HEDGING FX RISK

Measuring and Managing FX Exposure

(for private use, not to be posted/shared online)

- **Last Class**
- **Hedging Market-based Tools**:
  - ♦ **Futures/Forward**: Completely eliminates uncertainty
    - ◊ UP: *short* in the foreign currency.
      HP: ***long*** in currency futures.
    - ◊ UP: *long* in the foreign currency.
      HP: ***short*** in currency futures.
  - ♦ **Options**: Reduces uncertainty. How much? It depends on **X**.
    - ◊ UP: *short* in the foreign currency.
      HP: ***long*** in currency **calls**.
    - ◊ UP: *long* in the foreign currency.
      HP: ***long*** in currency **puts**.

• **This Class**

• **Exposure (Risk)**

- At the firm level, currency risk is called *exposure*.

• **Three areas**

(1) *Transaction exposure*: Risk of transactions denominated in FC with a payment date or maturity.

(2) *Economic exposure*: Degree to which a firm's expected cash flows are affected by unexpected changes in S_t.

(3) *Translation exposure*: Accounting-based changes in a firm's consolidated statements that result from a change in S_t. Translation rules create accounting gains/losses due to changes in S_t.

We say a firm is "*exposed*" or has exposure if it faces currency risk.

• **This Class**

Example: Exposure.

A. *Transaction exposure*.

Swiss Cruises, a Swiss firm, sells cruise packages priced in USD to a broker. Payment in 30 days.

B. *Economic exposure*.

Swiss Cruises has 50% of its revenue denominated in USD and only 20% of its cost denominated in USD. A depreciation of the USD will affect future CHF cash flows.

C. *Translation exposure*.

Swiss Cruises obtains a USD loan from a U.S. bank. This liability has to be translated into CHF following Swiss accounting rules. ¶

• This Class

Q: How can FX changes affect the firm?

- *Transaction Exposure*
  - Short-term CFs: Existing contract obligations.
- *Economic Exposure*
  - Future CFs: Erosion of competitive position.
- *Translation Exposure*
  - Revaluation of balance sheet (Book Value vs Market Value).

• This Class

• Measuring TE:

- $TE_{j,t}$ = **Value of a fixed future transaction in FC_j** * S_t
- Netting TE (portfolio approach) = NTE = $\sum_{J=1}^{J} TE_{j,t}$

Remark: The risk in TE is driven by S_t

⇒ $\Delta TE = TE_{t+T} - TE_t$ = **Value of a fixed future transaction in FC** * ΔS

• Range for TE:

(1) Ad-hoc rule (say, ±10%)

(2) Sensitivity Analysis (Simulating exchange rates).

(3) Assuming a statistical distribution for exchange rates.

• VaR: Worst case scenario in a given time interval within a (one-sided) CI.

- Lower-end of Receivables.
- Highest-end of Payables.

• **This Class**

• Measuring EE:

- Change in CF due to an *unexpected* change in S_t.

$$= \frac{\Delta CF_t}{\Delta S_t} \qquad \text{(differential or derivative, } \Delta S_t \text{ is small)}$$

- ΔCF_t can be approximated by change in Stock Prices.

Remark: If a company is publicly traded, ΔCF_t can be approximated by change in Stock Prices ΔP_t. A regression can be used.

Measuring Transaction Exposure

• Transaction exposure (TE) is easy to identify and measure.

- Identification: Transactions denominated in FC with a fixed future date
- Measure: Translate identified FC transactions to DC using S_t.

$TE_{j,t}$ = **Value of a fixed future transaction in FC_j** * S_t

Example: Swiss Cruises.

Sold cruise packages for USD 2.5 million. Payment: 30 days.

Bought fuel oil for USD 1.5 million. Payment: 30 days.

S_t = **1.45 CHF/USD**.

Thus, the net transaction exposure in USD 30 days is:

Net $TE_{j=USD}$ = (USD 2.5M – USD 1.5M) * **1.45 CHF/USD**

= **USD 1M** * **1.45 CHF/USD** = CHF 1.45M. ¶

• **Netting**

An MNC has many transactions, in different currencies, with fixed futures dates. Since TE is denominated in DC, all exposures are easy to consolidate in one single number: Net TE (NTE).

$$\text{NTE} = \text{Net } TE_t = \sum_{J=1}^{J} TE_{j,t} \qquad j = \text{EUR, GBP, JPY, BRL, MXN,...}$$

• NTE is reported by fixed date: up to 90 days, more than 90-days, etc.

Note: Since currencies are correlated, firms take into account **correlations** to calculate how changes in S_t affect Net TE ⇒ **Portfolio Approach**.

Example: A U.S. MNC: Subsidiary A with CF(in EUR) > 0
Subsidiary B with CF(in GBP) < 0

Since $\rho_{GBP,EUR}$ is very high and positive, NTE may be very low. ¶

⇒ Hedging decisions are usually made based on exposure of the **portfolio**.

• **Netting - Correlations**

Example: Swiss Cruises.

Net Inflows (in USD): **USD 1 million.** Due: 30 days.

Loan repayment: **CAD 1.50 million**. Due: 30 days.

S_t = 1.47 CAD/USD.

$\rho_{CAD,USD}$ = .843 (monthly from 1971 to 2017)

Swiss Cruises considers NTE to be close to zero. ¶

Note 1: Correlations vary a lot across currencies. In general, **regional** currencies are highly correlated.

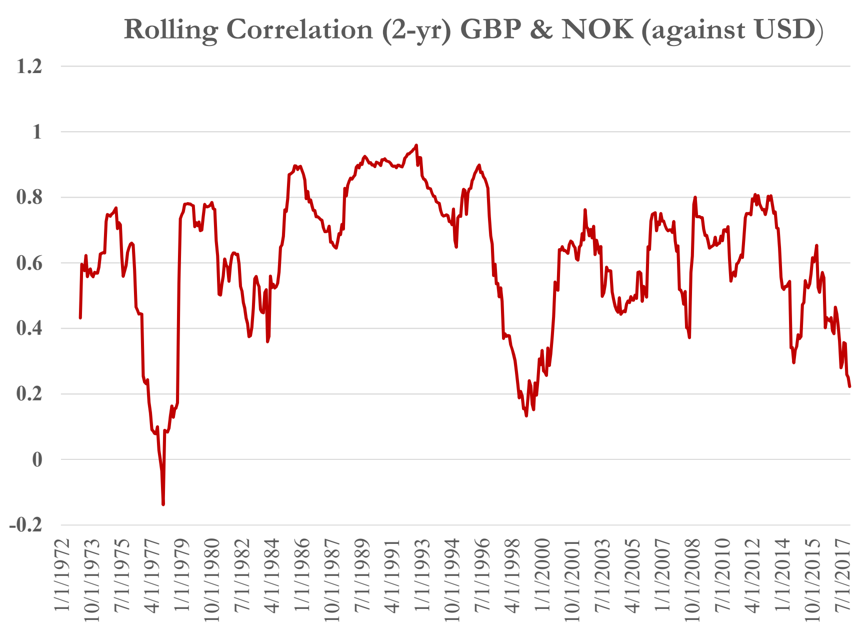
From **2000-2017**,

$\rho_{GBP,NOK}$ = **0.58**

$\rho_{GBP,JPY}$ = **0.04**

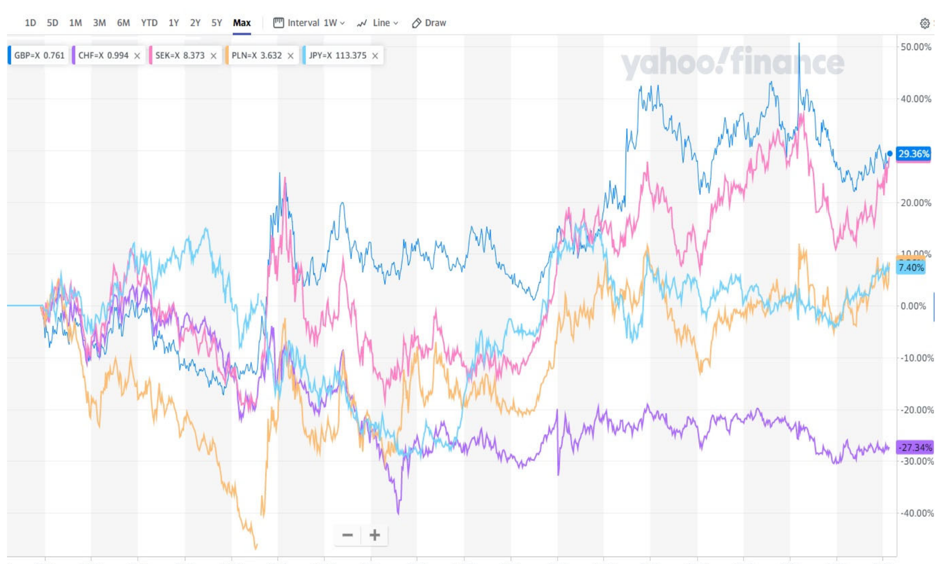
Note 2: Correlations also vary over time.

• Netting - Correlations



• Netting - Correlations

On average, currencies from developed countries tend to move together… But, not all and not always.



• **Q: How does TE affect a firm in the future?**

Firms are interested in how TE will change in the future, say, in T days when transaction will be settled.

- Firms do not know S_{t+T}, they need to forecast S_{t+T} $\Rightarrow$ $E_t[S_{t+T}]$

- Once we forecast $E_t[S_{t+T}]$, we can forecast $E_t[TE_{t+T}]$:

  $E_t[TE_{t+T}]$ = **Value of a fixed future transaction in FC** * $E_t[S_{t+T}]$

- $E_t[S_{t+T}]$ has an associated standard error, which can be used to create a range (or interval) for S_{t+T} & TE.

- Risk management perspective:

How much DC can the firm spend on account of a FC inflow in T days?

How much DC will be needed to cover a FC outflow in T days?.

Range Estimates of TE

• S_t is very difficult to forecast. Thus, a range estimate for NTE provides a useful number for risk managers.

The smaller the range, the lower the sensitivity of NTE.

• Three popular methods for estimating a range for NTE:

(1) Ad-hoc rule (say, $\pm$**10%**)

(2) Sensitivity Analysis (or simulating exchange rates)

(3) Assuming a statistical distribution for exchange rates.

- **Ad-hoc Rule**

Many firms use an *ad-hoc* ("arbitrary") rule to get a range: **±X%** (for example, a 10% rule)

Simple and easy to understand: Get TE and add/subtract ±X%.

Example: 10% Rule.

SC has a Net TE = **CHF 1.45M** due in 30 days

⇒ if S_t changes by **±10%**, NTE changes by ± **CHF 145,000**. ¶

Note: This example gives a range for NTE:

NTE ∈ **[CHF 1.305M; CHF 1.595M]**

Risk Management Interpretation: A risk manager will only care about the lower bound. If SC is counting on the **USD 1M** inflow to pay CHF expenses, these expenses should not exceed **CHF 1.305M**. ¶

- **Sensitivity Analysis**

Goal: Measure the sensitivity of TE to different exchange rates.

Example: Sensitivity of TE to extreme forecasts of S_t.

Sensitivity of TE to randomly simulate thousands of S_t.

Data: 20 years of monthly CHF/USD % changes (ED)

Mean (μ)	-0.00152	μ_m = **-0.152%**
Standard Error	0.00202	
Median	-0.00363	
Mode	#N/A	
Stand Deviation (σ)	0.03184	σ_m = **3.184%**
Sample Variance (σ^2)	0.00101	
Kurtosis	0.46327	
Skewness	0.42987	
Range	0.27710	
Minimum	**-0.11618**	
Maximum	**0.15092**	
Sum	0.0576765	
Count	248	

- **Sensitivity Analysis – Extremes (Worst Case & Best Case)**

Example: Extremes for Swiss Cruises Net TE (CHF/USD)
ED of S_t monthly changes over the past 20 years (1994-2014).
Extremes: **15.09%** (on October 2011) and **–11.62%** (on Jan 2009).

SC's net receivables in FC: **USD 1M**.

(A) *Best case scenario*: largest appreciation of USD: **0.1509**
NTE: **USD 1M** * **1.45 CHF/USD** * (1 + **0.1509**) = **CHF 1,668,805**.

(B) *Worst case scenario*: largest depreciation of USD: **-0.1162**
NTE: **USD 1M** * **1.45 CHF/USD** * (1 + (**–0.1162**)) = **CHF 1,281,510**.

That is,

NTE ∈ **[CHF 1,281,510; CHF 1,668,805]**

Note: If Swiss Cruises is counting on the USD 1M to cover CHF expenses, the expenses to cover should not exceed **CHF 1,281,510**. ¶

- **Sensitivity Analysis – Simulation**

Managers may consider the previous range, based on extremes, too conservative:

NTE ∈ [**CHF 1,281,510; CHF 1,668,805**].

⇒ Probability of worst case scenario is low: Only once in 240 months!

Under more likely scenarios, a firm may be able to cover more expenses.

A more realistic range can be constructed through sampling from the ED.

Example: Simulation for SC's Net TE (CHF/USD) over one month.

(i) Randomly pick 1,000 monthly s_{t+30}'s from the ED.

(ii) Calculate S_{t+30} for each s_{t+30} selected in (i).

(Recall: S_{t+30} = **1.45 CHF/USD** * (1 + s_{t+30}))

(iii) Calculate **TE** for each S_{t+30}. (Recall: **TE** = **USD 1M** * S_{t+30})

(iv) Plot the 1,000 **TE**'s in a histogram. (Simulated TE distribution.)

Example (continuation): In excel, using Vlookup function

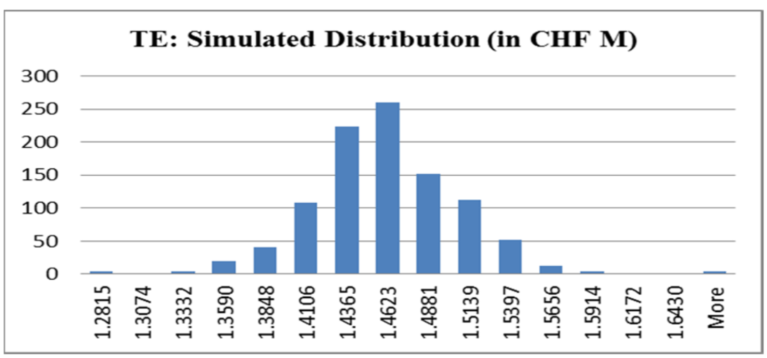
(i) Randomly draw $s_t = s_{sim,1}$ from ED: Observation 19: s_{t+30} = **0.0034**.

(ii) Calculate $S_{sim,1}$: S_{t+30} = **1.45 CHF/USD** * (1 + **.0034**) = **1.4549**

(iii) Calculate $TE_{sim,1}$: **TE** = **USD 1M** * S_{t+30} = **1,454,937.57**

(iv) Repeat (i)-(iii) 1,000 times. Plot histogram. Construct a (1-α)% C.I.

Lookup cell	s_t	Random Draw with Randbetween	Draw s_sim with Vlookup	S_sim	TE(sim)
1					
2	0.0025	19	**0.0034**	**1.4549**	**1,454,937.57**
3	-0.0027	147	-0.0104	1.4349	1,434,895.83
4	**0.0001**	99	0.0125	1.4682	1,468,189.96
5	-0.0443	203	-0.0584	1.3653	1,365,272.92
6	-0.0017	82	-0.0727	1.3446	1,344,597.25
7	-0.0031	**4**	**0.0001**	1.4502	1,450,168.79
8	-0.0227	67	-0.0226	1.4172	1,417,218.22
9	-0.0099	136	0.0095	1.4638	1,463,838.02
10	0.0098	232	0.0191	1.4777	1,477,749.46



Based on this simulated distribution, we can estimate a 95% range (leaving 2.5% observations to the left and 2.5% observations to the right)

⇒ NTE ∈ [**CHF 1.3661 M**; **CHF 1.5443 M**]

Practical Application: If SC expects to cover expenses with this USD inflow, the maximum amount in CHF to cover, using this 95% CI, should be **CHF 1,366,100**. ¶

• Aside: How many draws in the simulations?
Usually, we draw until the CIs do not change a lot.

Example: **1,000** and **10,000** draws
For the SC example, we drew **1,000** scenarios to get a 95% C.I.:
$\Rightarrow$ NTE ∈ [**CHF 1.3661 M**; **CHF 1.5443 M**]

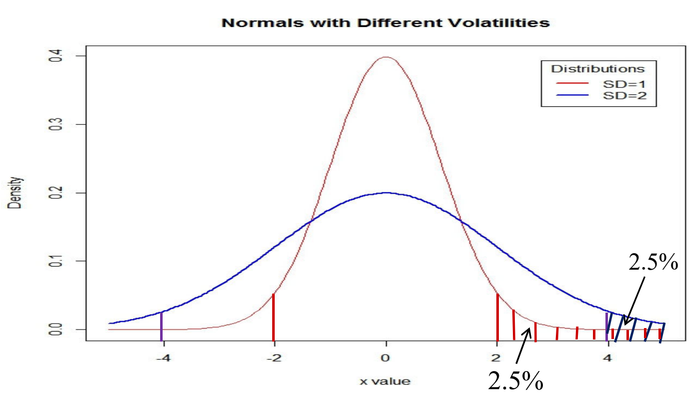
Now, we draw **10,000** scenarios and determined the following 95% C.I.:
$\Rightarrow$ NTE ∈ [**CHF 1.3670 M**; **CHF 1.5446 M**]

• Not a significant change in the range: 1,000 simulations seem enough.

• Assuming a Distribution
CIs based on an assumed distribution provide a range for TE.

For example, a firm assumes that $s_t \sim N(\mu, \sigma^2)$. ("~" = follows)
$\Rightarrow$ construct a $(1-\alpha)$% CI: $[\mu \pm z_{\alpha/2}\, \sigma]$.

Usual α's: $\alpha = .05$ $\Rightarrow$ $z_{.025} = 1.96$ (≈2)
$\alpha = .02$ $\Rightarrow$ $z_{.01} = 2.33$



• **Assuming a Distribution – Normal for s_t**

Example: CI range based on a Normal distribution.

Swiss Cruises believes that CHF/USD monthly changes follow a normal distribution. SC estimates:

μ = Monthly mean = **-0.00152** ≈ -0.15%

σ^2 = Monthly variance = 0.001014 ($\Rightarrow \sigma$ = **0.03184**, or 3.18%)

$s_t \sim N(\mathbf{-0.00152}, \mathbf{0.03184}^2)$ s_t = CHF/USD monthly changes.

SC builds a 95% CI for CHF/USD monthly changes:

$$[\mathbf{-0.00152} \pm \mathbf{1.96} * \mathbf{0.03184}] = [\mathbf{-0.06393}; 0.06089].$$

Based on this range for s_t, we derive bounds for the net TE:

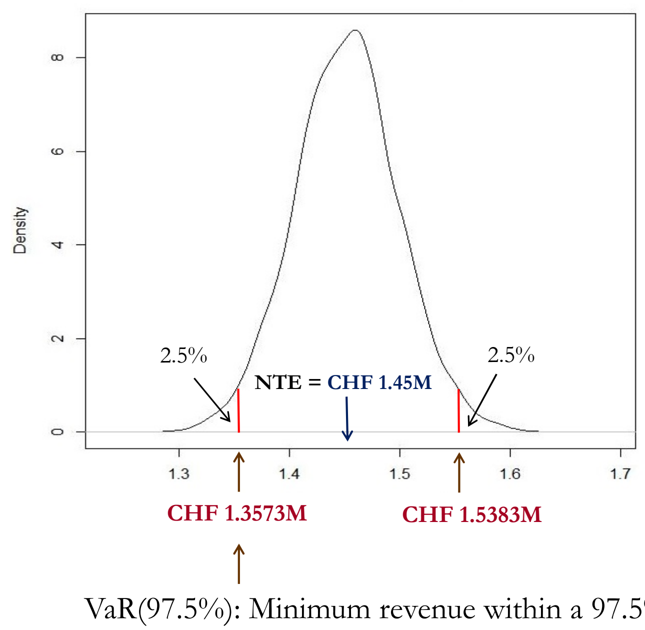
(A) Upper bound

NTE: **USD 1M** * **1.45 CHF/USD** * (1 + 0.06089) = **CHF 1,538,291**.

(B) **Lower bound**

NTE: **USD 1M** * **1.45 CHF/USD** * (1 + (**-0.06393**)) = **CHF 1,357,302**.

95% CI range based on a Normal Distribution and VaR(97.5%)



$\Rightarrow$ NTE $\in$ [**CHF 1.357 M**; **CHF 1.538 M**]

• The lower bound, for a receivable, represents the worst case scenario within the confidence interval.

There is a *Value-at-Risk* (VaR) interpretation:

VaR: *Maximum expected loss* in a given time interval within a (one-sided) CI.

In our case, we can express the "*expected loss*" relative to today's value:

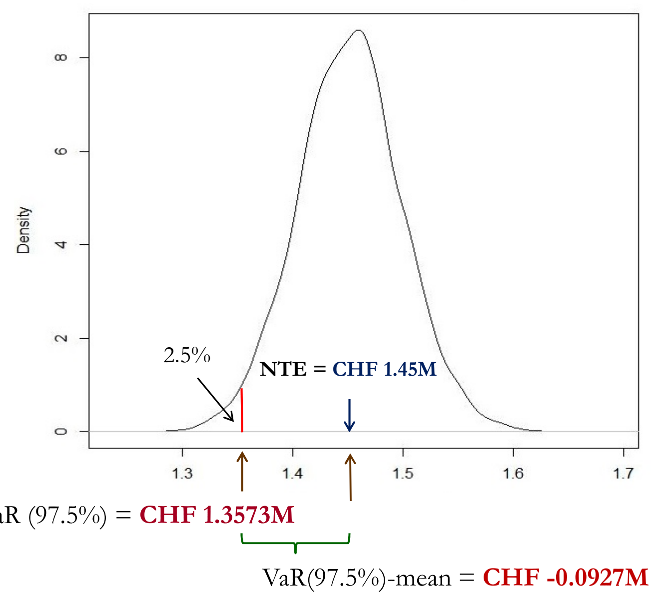
VaR-mean = VaR – **NTE**

Example (continuation): The minimum revenue to be received by SC in the next 30 days, within a 97.5% CI ($\Rightarrow$ $\mathbf{z_{.025}}$ = **1.96**):

VaR(97.5%) = **CHF 1.45M** [1 + (**-0.00152** – **1.96** * **0.03184**)]
= **CHF 1,357,302**.

$\Rightarrow$ VaR-mean (.975) = **CHF 1.3573M** – **CHF 1.45M** = **CHF -0.0927M**

97.5% one-sided CI: VaR & VaR-mean



Example (continuation): ⇒ NTE ∈ [**CHF 1.357 M**; **CHF 1.538 M**]

VaR(97.5%) = **CHF 1,357,302**

If SC expects to cover expenses with this USD inflow, the maximum amount in CHF to cover, within a 97.5% CI, should be **CHF 1,357,302**.

VaR-mean (97.5%) = **CHF -0.0927M**

Relative to today's valuation (or *expected valuation*, according to RWM), the maximum *expected loss* with a 97.5% "chance" is **CHF -0.0927M.** ¶

Note: We could have used a different significance level to calculate the VaR, for example 99% (⇒ $z_{.01}$ = 2.33). Then,

VaR(99%) = **CHF 1.45M** [1 + (**-0.00152** – **2.33** * **0.03184**)]
= **CHF 1.34023**. (A more *conservative* bound.)

⇒ VaR-mean (.99) = **CHF 1.34023M** – **CHF 1.45M** = **CHF -0.1098M**

● **Summary NTE for Swiss Cruises**:

- **NTE** = **CHF 1.45M**

• **NTE Range:**

◇ **Ad-hoc:**

NTE ∈ [**CHF 1.305M**; **CHF 1.595 M**].

◇ **Sensitivity Analysis:**

- Extremes: NTE ∈ [**CHF 1.281 M**; **CHF 1,6688 M**]
- Simulation: NTE ∈ [**CHF 1.3661 M**; **CHF 1.5443 M**]

◇ **Statistical Distribution (normal):**

NTE ∈ [**CHF 1.357 M**; **CHF 1.538 M**]

♦ **Approximating Returns**

In general, we use *arithmetic returns*: $s_t = S_t/S_{t-1} - 1$. To change the frequency, compounding is needed.

But, if we use *logarithmic returns* –i.e., $s_t = \log(S_t) - \log(S_{t-1})$–, changing the frequency of mean returns (μ) and return variances (σ^2) is simpler.

Let μ_b & σ_b^2 be measured in a given base frequency, say, *b*. Then,

$\mu_f = \mu_b * T$,

$\sigma_f^2 = \sigma_b^2 * T$ $\Rightarrow \sigma_f = \sigma_b * \text{sqrt}(T)$

T = # periods of base frequency *b* in new frequency, *f*.

♦ **Approximating Returns – From monthly to daily & annual**

Example: Using monthly data, compute daily and annual mean & SD.

From previous Table (base frequency: b = monthly, arithmetic computed):

$\mu_m = -0.00152$

$\sigma_m = 0.03184$

(1) Daily (i.e., *f* = d = daily & *T* = 1/30)

$\mu_d = (-0.00152) * (1/30) = .0000507$ (0.006%)

$\sigma_d = (0.03184) * (1/30)^{1/2} = .00602$ (0.60%)

(2) Annual (i.e., *f* = a = annual & *T* = 12)

$\mu_a = (-0.00152) * (12) = -0.01824$ (-1.82%)

$\sigma_a = (0.03184) * (12)^{1/2} = 0.110297$ (11.03%)

Check: The annual compounded arithmetic return:

$$(1 - 0.00152)^{12} - 1 = -0.01809.$$

When arithmetic returns are low, these approximations work well. ¶

♦ **Approximating Returns – From monthly VaR to annualized VaR**

Example: Using the annualized approximation, we can also approximate an annualized VaR(97.5%) for Swiss Cruises:

VaR(97.5%) = **USD 1M** * **1.45 CHF/USD** * [1 +(**-.01824** – 1.96***0.1103**)]
= **CHF 1,101,374**. ¶

Note II: Using logarithmic returns rules, we can approximate USD/CHF monthly changes by changing the sign of the CHF/USD, while the variance remains the same.

Then,

- Annualized USD/CHF mean percentage change ≈ **1.82%**,
- Annualized USD/CHF volatility ≈ **11.03%**

● **Sensitivity Analysis – Portfolio Approach**

A simulation: Draw different scenarios, pay attention to *correlations*!

Example: IBM has the following CFs in the next 90 days

	Outflows	Inflows	S_t	Net Inflows
GBP	100,000	25,000	**1.60 USD/GBP**	**(75,000)**
EUR	80,000	200,000	**1.05 USD/EUR**	**120,000**

NTE_0 = **EUR 120K** * **1.05 USD/EUR** + **(GBP 75K)** * **1.60 USD/GBP**
= **USD 6,000** (this is our baseline case)

Situation 1: Assume $\rho_{GBP,EUR} = 1$. (EUR and GBP correlation is high.)

Scenario (i): EUR appreciates by **10%** against the USD

Since $\rho_{GBP,EUR} = 1$, S_t = **1.05 USD/EUR** * (1 + **.10**) = **1.155 USD/EUR**
S_t = **1.60 USD/GBP** * (1 + **.10**) = **1.76 USD/GBP**

NTE = **EUR 120K** * **1.155 USD/EUR** + **(GBP 75K)** * **1.76 USD/GBP**
= **USD 6,600**. (**+10% change** = **USD -600**)

● **Sensitivity Analysis – Portfolio Approach**
Example (continuation): with $\rho_{GBP,EUR} = 1$.

Scenario (ii): EUR depreciates by **10%** against the USD
Since $\rho_{GBP,EUR} = 1$, S_t = **1.05 USD/EUR** * (1 – .10) = **0.945 USD/EUR**
S_t = **1.60 USD/GBP** * (1 – .10) = **1.44 USD/GBP**

NTE = **EUR 120K** * **0.945 USD/EUR** + **(GBP 75K)** * **1.44 USD/GBP**
= **USD 5,400**. (**-10% change** = **USD -600**)

Now, we can specify a range for NTE
⇒ NTE ∈ [**USD 5,400**; **USD 6,600**]

Note: The NTE change is exactly the same as the change in S_t. Then,
if $\mathbf{NTE_0} \approx \mathbf{0}$ ⇒ s_t has very small effect on NTE.

That is, if a firm has matching inflows and outflows in highly positively correlated currencies, then changes in S_t do not affect NTE. From a risk management perspective, this is very good.

● **Sensitivity Analysis – Portfolio Approach**
Example (continuation):
Situation 2: Suppose the $\rho_{GBP,EUR} = -1$ (NOT a realistic assumption!)
Scenario (i): EUR **appreciates** by **10%** against the USD
Since $\rho_{GBP,EUR} = -1$, S_t = **1.05 USD/EUR** * (1 + .10) = **1.155 USD/EUR**
S_t = **1.60 USD/GBP** * (1 – .10) = **1.44 USD/GBP**

NTE = **EUR 120K** * **1.155 USD/EUR** + **(GBP 75K)** * **1.44 USD/GBP**
= **USD 30,600**. (**410% change** = **USD 24,600**)

Scenario (ii): EUR **depreciates** by **10%** against the USD
Since $\rho_{GBP,EUR} = -1$, S_t = **1.05 USD/EUR** * (1 - .10) = **0.945 USD/EUR**
S_t = **1.60 USD/GBP** * (1 + .10) = **1.76 USD/GBP**

NTE = **EUR 120K** * **0.945 USD/EUR** + **(GBP 75K)** * **1.76 USD/GBP**
= **(USD 18,600).** (**-410% change** = **USD -24,600**)

Now, we can specify a range for NTE
⇒ NTE ∈ [**(USD 18,600)**; **USD 30,600**]

● **Sensitivity Analysis – Portfolio Approach**
Example (continuation):

Note: The NTE has ballooned. A **10% change** in S_t a dramatic increase in the NTE range.

⇒ Having non-matching exposures in different currencies with negative correlation is very dangerous.

Remarks:
- IBM can assume a correlation (estimated from the data). Then, draw many scenarios from a *bivariate normal distribution* to generate a simulated distribution for the NTE.

- Alternatively, IBM can just draw joint pairs from the ED. From this ED, IBM will get a range –and a VaR– for the NTE. ¶

Managing TE

- **A Comparison of External Hedging Tools**

Transaction exposure: Risk from the settlement of transactions in FC.

Example: Imports, exports, acquisition of foreign assets.

• Tools: Futures/forwards (FH)
Options (OH)
Money market (MMH)

• Q: Which hedging tool is better?

- New tool: MMH

Money market hedge: Based on a replication of IRPT arbitrage.

Let's take the case of *receivables* denominated in FC:

1) **Borrow FC**
2) Convert to DC
3) Deposit DC in domestic bank
4) **Transfer FC receivable** to cover loan (+ interest) from (1).

Under IRPT, step 4) involves buying FC forward, to repay loan in (1)

⇒ This step is not needed, instead, we just transfer the FC receivable.

Q: Why MMH instead of FH?

- Under perfect market conditions ⇒ MMH = FH
- Under less than perfect conditions ⇒ MMH ≠ FH

- New tool: MMH

Now, let's take the case of *payables* denominated in FC:

1) **Borrow DC**
2) Convert to FC
3) Deposit FC in domestic bank
4) **Transfer FC deposit** (+ interest) to cover payable in FC.

Under IRPT, step 4) involves selling FC/buying DC forward, to repay loan in (1)

⇒ This step is not needed, instead, we just transfer the FC deposit.

Q: Why MMH instead of FH?

- Under perfect markets ⇒ MMH = FH
- Under less than perfect markets ⇒ MMH ≠ FH

• Comparison of Hedging Strategies

Example: Iris Oil Inc. has a large FC exposure in the form of a CAD cash flow from its Canadian operations. Iris decides to transfer **CAD 300M** to its USD account in 90 days.

FX risk to Iris: CAD may depreciate against the USD.

Data:

S_t = 0.8451 USD/CAD

$F_{t,90\text{-day}}$ = 0.8493 USD/CAD

i_{USD} = **3.92%**

i_{CAD} = **2.03%**

X	Calls	Puts
.82 USD/CAD	----	0.21
.84 USD/CAD	1.58	**0.68**
.88 USD/CAD	**0.23**	----

Example (continuation):

Date	Spot market	Forward market	Money market
t	S_t = .8451 USD/CAD	$F_{t,90\text{-day}}$ = .8493 USD/CAD	i_{USD} = 3.92% i_{CAD} = 2.03%
$t + 90$	Receive **CAD 300M** and transfer into USD.		

NTE = **CAD 300M** * **.8451 USD/CAD** = **USD 253.53M**

• Hedging Strategies:

1. Do Nothing

Do not hedge and exchange the **CAD 300M** at S_{t+90}.

2. Forward Market

At t, sell the **CAD 300M** forward and at time $t + 90$ guarantee:

CAD 300M * **.8493 USD/CAD** = **USD 254,790,000**

Example (continuation):

3. Money Market

At t, Iris Oil takes the following three steps, simultaneously:

1) Borrow from Canadian bank at **2.03%** for 90 days :

CAD 300M / [1 + **.0203** * (90/360)] = **CAD 298,485,188**.

2) Convert to USD at S_t:

CAD 298,485,188 * **0.8451 USD/CAD** = **USD 252,249,832**

3) Deposit in US bank at **3.92%** for 90 days to guarantee at time t+90:

USD 252,249,832 * [1 + **.0392** * (90/360)] = **USD 254,721,880**.

Note: Both the FH and the MMH guarantee certainty at time t+90

FH delivers to Iris Oil: **USD 254,790,000**

MMH delivers to Iris Oil: **USD 254,721,880**

⇒ Iris Oil selects the FH. (MMH is a *dominated* strategy.)

Example (continuation):

4. Option Market

At t, buy a **put**. Available 90-day options:

X	Calls	Puts
.82 USD/CAD	----	0.21
.84 USD/CAD	1.58	**0.68**
.88 USD/CAD	**0.23**	----

Buy the **.84 USD/CAD put** ⇒ Total premium cost of **USD 2.04M**.

Position	Initial CF	Cash flows at t+90	
		S_{t+90} < .84 USD/CAD	S_{t+90} > .84 USD/CAD
Option (HP)	**USD 2.04M**	(.84 – S_{t+90}) * **CAD 300M**	0
Underlying (UP)	0	S_{t+90} * **CAD 300M**	S_{t+90} * **CAD 300M**
Total CF	**USD 2.04M**	USD 252M	S_{t+90} CAD 300M

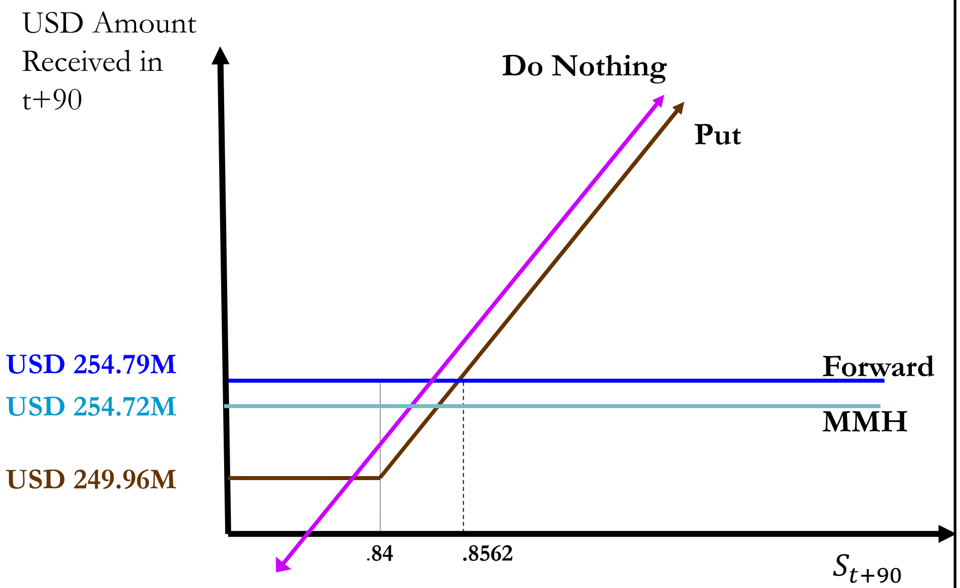
Net CF at $t + 90$:

USD 249,960,000 for $S_{t+90} < .84$ **USD/CAD**

or S_{t+90} * **CAD 300M** – **USD 2.04M** for $S_{t+90} > .84$ **USD/CAD**

Example (continuation):

• Let's plot all strategies:



Example (continuation): Companies do not like paying premiums.

5. Collar

At time t, *buy* a **put** and *sell* a **call**.

Buy **.84** put at **USD 0.0068**

Sell **.88** call at **USD 0.0023**. ⇒ Initial cost = **USD 0.0045** per collar

⇒ Total cost: **USD 1.35M**

Position	Initial CF	Cash flows at t+90		
		S_{t+90} < .84	.84 < S_{t+90} < .88	S_{t+90} > .88
Put	**USD 2.04M**	(.84 – S_{t+90}) * **CAD 300M**	0	0
Call	**-USD 0.69M**	0	0	(.88 – S_{t+90}) * **CAD 300M**
UP	**0**	S_{t+90} * **CAD 300M**	S_{t+90} * **CAD 300M**	S_{t+90} * **CAD 300M**
Total CF	**USD 1.35M**	USD 252M	S_{t+90} CAD 300M	USD 264M

Net CF at $t + 90$:

USD 250.65M for S_{t+90} < **.84 USD/CAD**

or S_{t+90} **CAD 300M – USD 1.35M** for **.84 USD/CAD** < S_{t+90} < **.88 USD/CAD**

or USD 262.65M for S_{t+90} > **.88 USD/CAD**

Note: This collar reduces the upside: establishes a floor and a cap.

Example (continuation):

***6. Alternative: Zero cost insurance*:**

At time t, *buy* puts and *sell* calls with overall (or ≈) matching premium.

Buy **.84 put**

Sell **3 .88 calls**. ⇒ Initial cost ≈ 0 (actually, a small profit. We'll ignore it).

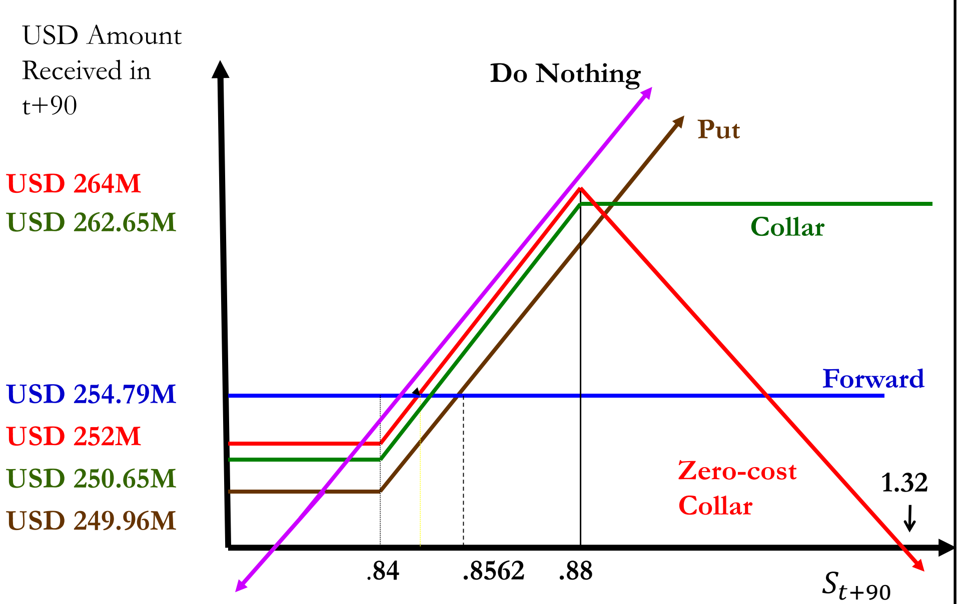
Position	**Cash flows at t+90**		
	S_{t+90} < .84	.84 < S_{t+90} < .88	S_{t+90} > .88
Put	(.84 – S_{t+90}) * **CAD 300M**	0	0
3 Calls	0	0	3 * (.88 – S_{t+90}) * **CAD 300M**
UP	S_{t+90} * **CAD 300M**	S_{t+90} * **CAD 300M**	S_{t+90} * **CAD 300M**
Total CF	USD 252M	S_{t+90} CAD 300M	USD 792M–2*S_{t+90} CAD 300M

Net CF at t + 90:

	USD 252M	for all S_{t+90} < .84 USD/CAD
or	S_{t+90} **CAD 300M**	for .84 USD/CAD < S_{t+90} < .88 USD/CAD
or	USD 792 M – 2 S_{t+90} **CAD 300M**	for all S_{t+90} > .88 USD/CAD

Example (continuation):

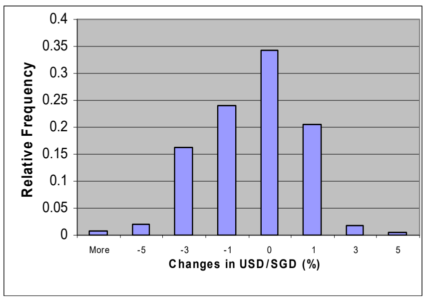
Let's plot all strategies:

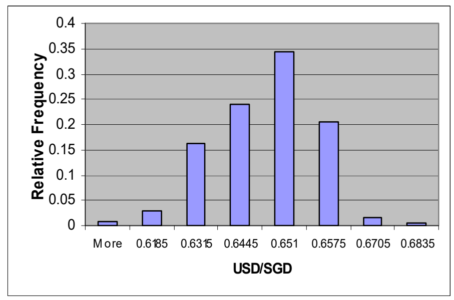


• Optimal Hedging Strategies?

Q: Which strategy is better? We need to say something about S_{t+90}. For example, we can assume a distribution (normal) or use the ED to say something about future changes in S_t.

Example: Suppose we have a **receivable in SGD** in 30 days. We can use the **distribution** for monthly USD/SGD changes from the past 30 years. Then, we get the distribution for S_{t+30} (USD/SGD).





Example (continuation): Distribution of monthly USD/SGD changes from past 30 years. Raw data & relative frequency for S_{t+30} (USD/SGD).

s_t (SGD/USD)	*Frequency*	*Rel frequency*	$S_t = 1/.65*(1+s_t)$	
-0.0494 or less	2	0.0058	1.462	0.6838
-0.0431	2	0.0058	1.472	0.6793
-0.0369	1	0.0029	1.482	0.6749
-0.0306	3	0.0087	1.491	0.6705
-0.0243	6	0.0174	1.501	0.6662
-0.0181	20	0.0580	1.511	0.6620
-0.0118	36	0.1043	1.520	0.6578
-0.0056	49	0.1420	1.530	0.6536
0.0007	86	**0.2493**	1.540	**0.6495**
0.0070	52	0.1507	1.549	0.6455
0.0132	41	0.1188	1.559	0.6415
0.0195	29	0.0841	1.568	0.6376
0.0258	5	0.0145	1.578	0.6337
0.0320	7	0.0203	1.588	0.6298
0.0383	5	0.0145	1.597	0.6260
0.0446	0	0.0000	1.607	0.6223
0.0508 or +	3	0.0058	1.617	0.6186

• Examples assuming an explicit distribution for S_{t+T}

Example – Receivables: Evaluate (1) FH, (2) MMH, (3) OH & (4) NH.

Cud Corp will receive **SGD 500,000** in 30 days. (SGD Receivable.)

Data:

- S_t = **.6500 - .6507 USD/SGD**.
- $F_{t,30}$ = **.6510 - .6519 USD/SGD**.
- 30-day interest rates: i_{SGD}: **2.65% - 2.75%** & i_{USD}: **3.20% - 3.25%**
- A 30-day put option on SGD: **X = .65 USD/SGD** and P_t= **USD.01**.
- Forecasted S_{t+30}:

Possible Outcomes	Probability
USD .63	18%
USD .64	24%
USD .65	34%
USD .66	21%
USD .68	3%

(1) FH: Sell SGD 30 days forward

USD received in 30 days = Receivables in SGD * $F_{t,30}$

= **SGD 500,000** * **.651 USD/SGD** = **USD 325,500**.

(2) MMH:

- Borrow SGD at **2.75%** for 30 days,
- Convert to USD at **.65 USD/SGD,**
- Deposit USD at **3.2%** for 30 days,
- Repay SGD loan in 30 days with SGD 500,000 receivable

Amount to borrow = **SGD 500,000**/(1 + **.0275** * 30/360) =

= SGD 498,856.79

Convert to USD (Amount to deposit in U.S. bank) =

= SGD 498,856.79 * **.65 USD/SGD** = USD 324,256.91

Amount received in 30 days from U.S. bank deposit =

= USD 324,256.91 * (1 + **.032** * 30/360) = **USD 325,121.60**

(3) OH: Purchase put option. **X = .65 USD/CHF**
P_t = premium = **USD .01**

Possible S_{t+30}	Premium per SGD + Op Cost	Exercise?	Net USD Received for SGD 0.5M	Prob
.63 USD/SGD	USD .010027	Yes	**USD 319,986.5**	18%
.64 USD/SGD	USD .010027	Yes	**USD 319,986.5**	24%
.65 USD/SGD	USD .010027	No	**USD 319,986.5**	34%
.66 USD/SGD	USD .010027	No	**USD 324,986.5**	21%
.68 USD/SGD	USD .010027	No	**USD 334,986.5**	3%

Note: In the Total Amount Received (in USD) we have subtracted the *opportunity cost* involved in the upfront payment of a premium:

USD .01 * **.032** * 30/360 = **USD .000027** (Total = **USD 13.50**)

⇒ Total Premium Cost: **USD 5,013.50**

E[Amount Received in USD] = **319,986.5** * .76 + **324,986.50** * .21 + + **334,986.50** * .03 = **USD 321,486.5**

(4) No Hedge (NH): Sell **SGD 500,000** in the spot market in 30 days.

Possible S_{t+30}	USD Received for SGD 0.5M	Probability
.63 USD/SGD	USD 0.315M	18%
.64 USD/SGD	USD 0.320M	24%
.65 USD/SGD	USD 0.325M	34%
.66 USD/SGD	USD 0.330M	21%
.68 USD/SGD	USD 0.340M	3%

Note: When we compare (1) to (4), it's not clear which one is better. Preferences will matter. We can calculate and expected value:

E[Amount Received in USD] = 315K * .18 + 320K * .24 + 325K * .34+ + 330K * .21 + 335K * . 03 = **USD 323,500**

Conclusion: Cud Corporation is likely to choose the FH. But, risk preferences matter. ¶

Example – Payables: Evaluate (1) FH, (2) MMH, (3) OH, (4) No Hedge

Situation: Cud Corp needs **CHF 100,000** in 180 days. (CHF Payable.)

Data:

- **S_t = .675 - .680 USD/CHF.**
- **$F_{t,180}$ = .695 - .700 USD/CHF.**
- 180-day interest rates are as follows:
  i_{CHF}: **9% - 10%;**
  i_{USD}: **13% - 14.0%**
- A 180-day call option on CHF: **X = .70 USD/CHF** and P_t = **USD.02**.

- Cud forecasted S_{t+180}:

Possible Outcomes	Probability
USD .67	30%
USD .70	50%
USD .75	20%

(1) FH: Purchase CHF 180 days forward
USD needed in 180 days = Payables in CHF x $F_{t,180}$
= **CHF 100,000** * **.70 USD/CHF** = **USD 70,000**.

(2) MMH:
- Borrow USD at **14%** for 180 days,
- Convert to CHF at **.680 USD/CHF** ,
- Invest CHF at **9%** for 180 days,
- Repay USD loan in 180 days & transfer CHF deposit to cover payable

Amount in CHF to be invested = **CHF 100,000**/(1 + **.09** * 180/360)
= **CHF 95,693.78**

Amount in USD needed to convert into CHF for deposit =
= **CHF 95,693.78** * **.680 USD/CHF** = **USD 65,071.77**

Interest and principal owed on USD loan after 180 days =
= **USD 65,071.77** * (1 + **.14** * 180/360) = **USD 69,626.79**

(3) OH: Purchase call option. X = .70 USD/CHF
C_t = premium = **USD .02**.

Possible S_{t+180}	**Premium per CHF + Op Cost**	**Exercise?**	**Net Paid for CHF 0.1M**	**Prob**
.67 USD/SGD	USD .0213	No	USD 69,130	30%
.70 USD/SGD	USD .0213	No	USD 72,130	50%
.75 USD/SGD	USD .0213	Yes	USD 72,130	20%

Note: In the Total USD Cost we have included the opportunity cost involved in the upfront payment of a premium = **USD 130**.

E[Amount to Pay in USD] = **USD 71,230**

• *Preferences matter*: A risk taker may like the 30% chance of doing better with the OH than with the MMH.

(4) Remain Unhedged: Purchase **CHF 100,000** in 180 days.

Possible S_{t+180}	**Net Paid for CHF 0.1M**	**Probability**
.67 USD/SGD	USD 67,000	30%
.70 USD/SGD	USD 70,000	50%
.75 USD/SGD	USD 75,000	20%

Preferences matter: Again, a risk taker may like the **30% chance** of doing better with the NH than with the MMH. (Actually, there is also an additional 50% chance of being very close to the MMH.)

E[Amount to Pay in USD] = **USD 70,100**

Conclusion: Cud Corporation is likely to choose the MMH. ¶

Internal Methods

• These are hedging methods that do not involve financial instruments.

• **Risk Shifting**

Q: Can firms completely avoid FX exposure?

A: Yes! By **pricing** all foreign transactions in **domestic currency**.

Example: Bossio Co., a U.S. firm, sells naturally colored cotton. Asuni, a Japanese company, buys Bossio's cotton. Bossio Co. prices all exports in USD. ¶

⇒ Currency risk is not eliminated. The foreign company bears it.

• Problem with risk-shifting: Reduces firm flexibility.

• **Currency Risk Sharing**

Two parties agree -with a customized hedge contract- to **share** the **FX risk** in a transaction.

Example: Asuni buys cotton for **USD 1 million** from Bossio Co.

Risk Sharing agreement:

• If S_t ∈ [**100 JPY/USD**; **140 JPY/USD**] ⇒ Transaction unchanged. (Asuni pays **USD 1 M** to Bossio Co.)

• If S_t< **100 JPY/USD** or S_t>**140 JPY/USD** ⇒ parties share risk equally

Suppose that when Asuni has to pay Bossio Co., **S_t = 180 JPY/USD**.
Then, settlement S_t= 160 JPY/USD (= **180** - **40**/2).

Asuni's final cost = JPY 160 million = USD 888,889 < **USD 1M**.

Note: Range where the transaction is unchanged is called *neutral zone*. ¶

• **Leading and Lagging (L&L)**
Firms can reduce FX exposure by **accelerating** or **decelerating the timing** of payments that must be made in different currencies:

⇒ ***Leading*** or ***Lagging*** the movement of funds.

L&L is done between the parent company and its subsidiaries or between two subsidiaries.

Example: Parent company: HAL (U.S. company).
Subsidiaries: Mexico, Brazil, and Hong Kong.
HAL Hong Kong's exposure is too large.
HAL orders HAL Mexico and HAL Brazil to accelerate (*lead*) payments to HAL Hong Kong. ¶

• L&L changes assets/liabilities in one firm, with reverse effect on the other firm.

⇒ L&L changes balance sheet positions.

Might be a good tool for achieving a hedged balance sheet position.

• **Funds Adjustments**
Key to hedging:
Match inflows & **outflows** denominated in the FC.

Chinese subsidiary in U.S. with **CF>0** in USD	Italian subsidiary in U.S. with **CF <0** in USD
Increase USD purchases	Decrease USD purchases
Decrease CNY purchases	Increase EUR purchases
Decrease USD sales	Increase USD sales
Increase CNY sales	Decrease EUR sales
Increase USD borrowing	Reduce USD borrowing
Reduce CNY borrowing	Increase EUR borrowing

Example: Japanese and German carmakers have built plants in the U.S.

Economic Exposure

Economic exposure (EE): Risk associated with a change in the NPV of a firm's expected cash flows, due to an *unexpected* change in S_t.

Note: S_t is very difficult to forecast. Actual change in S_t can be considered "unexpected."

• General definition: It can be applied to any firm (domestic, MNC, exporting, importing, purely domestic, etc.).

• The degree of EE depends on:
- Type & structure of the firm
- Industry structure in which the firm operates.

• In general:
- **Importing** & **exporting** firms face higher EE than purely domestic firms
- **Monopolistic** firms face lower EE than firms that operate in competitive markets.

Example: A U.S. firm face almost no competition in domestic market. Then, it can transfer to prices almost any increase of its costs due to changes in S_t. Thus, this firm faces no/low EE. ¶

• The degree of EE for a firm is an empirical question.

• Economic exposure is difficult to measure.

• We can use *accounting data* (EAT changes) or *financial/economic data* (returns) to measure EE. Economists like economic-based measures.

Measuring Economic Exposure

A Measure Based on Accounting Data

We use cash flows to estimate FX exposure. For example, we simulate a firm's **CFs** (EBT, Operating Income, etc.) **under several FX scenarios**.

Example: IBM HK provides the following info:

Sales and cost of goods are dependent on S_t:

	S_t = 7 HKD/USD	S_t = 7.70 HKD/USD
Sales (in HKD)	300M	400M
Cost of goods (in HKD)	150M	200M
Gross profits (in HKD)	150M	200M
Interest expense (in HKD)	20M	20M
EBT (in HKD)	**130M**	**180M**

Example (continuation):

A **10% depreciation** of the HKD **increases** HKD CFs from **HKD 130M** (=**USD 18.57M**) to **HKD 180M** (=**USD 23.38M**): A **25.92%** change in CFs measured in USD.

Q: Is EE **significant**?

A: We can calculate the elasticity of CF to changes in S_t:

$$\textbf{CF elasticity} = \frac{\%\text{ change in EBT}}{\%\text{ change in } S_t} = \frac{.2592}{.10} = 2.59$$

Interpretation: We say, a 1% depreciation of the HKD produces a change of **2.59%** in EBT. Quite significant. But the change in exposure is **USD 4.81M**. This amount may not be significant for IBM (*Judgment call* needed.)

IBM HK behaves like a net exporter: Weaker DC, Higher CFs. ¶

Note: Firms will simulate many scenarios & produce an expected value.

We can use historical accounting cash flows to calculate economic exposure.

Example: Kellogg's cash flow elasticity in 2020-2019.

From 2019 to 2020 (end-of-year to end-of-year), K's operating income increased **2.6%**. The USD depreciated against basket of major currencies by **3.58%**. Then,

$$\textbf{CF elasticity} = \frac{.026}{.0358} = \mathbf{0.73}$$

Interpretation: We say, a 1% depreciation of the USD produces a positive change of **0.73%** in operating income. K's behaves like a **net exporter**. ¶

A Regression based Measure and a Test

CF elasticity gives us a measure, but it is not a test of EE. A judgment call is needed.

It is easy to **test** regression coefficients (t-tests or F-tests).

• Simple steps:

(1) Get data: CF_t & S_t (available from the firm's past)

(2) Estimate regression:

$$\Delta CF_t = \alpha + \beta\, \Delta S_t + \varepsilon_t,$$

⇒ β: Sensitivity of ΔCF_t to ΔS_t.

⇒ The higher β, the greater the impact of ΔS_t on CF_t.

(3) Test for EE ⇒ H_0 (no EE): $\beta = 0$

H_1 (EE): $\beta \neq 0$

(4) Evaluation of this regression: t-statistic of ß and R^2.

Rule: $|t_\beta = \beta/SE(\beta)| > \mathbf{1.96}$ ⇒ β is significant at the 5% level.

A Regression based Measure and a Test

In general, regression is done in terms of % changes:

$$cf_t = \alpha + \beta\, s_t + \xi_t,$$

cf_t: % change in CF from t-1 to t.

Interpretation of β: A 1% change in S_t changes the CF_t by β%.

• Expected Signs

We estimate the regression from a Domestic (say, U.S.) firm's point of view: CF measured in DC (say, USD & S_t is USD/FC). Then, from the regression, we can derive the Expected sign (β):

Type of company	Expected sign for β
U.S. Importer	Negative
U.S. Exporter	Positive
Purely Domestic	Depends on industry

• Other variables also affect CFs: Investments, acquisitions, growth of the economy, etc.

We "*control*" for the other variables that affect CFs with a multivariate regression, say with k other variables:

$$cf_t = \alpha + \beta\, s_t + \delta_1 X_{1,t} + \delta_2 X_{2,t} + \ldots + \delta_k X_{k,t} + \varepsilon_t,$$

where $X_{k,t}$ represent one of the k^{th} other variables that affects CFs.

Note: Sometimes the impact of ΔS_t is not felt immediately.

⇒ contracts and short-run costs matter.

Example: For an exporting U.S. company a sudden appreciation of the USD increases CF in the short term. Solution: use a modified regression:

$$cf_t = \alpha + \beta_0\, s_t + \beta_1\, s_{t-1} + \beta_2\, s_{t-2} + \ldots + \beta_q\, s_{t-q} + \delta_1 X_{1,t} + \ldots + \varepsilon_t.$$

Sum of ß's: Total sensitivity of cf_t to s_t $(= \beta_0 + \beta_1 + \beta_2 + \beta_3 + \ldots)$

A Measure Based on Financial Data

Accounting data can be manipulated. Moreover, international comparisons are difficult. Instead, use financial data: Stock prices!

We can easily measure how returns and ΔS_t move together: *correlation*.

Example: Kellogg's and IBM's EE.

Using monthly stock returns for Kellogg's ($r_{K,t}$) and monthly changes in S_t (USD/EUR) from **33 years** (**1988:Jan** – **2022:Jan**), we estimate $\boldsymbol{\rho_{K,s}}$ (correlation between $r_{K,t}$ & s_t) = **0.150**. It looks small.

We do the same exercise for IBM, measuring the correlation between $r_{IBM,t}$ & s_t, obtaining $\boldsymbol{\rho_{IBM,s}}$= **0.089**, small and, likely, close to zero.

But, if we use USD/TWC, based on the major currencies, things change a bit: $\boldsymbol{\rho_{K,s}}$ = **0.1263** (similar to USD/EUR) & $\boldsymbol{\rho_{IBM,s}}$= **0.1795** (different). ¶

An Easy Measure of EE Based on Financial Data

• Better measure: A regression-based measure that can be used as a test.

Steps:

1) Regress, r_t, returns against (unexpected) ΔS_t.

$$r_t = \alpha + \beta\, s_t + \varepsilon_t$$

2) Check statistical significance of regression coefficient for s_t:

H_0 (No EE): $\beta = 0$.

H_1 (EE): $\beta \neq 0$.

⇒ A simple t-test can be used to test H_0.

Interpretation: A 1% change in S_t changes the Value of the firm by β%.

Example: Kellogg's EE.

Using **1988-2022** data (see previous example), we run the regression:

$$r_{K,t} = \alpha + \beta\, s_t \text{ (USD/TWC)} + \varepsilon_t$$

R^2 = 0.01596

Standard Error = 5.56447

Observations = 409

	Coefficients	*Standard Error*	*t-stat*	*P-value*
Intercept (α)	0.38592	0.27515	1.4026	0.1615
s_t (β)	**0.43775**	**0.17041**	**2.5688**	0.0106

Analysis: Reject H_0, $|t_\beta = \mathbf{2.57}| > \mathbf{1.96}$ (significantly ≠ 0) ⇒ EE!

β > 0, K behaves likes an exporter.

Interpretation of **β**: A 1% increase in exchange rates, increases K's returns by **0.44%**.

Note: R^2 is very low! ¶

Example: IBM's EE.

Now, using the IBM data (**1988-2022**), we run the regression:

$$r_{IBM,t} = \alpha + \beta\, s_t \text{ (USD/TWC)} + \varepsilon_t$$

R^2 = 0.03221

Standard Error = 7.4465

Observations = 409

	Coefficients	*Standard Error*	*t-stat*	*P-value*
Intercept (α)	0.38896	0.36821	1.0563	0.2914
s_t (β)	**0.83941**	0.22805	**3.6809**	0.0003

Analysis: Reject H_0, $|t_\beta = \mathbf{3.68}| > \mathbf{1.96}$ (significantly ≠ 0) ⇒ EE!

β > 0, DIS behaves likes an exporter.

Interpretation of **β**: A 1% increase in exchange rates, increases DIS's returns by **0.84%**.

Again, the R^2 is low! ¶

• Returns are not only influenced s_t. In investments, it is common to use the 3 factors from the **Fama-French models** to model stocks returns:

- **Market** ($[r_M - r_f]$)
- **SMB** (size)
- **HML** (value).

In Kellogg's case:

$$r_{K,t} = \alpha + \gamma_1 (r_M - r_f)_t + \gamma_2 SMB_t + \gamma_3 HML_t + \varepsilon_t$$

A momentum can be added to accommodate Carhart's (1997) model.

Note: In general, we find γ_1 & γ_3 significant. R^2 is not very high.

• Now, we test if Kellogg's faces EE, *conditioning* on the other drivers of K's returns. That is, we do a t-test on β on the following regression:

$$r_{K,t} = \alpha + \gamma_1 (r_{Mar} - r_f)_t + \gamma_2 SMB_t + \gamma_3 HML_t + \beta s_t + \varepsilon_t$$

Example (continuation): Kellogg's EE (with 3 FF factors):

	Coefficients	Std Error	t-stat
Intercept	0.0798	0.2691	0.2967
Market ($R_m - R_f$)	0.3893	0.0647	6.0204
Size (SMB)	-0.1144	0.0898	-1.2738
B-M (HML)	0.1546	0.0851	1.8157
s_t (β)	**0.2601**	0.1664	**1.5633**

$R^2 = 0.0995$ (a higher value driven mainly by the market factor).

Now, t-stat = 1.56 (*p-value* = .119). We say:

"After controlling for other factors that affect Kellogg's excess returns, we do not find evidence of EE at the 5% significance level."

⇒ Usual interpretation: No EE for K.

We also see a lower sensitivity, β: **0.2601**. ¶

Example (continuation): IBM's EE (with 3 FF factors):

	Coefficients	Std Error	t-stat
Intercept	-0.2894	0.3180	-0.9102
s_t (β)	**0.3963**	0.1966	**2.0157**
Market ($R_m - R_f$)	0.9506	0.0764	**12.4363**
Size (SMB)	-0.2557	0.1062	**-2.4085**
B-M (HML)	-0.1154	0.1006	-1.1471

$R^2 = 0.3092$.

The t-stat = **2.01** (*p-value* = .045).

⇒ Usual interpretation: IBM faces EE.

Again, we see a big reduction in lower sensitivity, β: **0.3963**. ¶

EE: Evidence

The above regression (for K) has been done for firms around the world.

Results from work by Ivanova (2014):

- Mean β = **0.57** (a 1% USD depreciation increases returns by 0.57%).
- But, only **40%** of the EE are *statistically significant* at the 5% level.
- For large firms (MNCs), EE is small –average β = **0.063**– & **not significant** at the 5% level.
- **52%** of the EEs come from U.S. firms that have **no international transactions** (a higher S_t "*protects*" these domestic firms).

Summary:

- On average, large companies (MNCs, Fortune 500) face no EE.
- EE is a problem of small and medium, undiversified firms.

EE: Evidence

• Check Ivanova's results for big firms, using the **S&P 100**.

We regress SP100 returns from past **38 years** (**1984:Apr** – **2022:Jan**) against s_t (USD/TWC) & the 3 FF factors:

R^2 = 0.9664

Standard Error = 0.8136

Observations = 454

	Coefficients	Std Error	t-stat	P-value
Intercept	-0.0247	0.0389	-0.6357	0.5253
s_t	**-0.0225**	0.0231	**-0.9756**	0.3298
Market - r_f	0.9988	0.0090	110.5233	>.00001
SMB	-0.2459	0.0133	-18.4659	>.00001
HML	0.0068	0.0126	0.5381	0.5907

Since $|t_\beta = -0.98| < 1.96$ ⇒ No evidence of EE for big U.S. firms.

CASE 2 – Hedging TE (Payable)

• Two parts – **Group assignment** (DW's hedging problem)
– **Class assignment**

• Group assignment

DW ordered Japanese parts valued at **JPY 200M**.

Payment: Delivery usually takes two months. Payment is due within **30 days** of delivery (*tentative* delivery payment date **April 17**).

PART I

Today: **December 6**, DW evaluates risk & hedging strategies.

- Risk evaluation: Construct Ranges, VaR
- Hedging strategies: Options, & Forwards.

• Group assignment (continuation)

PART II

Today: **May 6**. Parts arrived on April 11. Payment is due in five days (**May 11**). Evaluate cost of different hedging strategies.

• Class assignment

Get JPY/USD FX rate data from my homepage (**database2.xlsx**).

◊ Evaluate Risk, with **10 years of data** (adjust monthly frequency to **5-mo**):

- Construct a VaR (97.5%) assuming a Normal distribution
- Worst/Best Case Scenarios
- Construct a VaR (97.5%) using a simulation

◊ On **December 6, 2012**, you do a 6-mo futures hedge. DW buys the JPY Dec futures contract. Value this contract on **May 6, 2013**.

◊ On **December 6, 2012**, you do a 6-mo MM hedge. Calculate the cost on **May 6, 2013**. (Need to discount CFs back to May 6, 2013.)