Backus/December 8, 1998

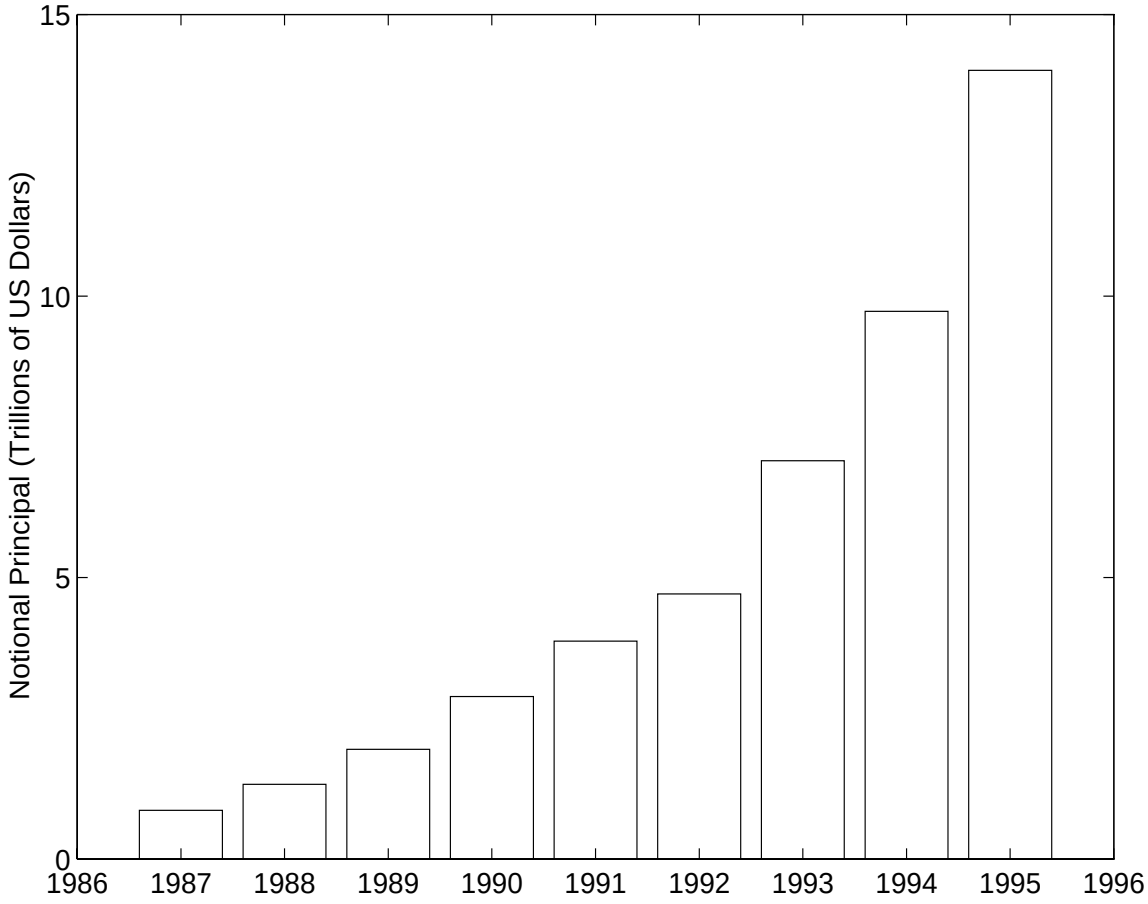
Floaters and Swaps

0. Overview

- Swaps as Derivatives
- Floaters and Inverse Floaters
- Swap Analytics
- Swap Engineering
- OTC v Exchange-Traded Products
- Credit Risk

1. The Swap Market

- Market is an outgrowth of the interbank market for currencies and short-term loans/deposits
- Started with international commercial banks, now includes major investment banks
- Market has grown dramatically:



1. The Swap Market (continued)

- Swaps by category and currency (1995):

Product	Notional Principal (US tr)
Interest rate swaps	12.811
US dollar	4.372
Japanese yen	3.854
Deutsche mark	2.128
Pound sterling	0.856
Cross-currency swaps	1.295
US dollar	0.419
Japanese yen	0.200
Deutsche mark	0.110
Pound sterling	0.046

Source: IMF, *International Capital Markets*, 1997.

2. Floating Rate Notes: Examples

- Example 1: Istituto Bancario San Paolo Torino
  - 5-year floating rate notes (FRNs)
  - Maturing June 18, 1997
  - Denominated in ecu's (European currency units)
  - Semiannual payments of ECU LIBOR + 20 bps
  - Rate set every 6 months, paid 6 months later
  - LIBOR day count convention (reminder):

$$\text{Interest Payment} = \frac{\text{“Actual”}}{360} \times (\text{LIBOR} + 0.20)$$

    for LIBOR quoted as a percent.

- Example 2: Citicorp DM notes
  - 5-year floaters
  - Maturing December 15, 1999
  - Quarterly payments of DM LIBOR + 25 bps

2. Floating Rate Notes: Examples (continued)

- Example 3: Daiwa Europe yen notes
  - 5.25-year floaters
  - Maturing March 17, 2000
  - Semiannual payments of 5-year yen swap rate – 90 bps

- Example 4: IBRD (World Bank) inverse floaters
  - 5-year US dollar floaters
  - Maturing October 1, 1997
  - Semiannual payments at a rate of

    $$\text{Rate} = 14.5 - 2 \times \text{Dollar LIBOR}$$

    (with a minimum of zero)

- Example 5: Deutsche Bank Finance NV notes
  - 10-year C-dollar floaters
  - Maturing September 3, 2002
  - Quarterly rate of 3-month BAs - 30 bps
  - Cap of 8.90, floor of 5-7/8

- Remark: Lots of variety!

3. Floating Rate Note Arithmetic

- Standard floater: 6-month payments of 6-month LIBOR
- Consider a 6-month floater
  - Let y be the bond equivalent of 6-m LIBOR
  - Value in 6 months is principal (100) plus interest
  - Present discounted value is

$$\text{Price} \;=\; \frac{100(1+y/2)}{1+y/2} \;=\; 100.$$

- Consider a 12-month floater
  - Value in 6 months is market price (100) plus interest
  - Present discounted value is

$$\text{Price} \;=\; \frac{100(1+y/2)}{1+y/2} \;=\; 100.$$

- Consider an 18-month floater ... (you get the idea)
- Remarks:
  - Floaters trade at par on reset dates
  - Despite the uncertain interest payments,
    this is no more complex than a conventional bond

4. Interest Rate Sensitivity of FRNs

- Standard floaters have short durations

- If fraction w of a period remains until the next payment:

$$\text{Price} \;=\; \frac{100 + \text{Interest}}{(1 + y/2)^w}$$

  (NB: the numerator was set at the start of the period.)

- DV01 computed the usual way (increase y by .01)

- Duration is

$$D \;=\; (1 + y/2)^{-1} w/2$$

5. Inverse Floaters

- Can be valued by replication
- Example: 5-year, Rate = 20 – LIBOR
  the 10% flat spot rate scenario of previous chapter
- Replication of cash flows:

Position	Interest Rate	Principal
Inverse Floater	20 – LIBOR	100
Long 2 10% Bonds	20	200
Short FRN	– LIBOR	–100

- Estimate price from components:

$$\text{Price} \;=\; 2 \times 100 - 100 \;=\; 100$$

- Duration (some numbers from previous set of overheads):

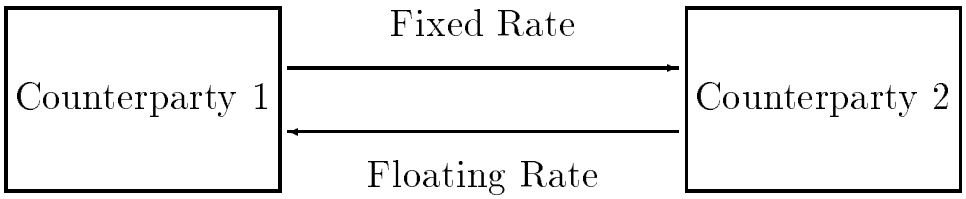
$$D \;=\; 3.86\left(\frac{200}{100}\right) + 0.48\left(\frac{-100}{100}\right) \;=\; 7.25$$

- Remarks
  - Despite the uncertain interest payments,
    this is no more complex than a conventional bond
  - Caveat: floater has floor at zero, replication doesn't
  - Long duration!

6. Plain Vanilla Interest Rate Swaps

Description

- Swap parties exchange fixed and floating interest payments:



- Only net payments are made

- Principals not exchanged (net to zero)

- Other parameters:
  - Notional principal (amount interest is applied to)
  - Maturity
  - Payment frequency
  - Index rate (floating rate typically tied to LIBOR)
  - Currency

6. Plain Vanilla Interest Rate Swaps (continued)

Swap arithmetic

- Vanilla swap has semiannual payments of 6-month LIBOR
- Fixed rate typically set to give swap zero value at start
- Valuation: What's the appropriate fixed rate?
  - Add principal payments $\Rightarrow$ exchange of bonds
  - Value to Counterparty 1 is

    Value of Swap = Price of FRN$-$Price of Fixed Rate Note
- Since FRN trades at par (100), we choose fixed rate so that the fixed rate note is par, too.
- Swap rate therefore satisfies

$$\begin{aligned} 100 &= (d_1 + \cdots + d_n)(\text{Swap Rate}/2) + d_n 100 \\ \text{Swap Rate} &= 2 \times \frac{1 - d_n}{d_1 + \cdots + d_n} \times 100 \end{aligned}$$

- Remarks:
  - Par yields again
  - Day count convention follows LIBOR

6. Plain Vanilla Interest Rate Swaps (continued)

Interest sensitivity

- DV01 is difference between DV01's of the two notes
- Duration not used: percent not defined when price is zero
- Duration of components sometimes used instead
  (we'll do an example shortly)

6. Plain Vanilla Interest Rate Swaps (continued)

Example

- Infer spot rates from swap quotes, interest rate futures, markup over treasuries, etc.

- Estimates for June 22, 1995:

Maturity (Yrs)	Discount Factor	Spot Rate (Annual %)
0.5	0.9707	6.036
1.0	0.9443	5.809
1.5	0.9175	5.824
2.0	0.8913	5.839
2.5	0.8644	5.914
3.0	0.8378	5.989

- 3-year swap rate:

$$\text{Swap Rate} = 2 \times \frac{1 - d_n}{d_1 + \cdots + d_6} \times 100$$

$$= 5.980$$

7. Swap Engineering

- Example: you have a 125m position with duration 2
  How can we use a swap to reduce duration to 1.5?

- Intuit: Swap should pay fixed
  (short the side with the longer duration)

- Swap product: the 3-year swap studied earlier
  - Fixed rate note has duration 2.709 years
    - Coupon is 2.99, price is 100 (trades initially at par), yield is $y = 5.98\%$
    - Standard bond duration calculation
  - Floating rate note has duration 0.485 years
    - It's like a 6-month zero

- Duration of position plus swap with notional x:

$$D \;=\; 1.50 \;=\; 2\left(\frac{125}{125}\right) + 0.485\left(\frac{x}{125}\right) + 2.709\left(\frac{-x}{125}\right)$$

  Answer: $x = 28.1$m.

- Remark: this accomplishes the duration target, but a complete risk analysis would include basis risk (non-parallel shifts again)

8. Non-Vanilla Swaps

There's no end to the variety:

- Variation over time in the notional principal:
  - Amortizing and accreting swaps
- Variation over time in the fixed payment:
  - Step up and step down swaps
- Basis swaps: two floating rates
  - The TED spread (treasury for LIBOR)
  - LIBOR for the prime rate
- Other index rates:
  - Constant Maturity Treasury (CMT)
  - Swap rates
- Total return swaps
  - Pay LIBOR, receive return on basket of Aa corporates
  - Pay LIBOR, receive return on basket of Bradies
  - Pay LIBOR, receive return on S&P 500

8. Non-Vanilla Swaps (continued)

Example 1: Step-up swap

- Description
  - Maturity is 2 years
  - Notional principal is 100
  - Semiannual payments
  - Swap rate is 4 the first year, C the second
- Valuation
  - Floating rate leg: value is 100
  - Fixed rate leg:

$$\text{Value} = (d_1 + d_2) \times 2 + (d_3 + d_4) \times C/2 + d_4 \times 100$$

- Market rate C:

$$100 = (d_1 + d_2) \times 2 + (d_3 + d_4) \times C/2 + d_4 \times 100$$

$$\Rightarrow C/2 = \frac{100(1 - d_4) - (d_1 + d_2) \times 2}{d_3 + d_4} = 7.788$$

(high to compensate for the initial low rate)

8. Non-Vanilla Swaps (continued)

Example 2: Amortizing swap

- Description
  - Maturity is 2 years
  - Notional principal is 100 the first year, 50 the second
  - Semiannual payments
  - Swap rate is C throughout
- Valuation: add principals of 50 after year one, another 50 after year two
  - Floating rate leg: sum of 1-year and 2-year FRNs, each with notional principal of 50
  - Fixed rate leg:

    $$\text{Value} = (d_1+d_2)\times C/2+d_2\times 50+(d_3+d_4)\times C/4+d_4\times 50$$

- Market rate C:

$$100 = (d_1 + d_2) \times C/2 + d_2 \times 50 + (d_3 + d_4) \times C/4 + d_4 \times 50$$

$$\Rightarrow C/2 = \frac{100 - (d_2 + d_4)50}{d_1 + d_2 + (d_3 + d_4)/2} = 5.830$$

(mixture of 1- and 2-year rates)

8. Non-Vanilla Swaps (continued)

Example 3: Forward-starting swap

- Description
  - Maturity is 2 years, starting in one year
  - Notional principal is 100
  - Semiannual payments
    (in 18, 24, 30, and 36 months)
  - Swap rate is C
- Valuation
  - Floating rate leg: in one year, this is an FRN

$$\text{Value} \;=\; d_2 \times 100 \;=\; 94.435$$

  - Fixed rate leg:

$$\text{Value} \;=\; (d_3 + d_4 + d_5 + d_6) \times C/2 + d_6 \times 100$$

- Market rate C:

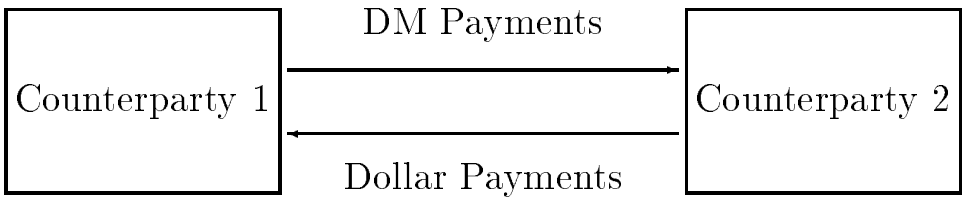
$$\begin{aligned} d_2 \times 100 \;&=\; (d_3 + d_4 + d_5 + d_6) \times C/2 + d_6 \times 100 \\ \Rightarrow C/2 \;&=\; \frac{(d_2 - d_6) \times 100}{d_3 + d_4 + d_5 + d_6} \;=\; 6.072 \end{aligned}$$

- This is the underlying for a swaption

9. Cross-Currency Swaps

Description

- Exchange interest and principal in two currencies, as in:



- Only net payments are made

- Principals *are* exchanged (they don't net to zero)

- Other parameters:
  - Notional principal (amount interest applied to)
  - Maturity
  - Payment frequency
  - Types of interest payments (fixed or floating)
  - Index rates (for floating rates)
  - Currencies

9. Cross-Currency Swaps (continued)

Risk assessment

- Value (in dollars) to Counterparty 1:

  $$\begin{aligned}\text{Value of Swap} &= \text{Price of Dollar Note} - \text{Price of DM Note} \\ &= p_1 - sp_2\end{aligned}$$

  where s is the exchange rate (dollar price of one DM).

- Change in value is approximately:

  $$\begin{aligned}\Delta v &\cong \Delta p_1 - s\Delta p_2 - sp_2\frac{\Delta s}{s} \\ &\cong -D_1 p\ \Delta y_1 + D_2 sp_2\ \Delta y_2 - sp_2\frac{\Delta s}{s}\end{aligned}$$

  (the usual linear approximation that underlies duration, with an extra term due to changes in the exchange rate)

- Sources of change in value:
  - Change in dollar yields (monthly std dev about 0.6%)
  - Change in DM yields (monthly std dev about 0.5%)
  - Change in exchange rate (monthly std dev about 3%)
- Except for very long durations, currency risk larger
- Statistical risk systems incorporate correlations among these three components

10. OTC v Exchange-Trade Derivatives

Relative to exchange-traded instruments, OTC products

- Can be custom made
- Generally have less liquidity
- Generally have greater credit risk
- Sometimes get different accounting treatment

11. Credit Risk

Methods used to control credit risk:

- Netting built into ISDA master agreement and US law
- Diversification across counterparties (standard practice)
- Collateral
- Mark-to-market (analogous to futures)
- Credit guarantees
- Termination triggers for downgrades
- Aaa-rated derivatives subsidiaries

Summary

- Floaters and swaps: no big deal!
- Floating rate notes make interest payments tied to market rates, typically LIBOR
- Inverse floaters often have long durations
- In a plain vanilla interest rate swap, two parties exchange the difference between fixed and floating interest payments
- In a cross-currency swap, two parties exchange the difference between interest and principal payments in two different currencies
- The OTC swap market has unlimited variety
- Swap contracts, like futures contracts, are designed to minimize the impact of credit risk