurobonds with a face value of $ 42,062,557 = $ 26,117,539 (1.10)^5.

Now suppose Heinz floats $-denominated Eurobonds at 10%, and sells them together with forward contracts with a forward rate of $0.84125/1SF. The latter is the $/SF 5-year forward rate implied by interest rate parity is: $0.66/1SF x (1.1/1.05)^5 = $0.84125/1SF.

At maturity, what happens? Heinz has SF 50m, but is short $ 42,062,557 (it needs to redeem the Eurobonds). However, it has a long position in $ (and a short position in SF) from the $/SF forward contract for a total SF amount of SF 50m, with a forward rate of $0.84125/1SF. In other words, it must deliver SF 50m in exchange for receiving SF 50m x $0.84125/1SF = $42,062,557. The $ cash-ins and outs cancel out, leaving H.J. Heinz exactly where it would have been if it had been able to float SF-denominated Eurobonds at a rate of 5%.
Swaps vs. Long-Dated Forwards 8

Solution 2: Heinz sells dollar Eurobonds and engages in a currency-swap.

Alternatively, Heinz could accomplish its SF funding goals by
  floating 5-year dollar-denominated zero-coupon Eurobonds,
  converting the proceeds at the current spot rate (so as to get SF now),
  and engaging in a $/SF currency swap with a company (most likely a Swiss bank)
  that already has borrowed SF
  and wants to convert that liability into a $ one
  (so as to repay SF, not $).

Of course, that SF liability must have the appropriate structure:
  5 years to maturity, zero-coupon, 5% all-in interest rate.

Swaps vs. Long-Dated Forwards 9

Heinz wants to obtain at least SF 39,176,308 now. As discussed in the previous
section, SF 39,176,308 = $ 26,117,539 at the current spot rate of SF1.5/$1. Hence, the
notional amount used for all swap payment computations is SF 39,176,308 = $ 26,117,539.

As a prelude to the swap, Heinz thus floats 5-year dollar-denominated zero-
coupon Eurobonds, with a face value of $ 42,062,557, for total current proceeds of $ 26,117,539. Similarly, Heinz's counterparty either already has outstanding, or must issue, a zero-coupon SF loan with five years to maturity, face value of SF 50m, present value of SF 39,176,308.
Swaps vs. Long-Dated Forwards 10

The swap agreement is simply for Heinz to pay both principal and interest SF 50m to the Swiss counterparty at the loan's maturity, while the Swiss counterparty pays Heinz both principal and interest on the Pittsburgh company's dollar loan.

It is important to notice that the exchange of principal at maturity takes place at the exchange rate in vigor at the time the swap was entered into. Similarly, interest payments are calculated on the notional amount -- i.e., using that same time 0 spot rate.

Swaps vs. Long-Dated Forwards 11

It is reasonable to assume that, at time 0, both parties convert the proceeds of the original loan on the spot market. As Heinz wants SF now, it will convert the proceeds of its dollar Eurobond sale into SF 39,176,308.

To understand the details of the swap obligations, recall that a zero-coupon bond's payoff at maturity (i.e., its face value) can be decomposed into a reimbursement of the amount obtained when the bond was floated, and of the interest accrued on the latter amount. Thus we can break down the $ 42,062,557 that Heinz has agreed to repay its original lenders into:

- reimbursement of $ 26,117,539 in principal
- payment of $ 15,945,018 in interests

Similarly, the SF 50m of the Swiss counterparty's original loan can be split between:

- reimbursement of SF 39,176,308 in principal
- payment of SF 10,833,692 in interests
### Heinz's cash-flows

<table>
<thead>
<tr>
<th></th>
<th>$ Eurobonds</th>
<th>spot SF purchase</th>
<th>swap</th>
<th>total cash-flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>t=0</td>
<td>$26,117,539</td>
<td>-$26,117,539</td>
<td>+SF 39,176,308</td>
<td>+SF 39,176,308</td>
</tr>
<tr>
<td>t=5</td>
<td>-$42,062,557</td>
<td></td>
<td>+$26,117,539 (P)</td>
<td>-$50,000,000</td>
</tr>
</tbody>
</table>

\[
= +$42,062,557
= -$26,117,539 (P)
= -$15,945,018 (I)
= -$50,000,000
\]

### Swiss counterparty's cash-flows

<table>
<thead>
<tr>
<th></th>
<th>SF funds</th>
<th>spot SF purchase</th>
<th>swap</th>
<th>total cash-flow</th>
</tr>
</thead>
<tbody>
<tr>
<td>t=0</td>
<td>+SF 39,176,308</td>
<td>-$39,176,308</td>
<td>$26,117,539</td>
<td>-$26,117,539</td>
</tr>
<tr>
<td>t=5</td>
<td>-$50,000,000</td>
<td></td>
<td>-$26,117,539 (P)</td>
<td>-$42,062,557</td>
</tr>
</tbody>
</table>

\[
= -$26,117,539 (P)
= -$15,945,018 (I)
= -$42,062,557
= +SF 39,176,308 (P)
= +SF 10,833,692 (I)
= +SF 50,000,000
\]