

SWAPS



SWAPS

- ▶ Forward or futures contracts settle on a single date
- ▶ However, many transactions occur repeatedly
- ▶ If a manager seeking to reduce risk confronts a risky payment stream, what is the easiest way to hedge this risk?
- ▶ You can enter into a separate forward contract for each payment you wish to hedge.
- ▶ However, transaction cost will be higher.

SWAPS

- ▶ Swaps are agreements between two companies to exchange cash flows in the future according to prearranged formula.
- ▶ Swaps may be regarded as portfolio of forward contracts.
- ▶ Swaps are common in interest rates, currencies and commodities.
- ▶ They often extend much further in to the future than exchange contracts.
- ▶ Swaps are generally intermediated by banks.

SWAPS

- ▶ One party makes a payment to the other depending upon whether a price turns out to be greater or less than a reference price that is specified in the swap contract.
- ▶ For example by entering into oil swap, an oil buyer confronting a stream of uncertain oil payments can lock in a fixed price for oil over a period of time. The swap payments would be based on the fixed price and for oil and a market price that varies over time.

A SIMPLE COMMODITY SWAP

- ▶ Suppose United Airlines is going to buy 100,000 barrels of oil 1 year from today and 2 years from today. Suppose that forward price for delivery in 1 year is \$75 per barrel and in 2 years is \$90 per barrel. Suppose 1 year and 2 year zero coupon bond yields are 5% and 5.5%.
- ▶ UA can use forward contract to guarantee the cost of buying oil for the next 2 years. The present value of this cost will be

$$\frac{\$75}{1.05} + \frac{\$90}{1.055^2} = \$152.29$$

COMMODITY SWAP

- ▶ UA could invest this amount to buy oil in 1 and 2 year
- ▶ Or UA could pay an oil supplier \$152.29 and oil supplier would commit delivering one barrel in each of the next two years. This is prepaid swap. If the payment is done after 2 years, this is postpaid swap.
- ▶ Credit risk? Oil might not be delivered or default in payment
- ▶ More attractive solution for both parties is to defer payment until the oil is delivered.

COMMODITY SWAP

- ▶ Typically, a swap will call equal payments in each year as long as any payment stream with a present value of \$152.29

$$\frac{x}{1.05} + \frac{x}{1.055^2} = \$152.29$$

- ▶ To satisfy this equation, the payments must be \$82.28 in each year. We then say that the 2-year swap price is \$82.28.
- ▶ However, any payments that have a present value of \$152.29 are acceptable.

COMMODITY SWAP

A simple Swap: Physical Delivery



PHYSICAL VERSUS FINANCIAL SETTLEMENT

- ▶ What if swap settled in cash?
- ▶ With cash settlement, oil buyer, UA, pays the swap counterparty the difference between \$82.28 and the spot price (if the difference is negative, the counterparty pays the buyer), and oil buyer then buys the oil in the spot market.
- ▶ For example, if the spot price is \$90, the swap counterparty pays the buyer

$$\text{Spot price} - \text{swap price} = \$90 - \$82.28 = \$7.72$$

COMMODITY SWAP

- ▶ If the spot price is \$80, then oil buyer makes a payment to the swap counterparty

$$\text{Spot price} - \text{swap price} = \$80 - \$82.28 = -\$2.28$$

- ▶ Whatever the spot price, the net cost to the buyer is the swap price, \$82.28



COMMODITY SWAP

- ▶ For a swap on 100,000 barrels, we simply multiply all cash flows by 100,000. In this example, 100,000 is the notional amount of the swap.
- ▶ Although, swap price is close to mean of forward prices (\$82.5), it is not exactly same. Why? Suppose swap price \$82.5, then the oil buyer would then be committing to pay more than \$7.5 more than forward price the first year and would pay \$7.5 less than the forward price the second year. Thus relative to the forward curve, the buyer would have made an interest-free loan to counterparty.

COMMODITY SWAP

- ▶ Swap price \$82.28, then we are overpaying 7.28 in the first year and underpaying \$7.72 in the second year, relative to forward curve.
- ▶ Swap is equivalent to being long the two forwards contracts, coupled with an agreement to lend 7.28 to the counterparty in the first year, receive \$7.72 in 2 years.
- ▶ The interest rate on this loan is $7.72/7.28 - 1 = 6\%$. Where does 6% come from? 6% is the 1 year implied forward yield from year 1 to year 2.

SWAP COUNTERPARTY

- ▶ Swap counterparty is a dealer, who hedges the oil price risk resulting from swap.
- ▶ The dealer can hedge in several ways. Suppose oil seller also lock in a fixed price. In this case dealer serves a go between for the swap, receiving payment from one party, passing them to another. In practice, the fixed price paid by buyer is higher than the fixed price received by the seller. This price difference is a bid-ask spread and is the dealer's fee.

SWAP COUNTERPARTY

- ▶ More interesting case where the dealer serves as counterparty and hedges the transaction using forward markets.

Year	Payment from Oil Buyer	Long Forward	Net
1	82.28-Year 1 Spot Price	Year 1 Spot Price-75	7.28
2	\$82.28-Year 2 Spot Price	Year 2 Spot Price-90	7.72

- ▶ Hedging the oil price risk in the swap does not fully hedge the position. The dealer also has interest rate exposure.

MARKET VALUE OF A SWAP

- ▶ When the buyer first enters the swap, its market value is zero, meaning that either party could enter or exit the swap without having to pay anything to the other party (apart from commissions and bid-ask spread).
- ▶ Once the swap is struck, its market value will generally no longer be zero, for two reasons. First, forward price for oil and interest rates will change over time.
- ▶ Second, even if oil and interest rate forward prices do not change, the value of the swap remain zero only until the first swap payment is made.

MARKET VALUE OF SWAP

- ▶ Suppose, interest rates did not change, but immediately after the buyer enters the swap, the forward curve for oil rises by \$5 in year 1 and 2. The original swap will no longer have a zero market value. The new swap price will be 87.28. The buyer could unwind the swap at this point by agreeing to sell oil at \$87.28, while the original swap still cast for buying oil at \$82.28. Thus, the net swap payments in each year are

$$(\text{Spot price} - \$82.28) + (\$87.28 - \text{Spot price}) = \$5$$

- ▶ The present value of this difference is 9.25. The buyer can receive a stream of payments worth \$9.25 by offsetting the original swap with new swap. Thus the \$9.25 is the market value of the swap.

SWAP COUNTERPARTY

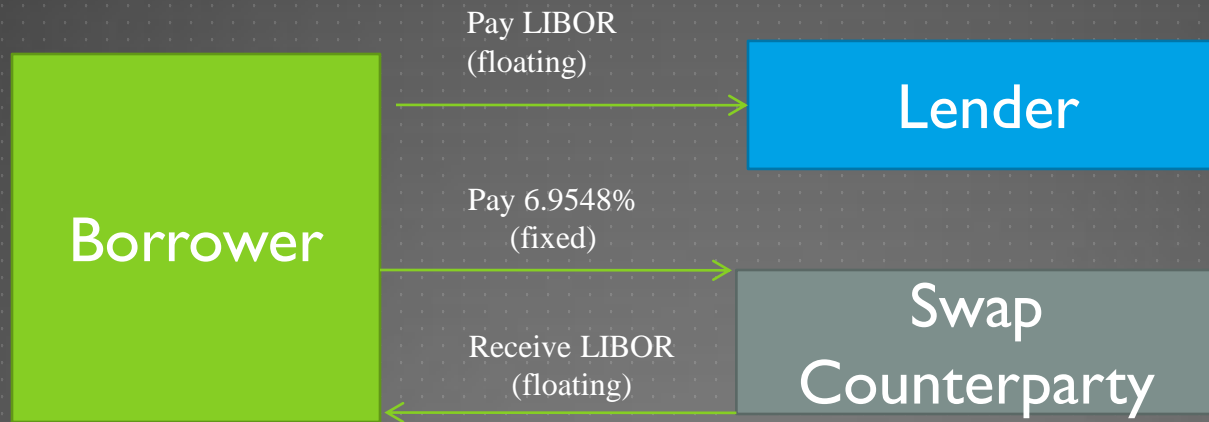
- ▶ The oil seller receives spot price for oil and receives the swap price less the spot price, on net receiving the swap price. The buyer pays spot price and receives spot price minus swap price. The situation is called back to back transaction. The dealer bears the credit risk of both parties but is not exposed to price risk.

INTEREST RATE SWAPS

- ▶ Use interest rate swaps to modify their interest rate exposures
- ▶ Suppose XYZ Corp has \$200m of floating rate debt at LIBOR but prefer to have fixed rate debt with 3 years to maturity.
 - ▶ Retire floating rate debt and issue fixed rate debt (transaction costs)
 - ▶ Enter s a strip of FRAs in order to guarantee the borrowing rate for the remaining life of the debt. Although it is fixed rate in advance the company will lock in a different rate each year.
 - ▶ Enter into swap contract in which they receive floating rate and pay the fixed rate, assume the fixed rate 6.9548%.

INTEREST RATE SWAPS

► Plain Vanilla Swap Cash-flow



$$\text{XYZ net payment} = -\text{LIBOR} + \text{LIBOR-fixed rate} = -6.9548\%$$

Swap Payment

INTEREST RATE SWAP

- ▶ The notional principal of the swap is \$200m. The life of the swap is called **swap term** or **swap tenor**.
- ▶ Borrowing rate is known at the beginning of the year, interest payment on the loan is due at the end of the year
- ▶ Only net swap payment are actually made between swap counterparties. If one party defaults, they owe to the other party at most the present value of net swap payments. This implies swaps generally have less credit risk than bond

PRICING AND SWAP COUNTERPARTY

- ▶ Counterparty: Market-maker
- ▶ Purpose: earn fees and not to take on interest rate risk. Therefore counterparty will hedge the transaction.
- ▶ Market-maker receives the fixed rate from the company and pays the floating rate: the danger for the market-maker is that floating rate will rise. The risk in this transaction can be hedged by entering into FRAs.
- ▶ Assume that the time 0 implied forward rate between time t_i and t_j is $r_0(t_i, t_j)$ and the realized 1 year rate as r_{t_i} and the current rate ,6% (assume also that 2 year zero coupon rate 6.5% and 3 year is 7%), is known. With the swap rate R , let's analyze risk-free cash flows faced by hedged market-maker.

PRICING AND SWAP COUNTERPARTY

Year	Payment on Forward	Net Swap Payment	Net
1	-	$R - 6\%$	$R - 6\%$
2	$\hat{r}_2 - 7.0024\%$	$R - \hat{r}_2$	$R - 7.0024\%$
3	$\hat{r}_3 - 8.0071\%$	$R - \hat{r}_3$	$R - 8.0071\%$

PRICING AND SWAP COUNTERPARTY

- ▶ How is R determined? Of course since swap market is competitive, present value of the hedged cash flows should be equal to zero.

$$\frac{R - 6\%}{1.06} + \frac{R - 7.0024\%}{1.065^2} + \frac{R - 8.0071\%}{1.07^3} = 0$$

- ▶ Solving for R gives us $R=6.9548\%$. *This is exactly equal to par coupon rate on 3-year bond.*
- ▶ In other words, an interest rate swap is equivalent to borrowing at a floating rate to buy a fixed rate bond.

PRICING AND SWAP COUNTERPARTY

- ▶ The borrower's calculations are exactly opposite of the market makers.

Year	Floating Rate Debt Payment	Net Swap Payment	Net
1	-6%	6%-6.9548%	-6.9548%
2	$-\hat{r}_2$	$\hat{r}_2 - 6.9548\%$	-6.9548%
3	$-\hat{r}_3$	$\hat{r}_3 - 6.9548\%$	-6.9548%

COMPUTING THE SWAP RATE IN GENERAL

- ▶ Suppose there are n swap settlement, occurring on dates $t_i, i=1,2,\dots,n$. The implied forward rate from time t_i and t_j , known at time 0, is $r_0(t_i, t_j)$. The price of zero coupon bond maturing on date t_i is $P(0, t_i)$. Then

$$\sum_{i=1}^n P(0, t_i) [R - r_0(t_{i-1}, t_i)] = 0$$

- ▶ Or equivalently;

$$R = \frac{\sum_{i=1}^n P(0, t_i) r(t_{i-1}, t_i)}{\sum_{i=1}^n P(0, t_i)} = \frac{\text{PV of interest payments implied by forward strip}}{\text{PV of \$1 annuity when interest rates vary over time}}$$

COMPUTING THE SWAP RATE IN GENERAL

- ▶ Or equivalently;

$$R = \sum_{i=1}^n \left[\frac{P(0, t_i)}{\sum_{j=1}^n P(0, t_j)} \right] r(t_{i-1}, t_i)$$

- ▶ Since the terms in brackets sum to one, the fixed swap rate is weighted average of the implied forward rates, where zero coupons bond prices are used to determine the weights.

SWAP RATE

- ▶ Let's look at another way
- ▶ Recall, implied forward rate between times t_1 and t_2 , $r_0(t_1, t_2)$ is given by the ratio of zero-coupon bond prices, i.e

Which implies

$$r_0(t_1, t_2) = \frac{P(0, t_1)}{P(0, t_2)} - 1$$

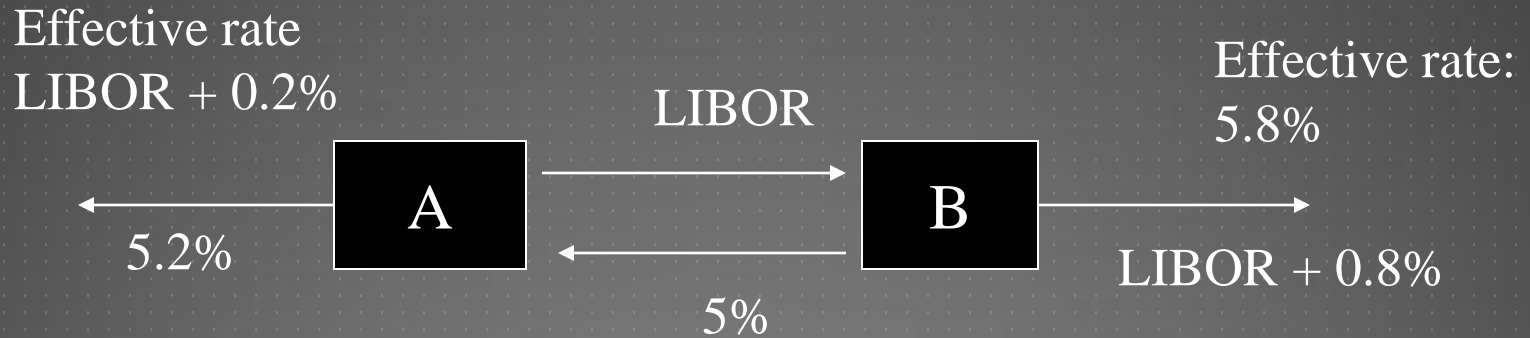
- ▶ Basically, the swap $R \sum_{i=1}^n P(0, t_i) + P(0, t_n) = 1$ upon bond.

USING THE SWAP TO TRANSFORM LIABILITY (I)

- ▶ For company B the swap could be used to transform a floating-rate loan into a fixed-rate loan. Suppose that B borrowed \$100 million at LIBOR + 80 basis point (0.8%). After B has entered into the swap, it has 3 sets of cash flows:
 - ▶ It pays LIBOR + 0.8% to the outside lender
 - ▶ It receives LIBOR (Swap)
 - ▶ it pays 5% (Swap)
 - ▶ Net effect: (Fixed) interest rate payment of 5.8%
- ▶ For company A the swap could have the effect of transforming a fixed-rate loan into a floating-rate loan. Suppose that A has a \$100 million loan on which it pays 5.2%. After A has entered into the swap, it has 3 sets of cash flows:
 - ▶ It pays 5.2% to the outside lender
 - ▶ It pays LIBOR (Swap)
 - ▶ it receives 5% (Swap)
 - ▶ Net effect: (Floating) interest rate payment of LIBOR + 0.2%.

USING THE SWAP TO TRANSFORM LIABILITY

(2)



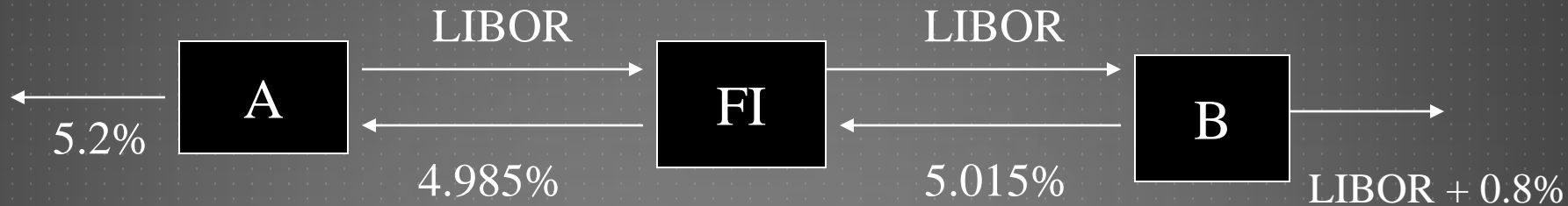
USING THE SWAP TO TRANSFORM AN ASSET

- ▶ Company B: The swap could have the effect of transforming an asset earning a fixed rate of interest into an asset earning a floated rate. Suppose that B owns \$100 million in bonds that will return 4.7%.
- ▶ Company A: The swap could have the effect of transforming an asset earning a floating rate of interest into an asset earning a fixed rate. Suppose that A has an investment of \$100 million that yields LIBOR minus 25 basis points.



FINANCIAL INTERMEDIARY

- ▶ Usually, two financial companies do not get in touch with each other directly ==> they deal with a financial intermediary. Plain vanilla swaps are structured so that the financial institution earns 3 basis points (0.03%).



- ▶ In each case the FI has two separate contracts. If one company defaults the financial institution still has to honour its agreement with the other company. The 3 basis point spread partly compensate the financial institution for the default risk it is bearing.

AMORTIZING AND ACCRETING SWAPS

- ▶ Notional value of swap might also vary over time
 - ▶ If the principal is declining over time (like floating rate mortgage), then swap is called amortizing swap.
 - ▶ If the principal is growing over time then the swap is called accreting swap

WHY DO WE NEED SWAPS?

THE COMPARATIVE ADVANTAGE ARGUMENT

- ▶ Some companies have a comparative advantage in borrowing in the fixed-rate market, while other companies have a comparative advantage in the floating-rate market. When obtaining a new loan it is convenient for a company to go to the market where it has a comparative advantage. This may lead to a company borrowing fixed when it wants floating and vice versa. The swap is used to transform the fixed-rate loan into a floating-rate loan or vice versa.

THE COMPARATIVE ADVANTAGE ARGUMENT (I)

	FIXED	FLOATING
A	10.0%	LIBOR + 0.3%
B	11.2%	LIBOR + 1.0%

- ▶ Suppose that A & B wish to borrow \$10 M for 5 years. We assume that B wants to borrow at a fixed rate, while company A wants to borrow at floating rate.
- ▶ Here, B has a comparative advantage in borrowing in the floating-rate market (interest rate differential 70 basis points against 120 basis points in the fixed-rate market). Company A appears to have a comparative advantage in the fixed-rate market.
- ▶ It is this anomaly that can lead to the swap.
- ▶ B borrows floating-rate at LIBOR + 1%. A borrows fixed-rate funds at 10%.

THE COMPARATIVE ADVANTAGE ARGUMENT (2)

- ▶ We assume that A & B get in touch directly (no financial institution). Company A agrees to pay company B interest at 6-month LIBOR on \$10M. Company B agrees to pay company A interest at a fixed rate of 9.95% on \$10M.
- ▶ Company A: it pays 10% to outside lender; it receives 9.95% from B; it pays LIBOR to B - net rate LIBOR + 0.05%, saving 25 basis points.
- ▶ Company B: it pays LIBOR + 1.0%; it receives LIBOR from A; it pays 9.95% to A - net rate 10.95%, saving 25 basis points.

Effective rate:
LIBOR + 0.05%



THE COMPARATIVE ADVANTAGE ARGUMENT

(3)

- ▶ The total gain is 0.50%: the total apparent gain from an interest rate swap is equal to $|a - b|$, where a is the difference between the interest rates in the fixed-rate market, $a = 1.2\%$, and b is the difference between the interest rates in the floating-rate market, $b = 0.70\%$.
- ▶ Why should the spreads between the rates offered to A & B be different in fixed and floating markets? \implies With swap market we might reasonably expect these differences to have been arbitrage away.
- ▶ Company B has a lower credit rating than company A: Fixed rate differential is higher because lender is locked in - floating rate loan more easily adjusted or terminated.

CRITICISM OF THE COMPARATIVE ADVANTAGE ARGUMENT

- ▶ The fixed rate is a long-term rate while the floating rate is a short-term rate → we cannot really compare them!

VALUATION OF INTEREST RATE SWAPS

(I)

- ▶ An interest rate swap may be thought of as the exchange of two bonds with the same maturity and same initial value Q .
- ▶ Consider the example of the financial intermediary: Company B has lent the financial institution \$100 M at 6-month LIBOR rate; and the financial institution has lent company B \$100 M at a fixed rate of 5.015% \implies the financial institution has sold a floating (LIBOR) bond to B and has purchased a fixed-rate bond from B \implies the value of the swap for the financial institution is the difference between the values of the two bonds.
- ▶ Assumptions:
 - ▶ time = zero
 - ▶ k : money that FI receives from B (fixed-rate)
 - ▶ V : value of the swap;
 - ▶ B_{fix} : value of the fixed-rate bond underlying the swap
 - ▶ B_{fl} : value of the floating-rate bond underlying the swap
 - ▶ Q : notional principal in swap agreement.

VALUATION OF INTEREST RATE SWAPS (2)

- ▶ For floating rate payer, a swap can be regarded as a long position in a fixed rate bond and a short position in a floating-rate bond.

- ▶ Then, $V = B_{fix} - B_{fl}$.

$$B_{fix} = \sum_{i=1}^n ke^{-r_i t_i} + Qe^{-r_n t_n}$$

- ▶ Consider the floating-rate bond. Immediately after the payment the floating-rate bond is always equal to notional principal, Q . In our notation (we are at $t = 0$), the next payment date is t_1 , so that:

$$B_{fl} = Qe^{-r_1 t_1} + k^* e^{-r_1 t_1}$$

- ▶ Where k^* is the floating rate payment (already known) that will be paid at time 1.
- ▶ In the situation in where the financial institution is paying fixed and receiving floating, we have

$$V = B_{fl} - B_{fix} .$$

CREDIT RISK WITH SWAPS

- ▶ Swaps are forward contracts and so not marked to market. The parties therefore bear counter-party risk.
- ▶ Risk associated with the principal remains with the lending institutions.
- ▶ Plain vanilla interest rate swaps start and end with zero value. If interest rates rise, the party paying the floating rate (A above) has negative value and the receiving party has positive value; vice versa for a fall in rates.

AN EXAMPLE OF A “PLAIN VANILLA” INTEREST RATE SWAP

- ▶ An agreement by Microsoft to receive 6-month LIBOR & pay a fixed rate of 5% per annum every 6 months for 3 years on a notional principal of \$100 million
- ▶ Next slide illustrates cash flows

CASH FLOWS TO MICROSOFT

-----Millions of Dollars-----

Date	LIBOR Rate	<i>FLOATING</i> Cash Flow	<i>FIXED</i> Cash Flow	Net Cash Flow
Mar.5, 2001	4.2%			
Sept. 5, 2001	4.8%	+2.10	-2.50	-0.40
Mar.5, 2002	5.3%	+2.40	-2.50	-0.10
Sept. 5, 2002	5.5%	+2.65	-2.50	+0.15
Mar.5, 2003	5.6%	+2.75	-2.50	+0.25
Sept. 5, 2003	5.9%	+2.80	-2.50	+0.30
Mar.5, 2004	6.4%	+2.95	-2.50	+0.45

CURRENCY SWAPS

- ▶ Firms sometimes issue debt denominated in a foreign currency.
- ▶ Firm might use forward contracts to hedge exchange rate risk
- ▶ Firm might use a currency swap, in which payments are based on the difference in debt payments denominated in different currencies

AN EXAMPLE OF A CURRENCY SWAP

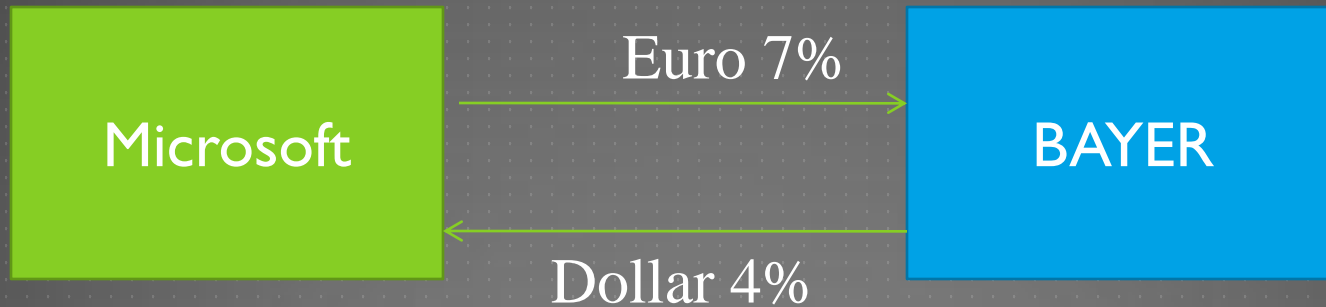
An agreement to pay 11% on a sterling principal of £10,000,000 & receive 8% on a US\$ principal of \$15,000,000 every year for 5 years

EXCHANGE OF PRINCIPAL

- ▶ In an interest rate swap the principal is not exchanged
- ▶ In a currency swap the principal is usually exchanged at the beginning and the end of the swap's life

CURRENCY SWAP

Fixed for Fixed Currency Swap



Microsoft pays a fixed rate of interest of 7% in euro and receives a fixed rate of 4% in dollars from Bayer. Interest rate payments are made once a year and the principal amounts are 15 million Dollar and 10 million Euro

THE CASH FLOWS TO MICROSOFT

	Dollars	Pounds
	\$	£
Year	-----millions-----	
2004	-15.00	+10.00
2005	+0.60	-0.70
2006	+0.60	-0.70
2007	+0.60	-0.70
2008	+0.60	-0.70
2009	+15.60	-10.70

TYPICAL USES OF A CURRENCY SWAP

- ▶ Conversion from a liability in one currency to a liability in another currency
- ▶ Conversion from an investment in one currency to an investment in another currency

COMPARATIVE ADVANTAGE ARGUMENTS FOR CURRENCY SWAPS

General Motors wants to borrow AUD

Qantas wants to borrow USD

	USD	AUD
General Motors	5.0%	12.6%
Qantas	7.0%	13.0%

VALUATION OF CURRENCY SWAPS

- ▶ Currency swaps can be valued either as the difference between 2 bonds or as a portfolio of forward contract.
- ▶ The home currency value of the swap

$$V_{SWAP} = B_{domestic} - S_0 B_{foreign}$$

where B cash flow of the swap and S is the exchange rate

- ▶ Similarly, the value of the swap where the foreign currency received and dollars paid is

$$V_{SWAP} = S_0 B_{foreign} - B_{domestic}$$

OTHER TYPES OF SWAP

▶ Interest Rate Swaps

- ▶ **Deferred Swap (forward swap)**: If the swap begins at some date in future, but for which the swap rate is agreed upon today.
- ▶ Constant Maturity Swap (exchange a LIBOR rate for a swap rate)
- ▶ Constant Maturity Treasury Swap (exchange a LIBOR rate for a particular Treasury rate)
- ▶ Compounding Swap

▶ Currency Swaps

- ▶ Fixed for floating currency swap (also known as cross currency interest rate swap, currency coupon swap or circus swap)
- ▶ Floating-for floating currency swap
- ▶ Diff swap (quanto): short for differential swap, payments are made based on the difference in floating interest rate in two different currencies, with the notional amount in single currency

OTHER TYPES OF SWAP

- ▶ **Equity Swap** (or total return swap): swap in which one party pays the realized return (dividends plus capital gains) on a reference asset, and other party pays a floating return such as LOBOR
- ▶ **Swaption**: An option to enter into a swap is called a swaption. One party with the right at a future time to enter into a swap where a predetermined fixed rate is exchanged for floating. (Payer and Receiver swaption)
- ▶ **Volatility swap**:

SWAPS & FORWARDS

- ▶ A swap can be regarded as a convenient way of packaging forward contracts
- ▶ The value of the swap is the sum of the values of the forward contracts underlying the swap
- ▶ Swaps are normally “at the money” initially
 - ▶ This means that it costs nothing to enter into a swap
 - ▶ It does not mean that each forward contract underlying a swap is “at the money” initially