FX Derivatives

1. FX Futures and Forwards

FX RISK

Example: ABYZ, a U.S. company, imports wine from France. ABYZ has to pay EUR 5,000,000 on May 2. Today, February 4, the exchange rate is 1.15 USD/EUR.

Situation: Payment due on May 2: EUR 5,000,000.
$S_{Feb\ 4}$ = 1.15 USD/EUR.

Problem: S_t is difficult to forecast $\Rightarrow$ Uncertainty.
Uncertainty $\Rightarrow$ Risk.
Example: on May 2, $S_{t=May\ 2}$ > or < 1.15 USD/EUR.

At $S_{Feb\ 4}$, ABYZ total payment would be:

EUR 5,000,000 x 1.15 USD/EUR = USD 5,750,000.

On May 2 we have two potential scenarios relative to Feb 4:

If the $S_{May\ 2}\downarrow$ (USD appreciates) $\Rightarrow$ ABYZ will pay less USD.

If the $S_{May\ 2}\uparrow$ (USD depreciates) $\Rightarrow$ ABYZ will pay more USD.

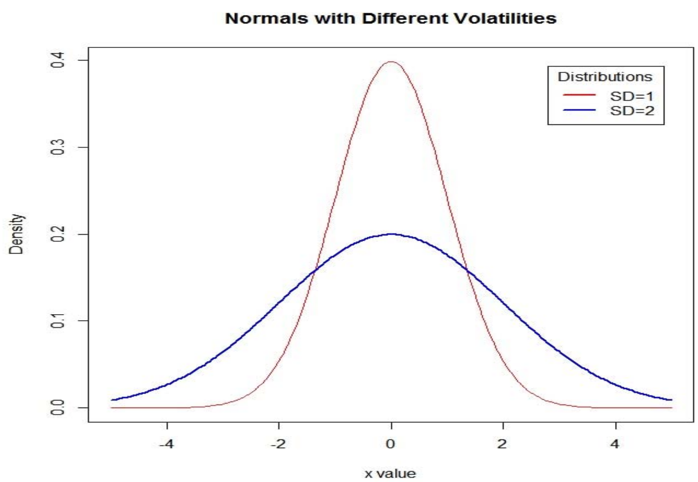
→ The second scenario introduces *Currency Risk*.

The relevance of FX risk for a firm depends on the *volatility* of S_t:

If $S_{May\ 2} \in [\ 1.13, 1.17]$, the payable will not move a lot. No big deal.

If $S_{May\ 2} \in [\ 0.8, 1.4]$, the payable can move a lot => Concern!

Higher Volatility ⇒ Concern!



FX Risk: Hedging Tools

- Hedging Tools:
  - Market-tools:
    - Futures/Forward
    - Money Market (IRPT strategy)
    - Options
  - Firm-tools:
    - Pricing in domestic currency
    - Risk-sharing
    - Matching Outflows and Inflows

Futures or Forward FX Contracts

Forward markets:	Tailor-made contracts. Location: none. Reputation/collateral guarantees the contract.
Futures markets:	Standardized contracts. Location: organized exchanges Clearinghouse guarantees the contract.

Comparison of Futures and Forward Contracts

	Futures	Forward
Amount	Standardized	Negotiated
Delivery Date	Standardized	Negotiated
Counter-party	Clearinghouse	Bank
Collateral	Margin account	Negotiated
Market	Auction market	Dealer market
Costs	Brokerage and exchange fees	Bid-ask spread
Secondary market	Very liquid	Highly illiquid
Regulation	Government	Self-regulated
Location	Central exchange floor	Worldwide

FX Futures/Forwards: Basic Terminology

Short: Agreement to Sell.

Long: Agreement to Buy.

Contract size: number of units of foreign currency in each contract.

CME expiration dates: Mar, June, Sep, and Dec + Two nearby months

Margin account: Amount of money you deposit with a broker to cover your possible losses involved in a futures/forward contract.

Initial Margin: Initial level of margin account.

Maintenance Margin: Lower bound allowed for margin account.

A margin account is like a checking account you have with your broker, but it is marked to market. If your contracts make (lose) money, money is added to (subtracted from) your account.

If margin account goes below maintenance level, a *margin call* is issue:
⇒ you have to add funds to restore the account to the initial level.

Example: GBP/USD CME futures

initial margin:	USD 2,800
maintenance margin:	USD 2,100

If losses do not exceed USD 700, no margin call will be issued.
If losses accumulate to USD 850, USD 850 will be added to account. ¶

Using FX Futures/Forwards

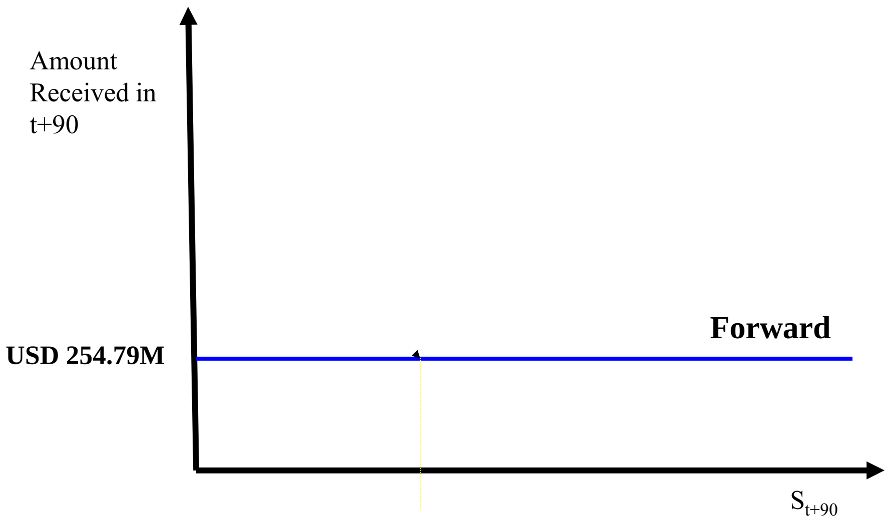
- Iris Oil Inc., a Houston-based energy company, will transfer CAD 300 million to its USD account in 90 days. To avoid FX risk, Iris Oil decides to *short* a USD/CAD Forward contract.

Data:
S_t = .8451 USD/CAD
$F_{t,90\text{-}day}$ = .8493 USD/CAD

In 90-days, Iris Oil will receive with certainty:
(CAD 300M) x (.8493 USD/CAD) = USD 254,790,000.

Note: The exchange rate at t+90 (S_{t+90}) is, now, irrelevant.

The payoff diagram makes it clear: Using futures/forwards can isolate a company from uncertainty.



Hedging with FX Futures Contracts

• FX Hedger

FX Hedger reduces the exposure of an *underlying position* to currency risk using (at least) another position (*hedging position*).

Basic Idea of a Hedger

A change in value of an underlying position is compensated with the change in value of a hedging position.

Goal: Make the overall position insensitive to changes in FX rates.

Hedger has an overall portfolio (OP) composed of (at least) 2 positions:

(1) Underlying position (UP)

(2) Hedging position (HP) with negative correlation with UP

Value of OP = Value of UP + Value of HP.

⇒ Perfect hedge: The Value of the OP is insensitive to FX changes.

• Types of FX hedgers using futures:

i. *Long hedger*: Underlying position: *short* in the foreign currency.
Hedging position: ***long*** in currency futures.

ii. *Short hedger*: Underlying position: *long* in the foreign currency.
Hedging position: ***short*** in currency futures.

Note: Hedging with futures is very simple: Take an opposite position!

We will present the simpler case, where the size of underlying position is equal to the size of hedging position. The so-called *Naive Approach.*

Example: Long Hedge and Short Hedge

(A) Long hedge.

A U.S. investor has to pay in 90 days 2.5 million Norwegian kroners.

⇒ UP: Short NOK 2.5 M.

HP: Long 90 days futures for NOK 2.5 M.

(B) Short hedge.

A U.S. investor has GBP 1 million invested in British gilts.

⇒ UP: Long GBP 1 M.

HP: Short futures for GBP 1 M.

Define:
V_t: value of the portfolio of foreign assets measured in GBP at time t.
V_t^*: value of the portfolio of foreign assets measured in USD at time t.

Example (continuation): Calculating the short hedger's profits.
It's September 12. An investor decides to hedge using Dec futures.
Situation:
UP: British bonds worth GBP 1,000,000.
$F_{Sep\ 12,Dec}$ = 1.55 USD/GBP
Futures contract size: GBP 62,500.
$S_{Sep\ 12}$: 1.60 USD/GBP.
number of contracts = ?

HP: Investor sells
GBP 1,000,000 / (62,500 GBP/contract) = 16 contracts.

Example (continuation): Calculating the short hedger's profits.
• On October 29, we have:

	Sep 12	Oct 29	Change
V_t (GBP)	1,000,000	1,000,000	0
V_t^* (USD)	1,600,000	1,500,000	**-100,000**
S_t	1.60	1.50	0.10
$F_{t,T=Dec}$	1.55	1.45	0.10

The USD change in UP ("long GBP bond position") is given by:
$V_t^* - V_0^* = V_t S_t - V_0 S_0 = V_0 \times (S_t - S_0)$
= USD 1.5M – USD 1.6M = **USD -0.1M**.

The USD change in HP ("short GBP futures position") is given by:
$-V_0 \times (F_{t,T} - F_{0,T})$ = Realized gain
(GBP -1M) x USD/GBP (1.45 – 1.55) = **USD 0.1M**.

USD Change in OP = USD Change of UP + USD Change of HP = 0
⇒ This is a perfect hedge! ¶

Note: In the previous example, we had a perfect hedge. We were lucky!

$V_{Sep\ 12} = V_{Oct\ 29} =$ GBP 1,000,000

$(F_{Sep\ 12,Dec} - S_{Sep\ 12}) = (F_{Oct\ 29,Dec} - S_{Oct\ 29}) =$ USD .05

An equal position hedge is not a perfect hedge if:

(1) V_t changes.

(2) The basis $(F_t - S_t)$ changes.

• Changes in V_t

If V_t changes, the value of OP will also change.

Example: Reconsider previous example.

On October 29: $F_{Oct\ 29,Dec} = 1.45$ USD/GBP.
$S_{Oct\ 29} = 1.50$ USD/GBP.
$V_{Oct\ 29}$ increases 2%.

Size of UP (long): GBP 1,020,000.

Size of HP (short): GBP 1,000,000.

USD change in UP (long GBP bond) is

$V_{Oct\ 29}$* (long) = GBP 1.02M x 1.50 USD/GBP =	USD 1,530,000
$V_{Sep\ 12}$* (long) = GBP 1.0M x 1.60 USD/GBP =	USD 1,600,000
USD Change in V_t* (long) =	**USD -70,000**

USD Change in HP (short GBP futures) = **USD 100,000**.

Net change on the overall portfolio = USD -70,000 + USD 100,000
= **USD 30,000**. ¶

⇒ Not a perfect hedge: only the principal (GPB 1 million) was hedged!

• Basis Change

Definition: Basis = Futures price - Spot Price = $F_{t,T} - S_t$.

Basis risk arises if $F_{t,T} - S_t$ deviates from a constant basis per period.

• If there is no basis risk ⇒ completely hedge the underlying position (including changes in V_t).

• If the basis changes ⇒ "equal" hedge is not perfect.

• In general, if $(F_{t,T} - S_t)$ ↑ (or "weakens"), the short hedger loses.
if $(F_{t,T} - S_t)$ ↓ (or "strengthens"), the short hedger wins.

Example (continuation): Now, on October 29, the market data is:
$F_{Oct\ 29,Dec}$ = 1.50 USD/GBP.
$S_{Oct\ 29}$ = 1.50 USD/GBP.
$Basis_{Sep\ 12} = F_{Sep\ 12,Dec} - S_{Sep\ 12}$ = 1.55 – 1.60 = -.05 (5 points)
$Basis_{Oct\ 29} = F_{Oct\ 29,Dec} - S_{Oct\ 29}$ = 1.50 – 1.50 = 0.

Compared to previous Example, basis increased from -5 points to 0 points. (The basis *has weakened* from USD .05 to USD 0.)

Date	Long Position ("Buy")	Dec Futures ("Sell")
September 12	1,600,000	1,550,000
October 29	1,500,000	1,500,000
Gain	**-100,000**	**50,000**

Note: $(F_t - S_t)\uparrow$ ⇒ Short hedger's profits loses (USD -50,000).
Equal hedge is not perfect! ¶

- **Basis risk**
- Recall IRPT. For the USD/GBP exchange rate, we have:

$$F_{t,T} = S_t \frac{(1 + i_{USD}\ x\ \frac{T}{360})}{(1 + i_{GBP}\ x\ \frac{T}{360})}$$

Assume T =360. After some algebra, we have:

$$F_{t,T} - S_t = S_t \frac{i_{USD} - i_{GBP}}{1 + i_{GBP}}$$

The basis is proportional to the interest rate differential.
⇒ As interest rates change, the basis changes too.

Hedging Strategies

- Three problems associated with hedging in the futures market:
  - Contract size is fixed.
  - Expiration dates are also fixed.
  - Choice of underlying assets in the futures market is limited.

- Imperfect hedges:
  - *Delta-hedge* when the maturities do not match
  - *Cross-hedge* when the currencies do not match.

• Another important consideration: liquidity.

- **Contract Terms (Delta Hedging)**

Major decision: choice of contract terms.

• Advantages of a short-term hedging:

- Short-term $F_{t,T}$ closely follows S_t.
  Recall linearized IRPT : $F_{t,T} \approx S_t [1+ (i_d - i_f) \times T/360]$
  As $T \to 0$, $F_{t,T} \to S_t$ (UP and HP will move closely)

- Short-term $F_{t,T}$ has greater trading volume (more liquid).

• Disadvantages of a short-term hedging:

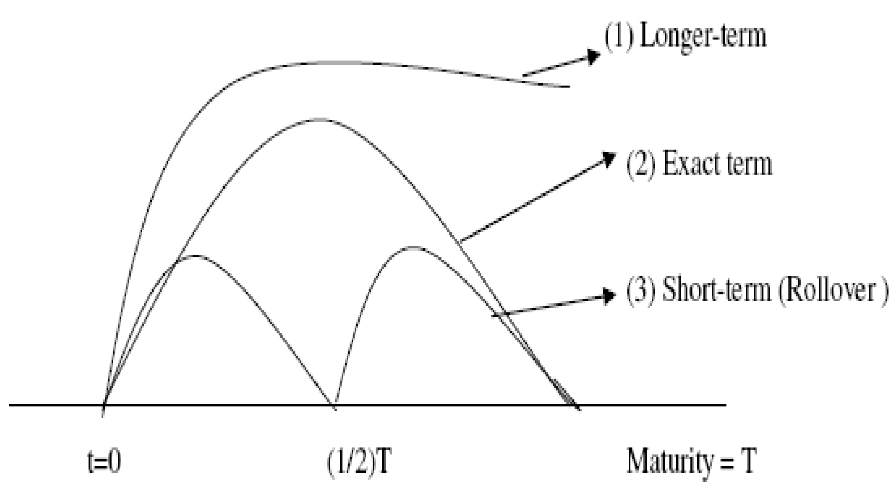
- Short-term hedges need to be rolled over: cost!

- **Contract Terms (Delta Hedging)**

• Short-term hedges are usually done with short-term contracts.

• Longer-term hedges are done using three basic contract terms:
- Short-term contracts, which must be rolled over at maturity;
- Contracts with a matching maturity (usually done with a forward);
- Longer-term contracts with a maturity beyond the hedging period.

Three Hedging Strategies for an Expected Hedge Period of 6 Months



• **Different Currencies (Cross-Hedging)**
Q: Under what circumstances do investors use cross-hedging?

• An investor may prefer a cross-hedge if:

(1) There is no available contract for the currency she wishes to hedge.
Futures contracts are actively traded for the major currencies
(at the CME: GBP, JPY, EUR, CHF, MXN, CAD, BRR).
Example: Want to hedge a NOK position using CME futures:
⇒ you must cross-hedge.

(2) Cheaper and easier to use a different contract.
Banks offer forward contracts for many currencies. These contracts might not be liquid (and expensive!).

• Empirical results:
(i) Optimal same-currency-hedge ratios are very effective.
(ii) Optimal cross-hedge ratios are quite unstable.

Example: Calculation of Cross-hedge ratios.
Situation:
- Veron SA, a U.S. firm, has to pay HUF 10 million in 180 days.
- No futures contract on the HUF.
- Liquid contracts on currencies highly correlated to the HUF.

<u>Solution</u>: Cross-hedge using the EUR and the GBP.
• Calculation of the appropriate OLS hedge ratios.
Dependent variable: USD/HUF changes
Independent variables: USD/EUR 6-mo. futures changes
USD/GBP 6-mo. futures changes
Exchange rates: .0043 EUR/HUF
.0020 GBP/HUF
$\Delta S_{USD/HUF} = \alpha + .84\ \Delta F_{USD/EUR} + 0.76\ \Delta F_{USD/GBP},\qquad R^2 = 0.81.$

The number of contracts bought by Veron SA is given by:
EUR: (-10,000,000 x .0043/125,000) x **-0.84** = 2.89 ≈ 3 contracts.
GBP: (-10,000,000 x .0020/62,500) x **-0.76** = 3.20 ≈ 3 contracts. ¶