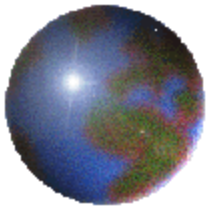
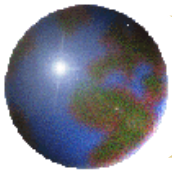


Swaps and FX Rates



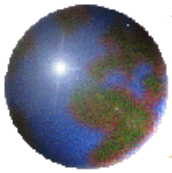
Definition

A swap is an agreement to exchange cash flows at specified future times according to certain specified rules

Types of swaps

- Interest rate swaps
  - Fixed vs floating payments
  - Floating vs floating payments
- Credit Default Swaps (to be discussed in Lecture 5)
- Currency swap
  - Exchange cash flows in different currencies

https://www.cmegroup.com/trading/interest-rates/cleared-otc.html



Outline of lecture

- Interest Rates swaps
  - Economic and financial uses
  - Swap valuation
- Introduction to FX exchange rates
  - Conventions
  - FX rates as financial asset
  - FX forward and currency swaps, and their valuation

An Example of a "Plain Vanilla" Overnight Indexed Swap

- Deal entered into on March 8, 2022 where Apple agrees to receive 3-month SOFR and pay a fixed rate of 3% per annum every 3 months for 2 years on a notional principal of $100 million
- Next slide illustrates cash flows that could occur (Day count conventions are not considered)

Cash Flows to Apple for One Outcome

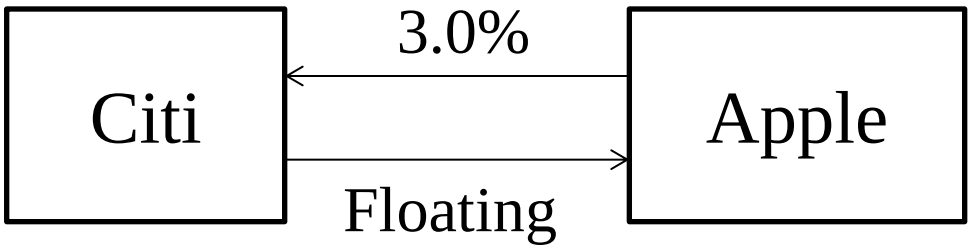
(See Table 7.1)

Date	SOFR Rate (%)	Floating Received ('000s)	Fixed Paid ('000s)	Net cash flow ('000s)
June 8, 2022	2.20	550	750	-200
Sept 8, 2022	2.60	650	750	-100
Dec. 8, 2022	2.80	700	750	-50
Mar. 8, 2023	3.10	775	750	+25
June 8, 2023	3.30	825	750	+75
Sept 8, 2023	3.40	850	750	+100
Dec 8, 2023	3.60	900	750	+150
Mar 8, 2024	3.80	950	750	+200

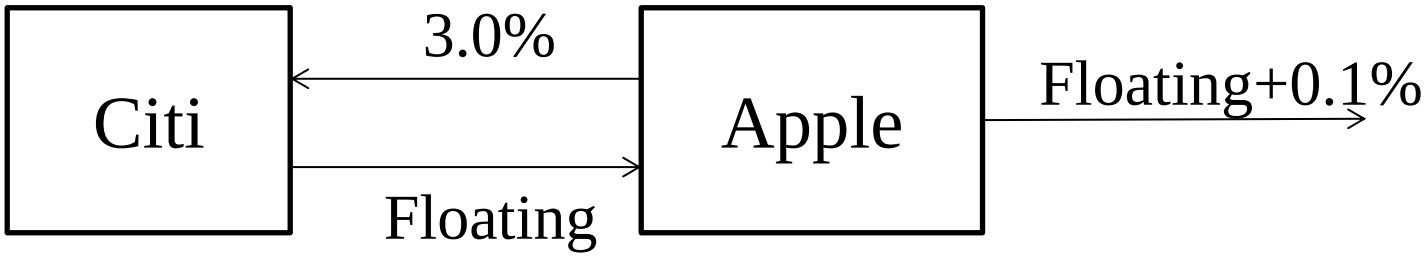
Typical Uses of Interest Rate Swaps

- Converting a liability from:
  - fixed rate to floating rate
  - floating rate to fixed rate
- Converting an investment from:
  - fixed rate to floating rate
  - floating rate to fixed rate

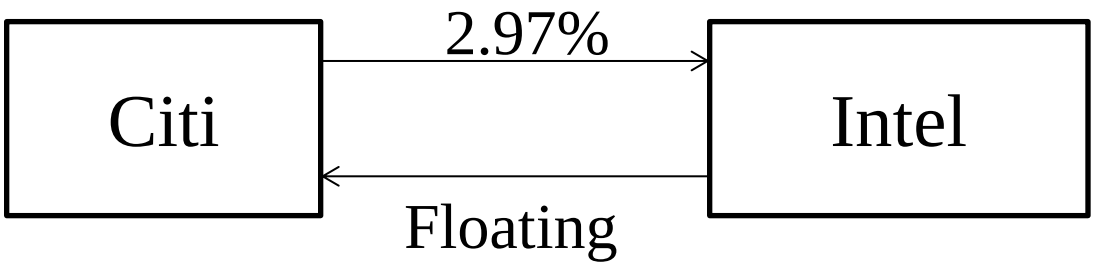
Interest Rate Swap Between Apple and Citigroup



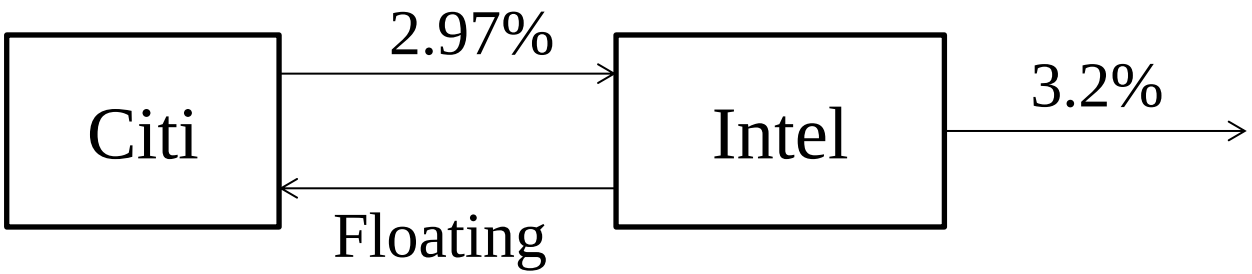
Apple Transforms a Liability from Floating to Fixed



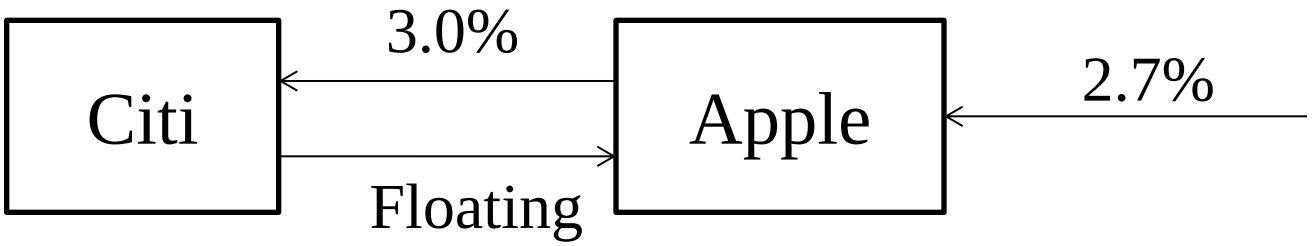
Interest Rate Swap Between Citigroup and Intel



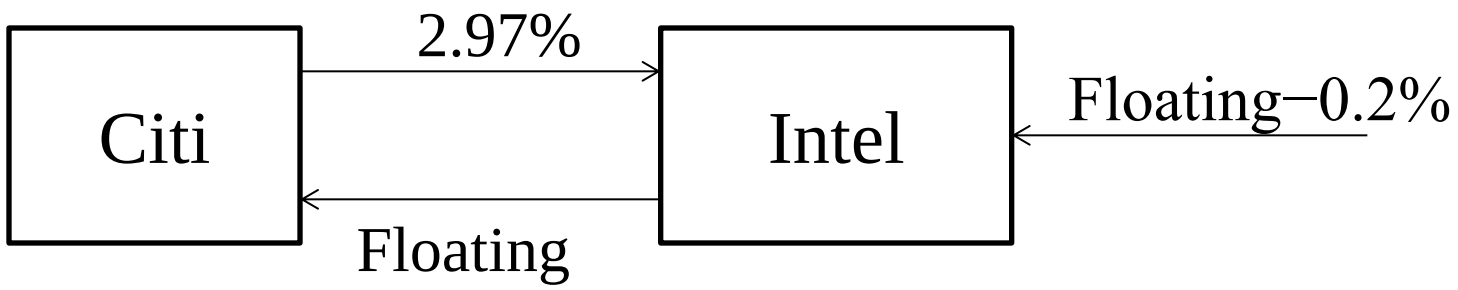
Intel Transforms a Liability from Fixed to Floating (Figure 7.4, page 159)



Apple Transforms an Asset from Fixed to Floating (Figure 7.5)



Intel Transforms an Asset from Floating to Fixed (Figure 7.6)

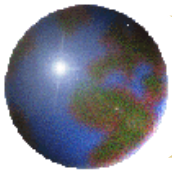


Swap Market Quotations

Swaps are quoted in the market by swap rate.
Recall that this is defined as that fixed rate which values the swap at zero.

Maturity	Bid (%)	Offer (%)	Swap Rate (%)
2 years	2.55	2.58	2.565
3 years	2.97	3.00	2.985
4 years	3.15	3.19	3.170
5 years	3.26	3.30	3.280
7 years	3.40	3.44	3.420
10 years	3.48	3.52	3.500

Swap rates in Bloomberg



Day Count

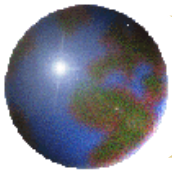
- A day count convention is specified for fixed and floating payments
- For example, SOFR is likely to be actual/360 in the U.S.
- The fixed rate might be quoted with actual/365 or 30/360

Valuation of an Interest Rate Swap

- A fixed-float swap can be valued by pricing the fixed and floating legs and adding them
- Equivalently, they can be valued as a portfolio of forward rate agreements (FRAs)
- The procedure is to
  - Calculate floating forward rates
  - Calculate the swap cash flows that will occur if floating forward rates are realized
  - Discount these swap cash flows at OIS rates

Example 7.1

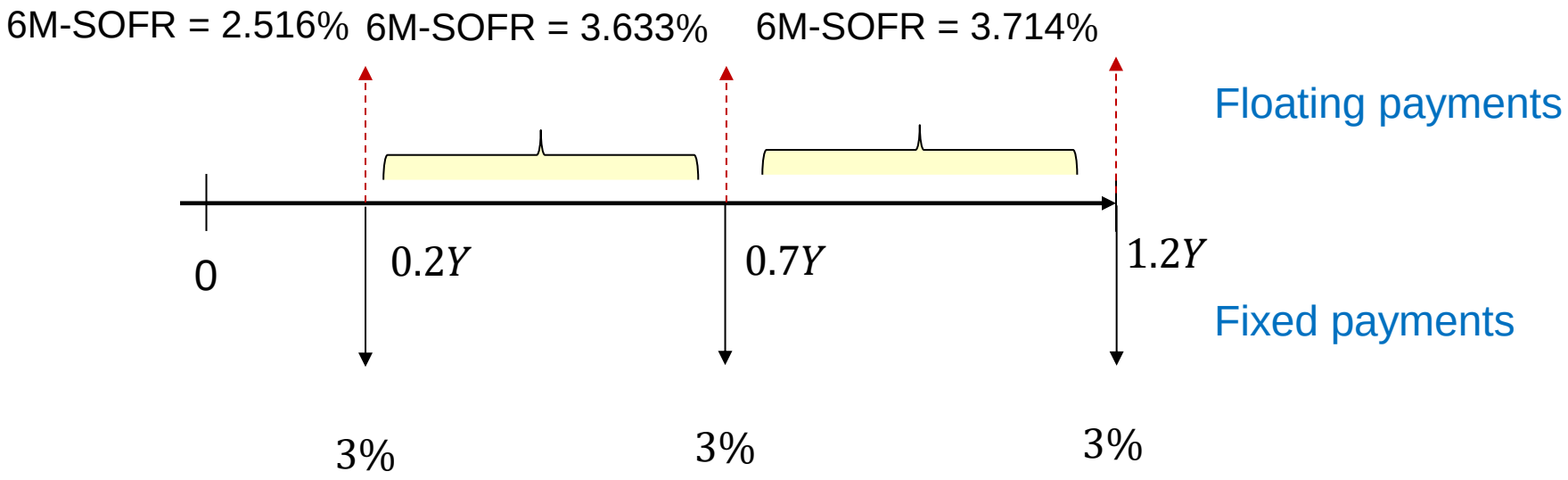
- Swap involves paying 3% per annum and receiving SOFR every six months on $100 million
- Swap has 1.2 years remaining (exchanges in 0.2, 0.7 and 1.2 years)
- Risk-free rate for 0.2, 0.7 and 1.2 years are 2.8%, 3.2% and 3.4%, respectively (continuously compounded).
- Rate observed for last 0.3 years is 2.3% continuously compounded



Example continued

- Floating rate for the exchange at 0.2 years is assumed to be 0.6×2.3%+0.4×2.8% or 2.50% (continuous comp) or 2.516% (semi-annual)
- Forward rate for 0.2 to 0.7 years is 3.36% (continuous comp) or 3.388% (semi-annual)
- Forward rate for 0.7 to 1.2 years is 3.68% (continuous comp) or 3.714% (semi-annual)

Swap valuation – Example 7.1



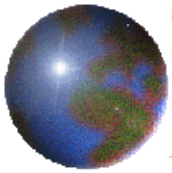
Calculations ($ million)

Time (yrs)	Fixed cash flow	Floating cash flow	Net cash flow	Discount factor	PV of net cash flow
0.2	−1.5000	+1.258	−0.242	0.9944	−0.241
0.7	−1.5000	+1.694	+0.194	0.9778	+0.190
1.2	−1.5000	+1.857	+0.357	0.9600	+0.343
					+0.292

Value of swap is $0.292 million

FX – Exchange rates

- FX – definition
- Interest rates and FX are closely linked
- FX derivatives:
  - Currency swaps
  - FX forward and FX futures
  - FX options
  - ….



Currency

- Currency: payment system, backed or not by a physical asset
- Examples: USD, EUR, JPY, GBP
- Bitcoin
- Exchange rates (FX): how many units of ccy1 correspond to one unit of ccy2?
- Example: 1 EUR = 1.0989 USD as of today (1-Feb-23)

Example: EUR/USD exchange rate

Euro to United States Dollar

1.1147 ↑2.52% +0.0274 6M

Sep 18, 7:15:00 PM UTC · Disclaimer

1D 5D 1M 6M YTD 1Y 5Y MAX

FX derivatives

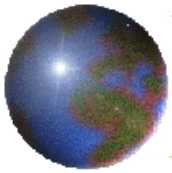
- FX forward contracts
- Currency swaps
  - Fixed-for-fixed
  - Fixed-for-floating
  - Floating-for-floating
- FX options
- …

https://www.cmegroup.com/education/courses/introduction-to-fx/what-is-fx.html

An Example of a Fixed-for-Fixed Currency Swap

Consider a 5 years agreement by BP to:

- Pay 3% on a US dollar principal of $15,000,000
- Receive 4% on a sterling principal of £10,000,000

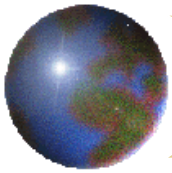


Exchange of Principal

- In an interest rate swap the principal is not exchanged
- In a currency swap the principal is exchanged at the beginning and the end of the swap

The Cash Flows (Table 7.5, page 170)

Date	Dollar Cash Flows (millions)	Sterling cash flow (millions)
Feb 1, 2016	+15.00	−10.00
Feb 1, 2017	−0.45	+0.40
Feb 1, 2018	−0.45	+0.40
Feb 1, 2019	−0.45	+0.40
Feb 1, 2020	−0.45	+0.40
Feb 1, 2021	−15.45	+10.40



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

Valuation of Fixed-for-Fixed Currency Swaps

Fixed for fixed currency swaps can be valued in two ways:

- using forward rates
- as the difference between 2 bonds

Valuation of FX forward

What is the value today (in USD) of $1 paid at time T?
Recall (from Lecture 2) that this is simply

$$V_{USD} = D_{USD}(T)$$

Valuation of payments in a foreign currency

What is the value today (in USD) of 1 EUR paid at time T?

We know the FX rate today $X(0)$= # of USD/1 EUR

Note that we know the value in EUR of this payment: $V_{EUR} = D_{EUR}(T)$
Convert in USD at the present FX rate.

$$V_{USD} = X(0)D_{EUR}(T) = D_{USD}(T)\frac{D_{EUR}(T)}{D_{USD}(T)}\,\mathrm{X}(0) = D_{USD}\,(T)X_{fwd}(T)$$

Valuation of FX forward

- The payment of 1 EUR at time T is equivalent to a payment in USD equal to the “FX forward” rate

$$X_{fwd}(T) = \frac{D_{EUR}(T)}{D_{USD}(T)} X(0)$$

- Using continuous compounding this can be expressed using the risk-free rates in USD/EUR

$$X_{fwd}(T) = e^{-(r_{\{EUR\}} - r_{\{USD\}})T} X(0)$$

Types of FX forwards traded

- Cash-settled FX forwards (payment is made in the “domestic” currency)
- Physically-settled FX forwards (payment is made in the ”foreign” currency)
- Non-Deliverable Forwards

https://www.cmegroup.com/trading/fx/otc.html

Swaps & Forwards

- A swap can be regarded as a convenient way of packaging forward contracts
- When a swap is initiated the swap has zero value, but typically some forwards have a positive value and some have a negative value

Examples 7.3 and 7.4 (pages 172-174)

- All Japanese interest rates are 1.5% per annum (cont. comp.)
- All USD interest rates are 2.5% per annum (cont. comp.)
- 3% is received in yen; 4% is paid in dollars. Payments are made annually
- Principals are $10 million and 1,200 million yen
- Swap will last for 3 more years
- Current exchange rate is 110 yen per dollar

Valuation in Terms of Forward Rates *(page 173)*

Time	Dollar Cash Flow	Yen cash flow	Forward rate	Dollar value of yen cash flow	Net cash flow	Present value
1	−0.4	+36	0.009182	0.3306	−0.0694	−0.0677
2	−0.4	+36	0.009275	0.3339	−0.0661	−0.0629
3	−10.4	+1236	0.009368	11.5786	+1.1786	+1.0934
Total						+0.9629

Other Currency Swaps

- Fixed-for-floating: equivalent to a fixed-for-fixed currency swap plus a fixed for floating interest rate swap
- Floating-for-floating: equivalent to a fixed-for-fixed currency swap plus two floating interest rate swaps

Other Types of Swaps

- Basis swaps: cash flows exchanged are linked to interest rates with different tenors (e.g. 3M vs 6M)
- Overnight Interest Rate swap (OIS): the floating payment is linked to a geometric average of the SOFR over the lifetime of the swap
- Credit Default Swaps (to be discussed in lecture 5)

FX options

Options on exchange rates (forex) give the holder the right to exchange one currency for another at a fixed rate K (strike).

- Call options on EUR/USD: gives the right to buy certain fixed amount of EUR at rate K USD.
- Put options on EUR/USD: gives the right to sell fixed amount of EUR at rate K USD.

Options on FX futures or with direct delivery in cash.