# Financial Risk Management

## Derivatives

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# What are derivatives

A derivative is

- a financial security or contract whose value **derives** from the value of another asset / assets, known as the **underlying** (UL)
- an instrument for **transferring risk** and can therefore be used for
  - **hedging**: alter the exposure to an asset / risk you already have
  - **investment / speculation**: take on an exposure to an asset / risk

# Forward

A forward is

- an OTC (over-the-counter) contract in which two counterparties agree, with zero money down, to buy / sell the UL at a pre-agreed *forward price* at a given *delivery date* in the future

The contract is an *obligation* of both parties to transact, designed to protect both the buyer and the seller from price fluctuations in the future.

# Investment assets and consumption assets

**Investment asset**: asset normally held for investment purposes

- financial assets: stocks, bonds
- precious metal: gold, silver

**consumption asset**: asset NOT normally held for investment purposes

- industrial metals: copper, aluminium
- agricultural products: orange juice, pork bellies
- energy products: natural gas, heating oil

**Example**

a forward contract to exchange 1m barrels of crude oil in 3 months at a forward price of USD 95/barrel

At the *delivery date*:

- The buyer (Long) delivers: forward price USD 95m
- The seller (Short) delivers: UL 1m barrels of crude oil

# Payoff of a forward

## Notations

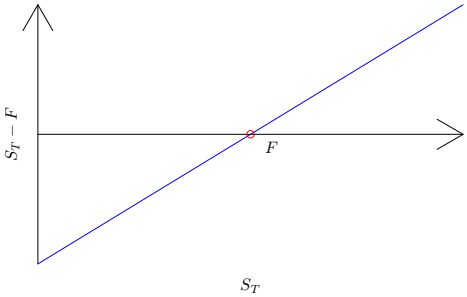
$F$: forward price

$T$: delivery date

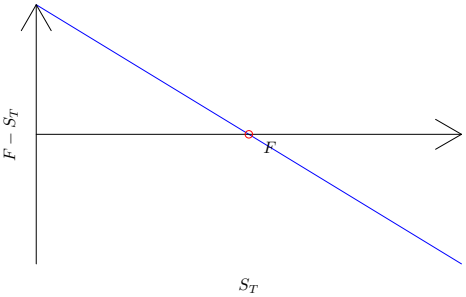
$S_T$: the spot price of the underlying on the delivery date

## Payoff diagrams

**Payoff to Long at $T$**




**Payoff to Short at $T$**



# Fair forward price

- Consider a stock
  - currently traded at £40
  - does not pay dividends
  - with an expected return of 5% p.a.
  - risk-free rate is 2% p.a.
- How much would you **agree to** today, to pay to buy the stock a year from now?

**(a)** £40
**(b)** £40.8
**(c)** £42

# Arbitrage-free pricing

Replicate the same cashflow as a long forward contract by buying the stock today using borrowed money and repaying the borrowing with interest at $T$:

| | Today | **Delivery date $T$** |
|---|---|---|
| **Long forward** | 0 | $S_T - F$ |
| "Cash and carry" replicating strategy: | | |
| Buy stock today | $-40$ | $S_T$ |
| Borrow £40 for 1 year at 2% | 40 | $-40.8$ |
| **Net** | 0 | $S_T - 40.8$ |

The fair forward price is 40.8; otherwise there is an arbitrage opportunity.

For example, if the actual forward price is quoted at 41.2

| | | Today | **Delivery date $T$** |
|---|---|---|---|
| **Buy low:** | Buy stock today | $-40$ | $S_T$ |
| | Borrow £40 for 1 year at 2% | 40 | $-40.8$ |
| | Net | 0 | $S_T - 40.8$ |
| **Sell high:** | Short forward | 0 | $41.2 - S_T$ |
| **Net cash flows** | | 0 | £0.4 |

# Holding benefits / costs

- Consider another stock
  - currently traded at £40
  - pays a dividend of £1 in 6 months
  - with an expected return of 5% p.a.
  - risk-free rate is 2% p.a.
- How much would you **agree to** today, to pay to buy the stock a year from now?

$$40 \times (1 + 2\%) - 1 \times (1 + 2\% \times \tfrac{6}{12}) = 39.79$$

For assets that can be traded spot and stored, forwards futures prices are linked to spot prices through the "cost of carry" relationship:

$$F = S \times (1 + r_j)^T - FV(\text{holding benefits}) + FV(\text{holding costs})$$

where

$F$: forward price

$S$: current spot price

$r_f$: risk-free rate

$T$: maturity of the contract

Holding benefits (costs) are the benefits (costs), typically cashflows, associated with holding the UL that you miss when buying in the future compared to buying now

$FV$: future value, i.e. compounded to $T$ at risk-free rate

# Futures

**Futures contract**: fungible, standardized contract for delivery of a specific commodity at a specific delivery or maturity date for an agreed-upon price (the **futures price**), to be paid at contract maturity

**Futures market**: market for trading **futures contracts** wherein buyers and sellers in a centralized futures exchange (wherein some flexibility is sacrificed for **liquidity**)

The **futures exchange** establishes features of the contract:

- **size** of the contract: mass, volume, number of units
- acceptable **grade** of the commodity
- contract **delivery dates**
- nature of **settlement**: cash, warehouse receipts

The trader with the **long position** (the buyer) commits to purchasing the commodity on the delivery date.

The trader with the **short position** (the seller) commits to delivering the commodity on the delivery date.

# Forwards vs Futures

Futures are **exchange-traded** version of forwards

| | **Forwards** | **Futures** |
|---|---|---|
| Buyer-seller interaction | Direct | Via exchange |
| Default-risk borne by | Individual parties | Clearinghouse |
| Default controlled by | Collateral | Margin accounts daily "marking to market" |
| Contract terms | Tailored | Standardized |
| Unilateral reversal | Difficult | Easy |

# The clearinghouse

**Clearinghouse**: designated intermediary between a buyer and a seller in a financial market that validates and finalizes the transaction, ensuring that both the buyer and the seller honor their contractual obligations.

- Traders on both sides face the **clearinghouse** rather than each other.
- The **clearinghouse** bears the risk of non-performance by any trader.
- Contracts are therefore **fungible**: traders can reverse a position by entering the countervailing position with the clearinghouse.

# Examples of futures contract

Commodities:

- agricultural: oats
- metals: copper, gold
- energy: crude oil

Financial assets:

- foreign currencies: euro
- interest rates
- equity indices
- single stocks

Delivery can be specified as **physical** or **cash-settled**.

- Cash settlement provides the trader with the same profit that would result from directly purchasing the units in the spot market.

# E-mini S&P500 Index Futures Contract

Most popular equity index futures contract in the world

- **Contract size**: \$50 $\times$ S&P500 Index price (0.2 of the standard S&P500 futures contract which has a multiplier of \$250)
- **Contract month**: March quarterly expiration cycle (Mar, Jun, Sep, Dec)
- **Trading hours**: CME Globex (essentially around the clock from Sunday evening to late Friday afternoon)
- **Trading termination**: 8.30am on the Settlement Date (3rd Friday of the contract month)
- **Settlement procedure**: Cash settlement based on the Special Opening Quotation on Friday morning of the S&P500 Index
- **Position limits**: 20,000 S&P500 contracts or equivalent net long or short in all contract months combined

# Futures contracts - marking to market

- Similar economic effect to forwards, but, due to **marking to market**, gains and losses on futures positions are settled each day
- After **marking to market**, both sides have a zero value position with the new (end of day) futures price.
- The long receives from (pays to) the short any increase (decrease) in the futures price from the previous day

| Date | 0 | 1 | 2 | 3 | $T = 4$ |
|---|---|---|---|---|---|
| Future price | 106 | 108 | 104 | 105 | $S_T = 107$ |
| Long receives | 0 | $108 - 106 = 2$ | $104 - 108 = -4$ | $105 - 104 = 1$ | $107 - 105 = 2$ |

- Note that $\sum$(cash flow long receives) $= 1$, equal to the payoff on a forward position where the forward price is the original futures price $S_T - F = 107 - 106 = 1$
- **Convergence property**: at maturity, the futures price and spot price must converge; $F_T = P_T$

# Normal backwardation and contango

The terms **normal backwardation** and **contango** describe the state of a futures market:

- In **normal backwardation**, the futures price is less than the expected future spot price, $F_0 < \mathbb{E}(S_T)$
- In **contango**, the futures price is greater than the expected future spot price, $F_0 > \mathbb{E}(S_T)$

In practice, theses terms are sometimes used with reference to the current spot price rather than the expected future spot price.

# Margin and open interest

**Margin**: a good-faith deposit to guarantee contract performance

**Marking to market**: daily settling (realizing) of gains and losses with the clearinghouse

**Maintenance margin**: minimum quantity that a trader must hold in reserve with the clearinghouse

- Margin safeguards the position of the clearinghouse.
- If the mark-to-market value of the trader's account falls below the maintenance margin, the trader receives a **margin call**.
- A **margin call** requires the trader to replenish the margin account to the maintenance margin. Otherwise, the position is reduced to a size commensurate with the remaining funds (the trader is **bought in** by the exchange).

**Open interest**: the number of contracts outstanding

- The position of the clearinghouse always nets out to zero.

# Hedging and speculation

**Hedgers** use futures to insulate themselves (**hedge**) against price movements in the underlying asset.

- Example: both airplane manufacturers and bauxite miners might seek to hedge their exposure to the price of aluminium.

**Speculators** use futures to profit from movements in futures prices.

- Speculators take **long** position if they expect an increase in price and a **short** position if they expect a decrease in price.
- Usually, **transaction costs** in future markets are considerably smaller than in markets for the UL.
- Speculators also gain the advantage of **leverage** because margin requirements are generally much less than the value of the UL.

# Is the forward price the expected spot price?

- is $F = \mathbb{E}[S_T]$?
- Simplest setting: ignoring holding costs / benefits, using simple compounding at an annual risk-free rate $r_f$, for a 1-year forward

$$F = S \times (1 + r_f)$$

- According to standard finance theories, the (risky) UL should earn a risk premium $\pi$

$\mathbb{E}[S_T] = S \times (1 + r_f + \pi)$

therefore $F \neq \mathbb{E}[S_T]$

- Actual payoff on a long forward: $S_T - F$
- The **expected** payoff on a long forward is

$$\mathbb{E}[S_T - F] = S \times (1 + r_f + \pi) - S \times (1 + r_f) = S \times \pi$$

- The expected return on the long forward (as a percentage of the *current price of the underlying*) is the risk premium
- By going long (short) forwards / futures you assume (lay off) the risk premium on the UL

# Commodity forwards / futures pricing

- The cost of carry relationship

$F = S +$ intest cost $-$ holding benefit $+$ holding costs

- For commodities, this becomes

$F = S +$ intest cost $-$ convenience yield $+$ storage costs

Convenience yield

- The convenience yield (CY) is a holding benefit, the value of holding a physical asset to keep a production process running or to profit from temporary local shortages
- Unlike holding benefits on financial assets (eg dividends or coupons), CY is NOT a cashflow ensured if you are long the underlying
- The CY captures the "intangible" benefits of holding the underlying spot for those who consume it / use it in production

# Investing in commodities

Commodities as an asset class

- low (negative) correlations with stocks and bonds
- hedge against inflation ("real return" asset class)
- exposure to emerging markets growth ("commodities super cycle")
- strong performance (relative to equities) during 2000-2007

# Interest rate futures: estimating forward interest rates

interest rate futures can be used to bootstrap zero curves (e.g. Sterling Overnight Index Average, or SONIA):

$$R_F = \frac{R_2 T_2 - R_1 T_1}{T_2 - T_1}$$

$$R_2 = \frac{R_F(T_2 - T_1) + R_1 T_1}{T_2}$$

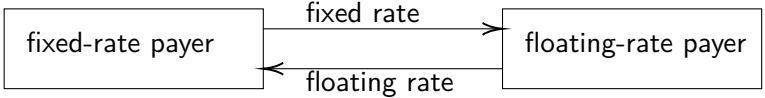
$R_1, R_2$: zero rate for maturities $T_1, T_2$ respectively

$R_F$: forward rate applicable to the period from $T_1$ to $T_2$

# Swap

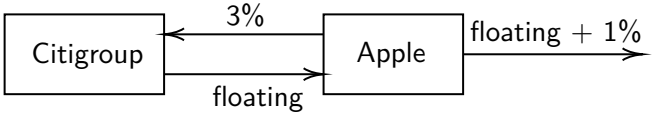
## Interest rate swap

Arrangement, applied to some notional principal, wherein interest at a predetermined fixed rate is exchanged for interest at a floating reference rate is exchanged for interest at a flating interest rate, with one or more regular exchanges being made for an agreed period of time

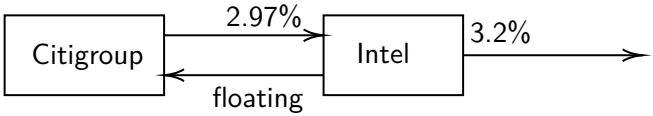


# Interest rate swaps: transferring liabilities

Apple uses a swap to convert **floating**-rate borrowings to **fixed**-rate borrowings:

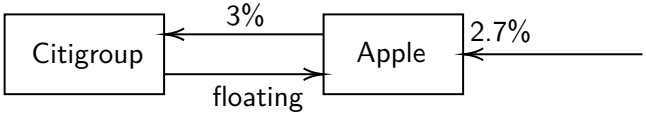



Intel uses a swap to convert **fixed**-rate borrowings to **floating**-rate borrowings:



# Interest rate swaps: transferring assets

Apple converts a **fixed**-rate investment to **floating**-rate investment:

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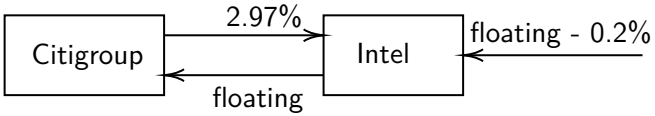
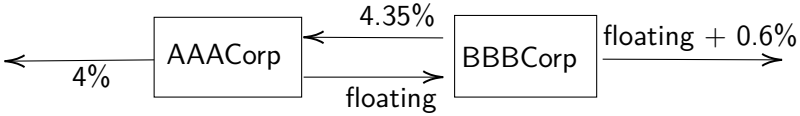


# Comparative advantage

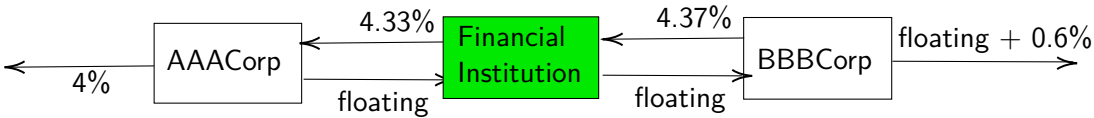
Why use swaps? One reason might be **comparative advantage**: a company might have a relative advantage to borrowing in either fixed-rate markets or floating-rate markets.

| | fixed rate | floating rate |
|---|---|---|
| AAACorp | 4.0% | floating $-0.1\%$ |
| BBBCorp | 5.2% | floating $+0.6\%$ |

Here, AAACorp and BBBCorp might seek to collaborate:



In practice, the swap might be **brokered** by a financial institution:



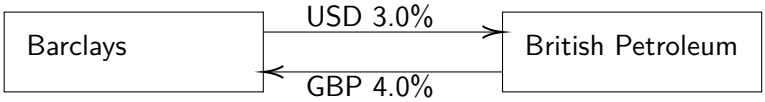

Why has comparative advantage not been arbitraged away?

The **maturities** of contracts available via fixed-rate financing are generally different than those available via floating-rate financing:

- Fixed-rate contracts are often longer than floating-rate contracts
- The spread over the reference rate can effectively be adjusted by floating-rate lenders
- Fixed-rate lenders often lack this option

# Currency swaps

**fixed-for-fixed currency swap**: arrangement wherein principal and interest payments in one currency are exchanged for principal and interest payments in another currency

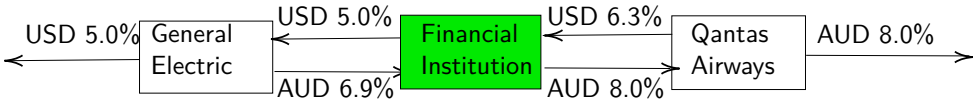



Variations:

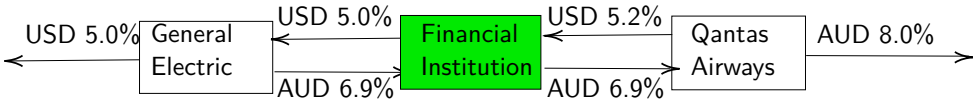
- fixed-for-floating currency swap
- floating-for-floating currency swap
- quanto (or diff swap): arrangement wherein a rate observed in one currency is applied to a principal amount in another currency

# Currency swaps: example with comparative advantage

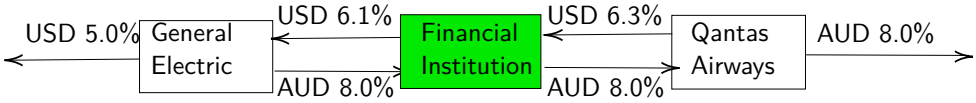
Suppose that General Electric has a **comparative advantage** to borrowing in USD and Qantas Airways has a **comparative advantage** to borrowing in AUD. Financial institution could reduce both of their costs by taking on FX risk:




It might be more cost-effective for Quantas Airways to bear some FX risk:




Or it might be more cost-effective for General Electric to bear some FX risk:



# Other swaps

**Equity swap**: agreement to exchange the total return (dividends plus gains) of an equity index for a fixed or floating rate of interest.

**Credit default swap**: agreement that generates a payment if a particular company (the reference entity) defaults

- the **protection buyer** pays the **CDS spread** (and insurance premium) over the life of the contract
- in the event of default, the **protection seller** pays an amount that would restore the value of the hypothetical portfolio of the bonds of the reference entity to the value of its principal

Options:

- entendable swap: one party can extend the swap arrangement
- puttable swap: one party can terminate the swap arrangement early
- swaption: option on a swap

# Premier Foods PLC

# Premier Foods PLC

- What general information can we extract from Premier's financial statement?
- What are interest rate swaps and why do firms issue them?
- What is the value to Premier of its fixed / floating short-term interest rate swaps?
- What are interest rate caps and floors? What motivate a firm to buy a cap? To sell a floor? Why do you think these instruments are often issued in conjunction (i.e. a firm buys a cap and writes a floor, forming a "collar"), as in Premier's case?
- What is the value of Premier's cap? What is the value of its floor? You will need to refer to the LIBOR swap curve and the LIBOR implied forward curve?
- Should a hedge fund buy 5 per cent of Premier?

# Thank you!

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