Paul Krugman: "The world economy has turned out to be a much more dangerous place than we imagined."
Outline  Risk management is a four steps process

- Identification of risks and their causes
- Estimate likelihood and impact of risks
- Quantitative vs. qualitative
- Continuous monitoring of risks and actions to control them
- Actions and mechanisms to minimize risks
- Risk acceptance
Definition

- Risk may be defined as “exposure to uncertainty”

Three generic categories of risk:

- Credit risk
- Operational risk
- Market risk
  - Interest Rate Risk,
  - Exchange Rate Risk,
  - Commodities Price risk
  - Equity Price Risk.
Definition

- Exchange rate risk is defined as the variability of a firm’s value due to uncertain changes in the rate of exchange.
- Exposure refers to the degree to which a company is affected by exchange rate changes.
- The effect of unexpected exchange rate changes on the value of the firm.
- The possible direct loss (as a result of an unhedged exposure) or indirect loss in the firm’s cash flows, assets and liabilities, net profit and, in turn, its stock market value from an exchange rate move.
Main types of exchange rate risk

- Although exchange rates cannot be forecasted with perfect accuracy, firms can at least measure their exposure to exchange rate fluctuations.

  1. Transaction risk
  2. Translation risk
  3. Economic risk
Transaction risk

- which is basically cash flow risk and deals with the effect of exchange rate moves on transactional account exposure related to receivables (export contracts), payables (import contracts) or repatriation of dividends.

- The risk that the local currency value of foreign currency receipts will fall or that the local value of foreign currency payments will rise between the fixing of a contract and the date of payment or receipt.

- An exchange rate change in the currency of denomination of any such contract will result in a direct transaction exchange rate risk to the firm.
Transaction risk

- This risk is encountered across many sectors: from manufacturers, through the travel industry to universities with foreign students. It is at its most significant in the case of cross-border acquisitions.

- To measure transaction exposure:
  - project the net amount of inflows or outflows in each foreign currency, and
  - determine the overall risk of exposure to those currencies.
Transaction risk Example

- An MNC’s overall exposure can be assessed by considering each currency position together with the currency’s variability and the correlations among the currencies.

- The standard deviation statistic on historical data serves as one measure of currency variability. Note that currency variability levels may change over time.

- The correlations among currency movements can be measured by their correlation coefficients, which indicate the degree to which two currencies move in relation to each other.
Translation risk

- encountered by businesses with overseas assets, liabilities or income streams: the requirement to translate the value of overseas assets and liabilities into the accounting currency at the end of an accounting period creates the risk that the balance sheet value of assets denominated in foreign currency will fall or that the value of liabilities will rise from one year to the next.

- Is basically balance sheet exchange rate risk and relates exchange rate moves to the valuation of a foreign subsidiary and, in turn, to the consolidation of a foreign subsidiary to the parent company’s balance sheet. Translation risk for a foreign subsidiary is usually measured by the exposure of net assets (assets less liabilities) to potential exchange rate moves. In consolidating financial statements, the translation could be done either at the end-of-the-period exchange rate or at the average exchange rate of the period, depending on the accounting regulations affecting the parent company.
Does Translation Exposure Matter?

- **Cash Flow Perspective** - Translating financial statements for consolidated reporting purposes does not by itself affect an MNC’s cash flows.

- However, a weak foreign currency today may result in a forecast of a weak exchange rate at the time subsidiary earnings are actually remitted.

- **Stock Price Perspective** - Since an MNC’s translation exposure affects its consolidated earnings and many investors tend to use earnings when valuing firms, the MNC’s valuation may be affected.
Translation Exposure

- An MNC’s degree of translation exposure is dependent on:
  - the proportion of its business conducted by its foreign subsidiaries,
  - the locations of its foreign subsidiaries, and
  - the accounting method that it uses.
Measuring Translation Exposure

- The difference between exposed assets and exposed liabilities.
  - Exposed assets and liabilities are translated at the current exchange rate.
  - Non-exposed assets and liabilities are translated at the historical exchange rate.
Translation Methods

- Two basic methods for the translation of foreign subsidiary financial statements:
  - The current rate method
  - The temporal method
- Regardless of which is used, either method must designate
  - The exchange rate at which individual balance sheet and income statement items are remeasured
  - Where any imbalances are to be recorded
Current Rate Method

- All financial statement items are translated at the “current” exchange rate.
  - Assets & liabilities
  - Income statement items
  - Dividends
  - Equity account

- Unrealized translation gains or losses are recorded in a separate equity account on the parent’s consolidated balance sheet called the “Cumulative Translation Adjustment (CTA)” account.
Temporal Method

- Specific assets and liabilities are translated at exchange rates consistent with the timing of the item’s creation.
  - It assumes that a number of line items such as inventories and net plant and equipment are restated to reflect market value.
  - If these items were not restated and carried at historical costs, then the temporal method becomes the monetary/non-monetary method.
Temporal Method

- Line items included in this method are
  - Monetary balance sheet items
  - Non-monetary balance sheet items
  - Income statement items
  - Dividends
  - Equity account

- Unrealized translation gains or losses are recorded within the income statement, not to equity reserves, thereby affecting net income.
Economic risk

- Is the risk that adverse currency movements will affect the customer’s core business, rather than an individual transaction. This risk reflects basically the risk to the firm’s present value of future operating cash flows from exchange rate movements. In essence, economic risk concerns the effect of exchange rate changes on revenues (domestic sales and exports) and operating expenses (cost of domestic inputs and imports). Economic risk is usually applied to the present value of future cash flow operations of a firm’s parent company and foreign subsidiaries.
Economic risk

- With increasing globalization, capital moves quickly to take advantage of changes in exchange rates. Devaluations of foreign currencies can lead to increased competition in both overseas and domestic markets. Economic risk is the most crucial to hedge but is rarely addressed. For example, after sterling’s expulsion from the ERM in September 1992, the pound’s relative weakness dramatically improved trading conditions for British exporters. Unfortunately, if something is too good to be true, it usually is, and the advantage was short-lived. By April 1997, sterling had regained 2.7780 against the German Mark - the bottom of the old ERM band. Clearly, substantial advantage could have been gained by an appropriate hedging strategy.
Economic risk

- One measure of economic exposure involves classifying the firm’s cash flows into income statement items, and then reviewing how the earnings forecast in the income statement changes in response to alternative exchange rate scenarios.

- In general, firms with more foreign costs than revenues will be unfavorably affected by stronger foreign currencies.

- Another method of assessing a firm’s economic exposure involves applying regression analysis to historical cash flow and exchange rate data.
Economic risk

- $PCF_t = a_0 + a_1 e_t + \varepsilon_t$
  - $PCF_t = \% \text{ change in inflation-adjusted cash flows measured in the firm's home currency over period } t$
  - $e_t = \% \text{ change in the currency exchange rate over period } t$

- The regression model may be revised to handle multiple currencies by including them as additional independent variables, or by using a currency index (composite).

- By changing the dependent variable, the impact of exchange rates on the firm’s value (as measured by its stock price), earnings, exports, sales, etc. may also be assessed.
Impact of Exchange Rate Exposure on firm Value

\[
\text{Value} = \sum_{t=1}^{n} \left\{ \sum_{j=1}^{m} \left[ \underbrace{E\left(\text{CF}_{j,t}\right)}_{\text{Transaction Exposure}} \times E\left(\text{ER}_{j,t}\right) \right] \right\} \frac{1}{(1+k)^t}
\]

- $E\left(\text{CF}_{j,t}\right)$ = expected cash flows in currency $j$ to be received by the U.S. parent at the end of period $t$
- $E\left(\text{ER}_{j,t}\right)$ = expected exchange rate at which currency $j$ can be converted to dollars at the end of period $t$
- $k$ = weighted average cost of capital of the parent
Conclusion

- Many situations typically involve more than one of the above risks. For example, a UK-based manufacturer with a US subsidiary may face transaction risk on its exports to Europe; translation risk on the sterling value of its US plant and the associated profit remittances; and the economic risk of a weaker Euro enabling foreign competition to enter its US and UK markets.

- Moreover, indirect risks might include, for instance, the differing impact that a movement in foreign exchange parities could have on an overseas-based competitor in becoming more competitive than our client.
Hedging

- Entering into an offsetting currency position so whatever is lost/gained on the original currency exposure is exactly offset by a corresponding currency gain/loss on the currency hedge.

- The coordinated buying or selling of a currency to minimize exchange rate risk.
Measurement of Exchange Rate Risk
Measurement of Exchange Rate Risk

- Measuring currency risk may prove difficult, at least with regards to translation and economic risk. At present, a widely used method is the value-at-risk (VaR) model.

- The VaR methodology can be used to measure a variety of types of risk, helping firms in their risk management.

- The VaR measure of exchange rate risk is used by firms to estimate the riskiness of a foreign exchange position resulting from a firm’s activities, including the foreign exchange position of its treasury, over a certain time period under normal conditions.
Definition of Value at Risk (VaR)

- VaR is an estimate of the worst possible loss (i.e., the decrease in the market value of a foreign exchange position) an investment could realize over a given time horizon, under normal market conditions (defined by a given level of confidence).

**Daily VaR: What does it mean?**

- If the reported daily VaR (at 5% probability or 95% confidence level) is $6.6m then: Maximum amount I expect to lose on any one day, in 19 out of the next 20 days is $6.6m

- I expect to lose more than $6.6m only 1 day in every 20 days under normal market conditions (i.e. 5% of the time)
Value at Risk (VaR)

The VaR calculation depends on 3 parameters:

- • The holding period, i.e., the length of time over which the foreign exchange position is planned to be held. The typical holding period is 1 day.
- • The confidence level at which the estimate is planned to be made. The usual confidence levels are 99 percent and 95 percent.
- • The unit of currency to be used for the denomination of the VaR.

As proposed by the Basle Committee on Banking Supervision, banks are now allowed to calculate capital requirements for their trading books and other involved risks based on a VaR concept (Basle, 1995) and (Basle, 1996) and in Basel committee VaR is recognized as the most comprehensive benchmark for risk measurement.
“We are X percent certain that we will not lose more than V dollars in the next N days.” – Hull

Thus, if the foreign exchange position has a 1-day VaR of $10 million at the 99 percent confidence level, the firm should expect that, with a probability of 99 percent, the value of this position will decrease by no more than $10 million during 1 day, provided that usual conditions will prevail over that 1 day. In other words, the firm should expect that the value of its foreign exchange rate position would decrease by no more than $10 million on 99 out of 100 usual trading days, or by more than $10 million on 1 out of every 100 usual trading days.
Types of losses

1) **Expected loss**: statistical estimate of losses mean.

2) **Unexpected loss**: maximum loss at a specified tolerance.

3) **Extra loss**: somewhat higher than the maximum loss with very low probability.

- Value at risk is the unexpected loss, and tolerance level is the probability of loss occurrence that is more than the maximum of the predicted losses. Therefore, to obtain VaR it can be appropriate to focus on the left tail of the return distribution (loss distribution). So VaR is defined as the highest loss over a certain period of time at a given confidence level. Confidence level in VaR definition depends on risk aversion level of individuals involved with the issue.
Suppose $v$ is the value of an investment at the end of time horizon, so we define $v^*$ such that:

$$\text{prob}(v \leq v^*) = \int_{-\infty}^{v^*} dF(v) = 1 - c$$

- $c$ = confidence level and $F(v)$ = cumulative distribution function.
- So the investment's value with the probability of $1-c$ will be less than $v^*$. We just have to define a benchmark point so that the values less than the benchmark are considered as loss.
This is common to define losses associated with the previous value of investments ($v_0$) or the expected value of investment ($E(v)$), so VaR can be defined as:

$$\text{VaR}_{c,\Delta T}^{\text{Zero}} = v_0 - v^*$$

$$\text{VaR}_{c,\Delta T}^{\text{Mean}} = E(v) - v^*$$

Where $\Delta T$ is the time horizon, and Zero refers to the benchmark point ($v_0$) and Mean refers to the benchmark point ($E(v)$). This definition of VaR is shown in Figure.
confidence level – 95%

Normal market conditions: the returns that account for 95% of the distribution of possible outcomes.

Abnormal market conditions: the returns that account for the other 5% of the possible outcomes.
VaR Measurement Techniques

- Parametric VaR (also known as Linear VaR, Variance-Covariance VaR and ‘delta-normal’ approach)
- Historical Simulation + Bootstrapping
- Monte Carlo Simulation
Parametric Method

- is one of the basic and most straightforward techniques used in VaR measurement. The parametric approach assumes that currency returns on a firm’s total foreign exchange position are always (jointly) normally distributed (the distribution of returns and thus its probability density function is available) and that the change in the value of the foreign exchange position is linearly dependent on all currency returns.

- The approach is parametric in that it assumes that the probability distribution is Normal and then requires calculation of the variance and covariance parameters.

- The approach is linear in that changes in instrument values are assumed to be linear with respect to changes in risk factors.
In this equation, $F$ and $R$ represent the cumulative distribution function and the returns random variable respectively. With standard normal distribution transform we get:

$$\Phi(VaR) = P\left(Z < \frac{VaR - \mu}{\sigma}\right) = a$$

$$VaR = \mu + \sigma \cdot \Phi^{-1}(a)$$

In these equations, $Z$ represents the standard normal distribution variable, $\mu$ and $\sigma$ are mean and standard deviation of normal distribution and $\phi$ is the standard normal distribution function.
Parametric Method Example

- Mean return = 0 %
- Let \( \sigma_1 = 0.02 \) (per.day) (equivalent to 2% per day)
- Only 5% of the times will the loss be more than 3.3% (=1.65 x 2%)

- VaR of a single asset (Initial Position V1 = $200m in equities)
- \( \text{VaR}_1 = V1 \times 1.65 \times \sigma_1 = 200 \times 0.033 = $6.6m \)
- VaR is reported as a positive number (even though it’s a potential loss)
Can we express the above formula in terms of VaR of each individual asset?

Note:
Estimates/forecasts of $\sigma_i$ and $\rho$ required
Historical Simulation Method

- This is a non parametric method since we do not estimate any variances or covariances or assume normality, or independence over time. Like all statistical techniques HS does rely on ‘tomorrow’ being like ‘the past’. Or assumes that currency returns on a firm’s foreign exchange position will have the same distribution as they had in the past.

- is strongly backward-looking, meaning the firm is, in effect, protecting itself from the last crisis, but not necessarily preparing itself for the next.

- Conceptually, historical simulation is the most simple VaR technique, but it takes significantly more time to run than parametric VaR.
This involves running the firm’s current foreign exchange position across a set of historical exchange rate changes to yield a distribution of losses in the value of the foreign exchange position, say 1,000, and then computing a percentile (the VaR). Thus, assuming a 99 percent confidence level and a 1-day holding period, the VaR could be computed by sorting in ascending order the 1,000 daily losses and taking the 11th largest loss out of the 1,000 (since the confidence level implies that 1 percent of losses — 10 losses — should exceed the VaR).
Implementing historical simulation method for VaR measurement

1) Obtain historical data; the data must be long-term sufficiently
2) Adjust the simulated data (with weighting or etc.) to reflect current market conditions.
3) Fit the empirical distribution of adjusted data.
4) Derive the VaR for the relevant significance level and risk horizon.
‘Stylised’ Historic Simulation (daily data)

- Currently hold $100 in each of 2 assets (to make calc. easy)

- Above is equivalent to plotting the histogram

- C = column in Excel

- Order dV_p in ascending order (of 1000 numbers) e.g.

  -12, -11, -11, -10, -9, -9, -8, -7, -7, -6 | | -5, -4, -4, ..., 0.. +2, +3, +3, +4, +5 .... +8, ....... +14

- VaR forecast using HS, for tomorrow at 1% tail (10th most negative) = -$6
The main problem with all equally weighted VaR estimates is that extreme market events can influence the VaR estimate for a considerable period of time. With equal weighting, the ordering of observations is irrelevant. This problem can be mediated by weighting the returns so that their influence diminishes over time. For this purpose, we use the exponentially weighting approach, such that the weights decrease while we go toward the initial observations. First we define a smoothing constant \( \lambda \) in an open unit interval as \( \lambda \in (0,1) \) then \( (1-\lambda) \) is assigned to the last observation (T th observation) and \( \lambda (1-\lambda) \) for the (T-1) th observation, therefore the weights for (T-2) th and the observations prior to the (T-2) th respectively are:

\[
\lambda^2(1 - \lambda), \quad \lambda^3(1 - \lambda), \quad \lambda^4(1 - \lambda)
\]

\[
\sum_{i=0}^{n-1} \lambda^i(1-\lambda) = 1 - \lambda^n \rightarrow 1, \quad 0 < \lambda < 1
\]
Exponentially Weighted Data and Historical VaR

- We use these probability weights to find the cumulative probability associated with the returns when they are put in increasing order of magnitude. That is, we order the returns, starting at the smallest (probably large and negative) return, and record its associated probability weight. To this we add the weight associated with the next smallest return, and so on until we reach a cumulative probability of 100a%, the significance level for the VaR calculation.

- The VaR estimation is influenced by the value chosen for $\lambda$. An appropriate value for $\lambda$ depends on sample size and the time effect (i.e. the similarity and relationship between current and past data). In most cases $\lambda$ takes the values of 0.99 or greater, if the similarity and relationship between current and past data is high then a higher value must be assigned to $\lambda$, and vice versa.
Historic Simulation to “Bootstrapping”

- Is data >3 years ago useful for forecasting tomorrow?
- Maybe use most recent data - say last 100 days?
- But then the “1% tail” has only one number in the tail!
- Bootstrapping: To obtain “1%, Bootstrap –VaR”: One Asset Only
- You only want to use 100 days of historic data to estimate B-VaR (at 1% tail)
- Because you think data prior to 100 days ago, is irrelevant to your forecast VaR for tomorrow. But you want to introduce an element of chance/randomness so that your forecast B-VaR does not depend only on the most negative of the 100 data points you have (as it does with HS, with 100 days of data).
Monte Carlo Simulation VaR

- Monte Carlo simulation (MCS) is also known as Monte Carlo evaluation (MCE). It estimates VaR by randomly creating many scenarios for future rates.
- Using nonlinear pricing models to estimate the change in value for each scenario, and then calculating VaR according to the worst losses.
- Unlike Parametric VaR, it uses full pricing models and can therefore capture the effects of nonlinearities.
- Unlike Historical VaR, it can generate an infinite number of scenarios and therefore test many possible future outcomes.
- Unlike Historical VaR, it typically requires the assumption that the risk factors have a Normal or Log-Normal distribution.
The Monte Carlo approach assumes that there is a known probability distribution for the risk factors. The usual implementation of Monte Carlo assumes a stable, Joint-Normal distribution for the risk factors. Define joint stochastic model for risk factor. MCS assumes that future currency returns will be randomly distributed. Option premia are non-linear (convex) function of underlying asset. Distribution of underlying (e.g. stock returns) may be normal but distribution of gains/losses on call option is not normally distributed therefore dangerous to use Var-Cov method for options.
**MCS VaR Example**

- **Assets Held:** One call option on exchange rate
- **Problem:** Find the VaR over (say) a 5-day horizon
- **Notation**
  - \( V = \) price of the option (call or put)
  - \( P = \) price of underlying asset in the option contract (Currency)
  - \( V \) will change from minute to minute as \( P \) changes
  - In the MCS we simulate \( P \) and then use Black-Scholes to (re-)price the option for each “run” of the MCS.
MCS VaR Example

- Due to "non-normality" for distribution of the change in call premium $\Delta V$, so we cannot use "1.65" from normal distribution to calculate the VaR of the option.
- Given $P_0$ calculate the option price
  
  $V_0 = BS(P_0, T_0)$

- This is fixed throughout the MCS
- MCS = Simulate the price and calculate $P_{5}$
MCS VaR Example

- Calculate the new option price using Black-Scholes
  \[ V_5 = BS(P_5, T_0 - 5/365, \ldots) \]
- Calculate change in option premium
  \[ \Delta V(1) = V_5 - V_0 \]
- Repeat above steps 10,000-times and plot a histogram of the change in the call premium.
- We can then find the 5% lower cut-off point for the change in value of the call (i.e., it’s VaR).

If you do 10,000 simulations then the shape of the histogram will not change if you do additional Monte Carlo runs. (e.g., 11,000 runs)
How do we simulate price series?

1) Use Discrete Version of Brownian Motion/Random walk for daily returns and “scale up to 5-days”, using the “root T” rule

2) Use Discrete Version of Brownian Motion and apply recursively over 1, 2...5 days

Model of daily returns is:

\[ R_{t+1} = \mu + \sigma \varepsilon_{t+1} \]

\( \varepsilon \text{-iid}(0,1) \)

Continuously compounded returns is defined as:

\[ R_{t+1} = \ln \left( \frac{P_{t+1}}{P_t} \right) \]

Over 5-days - use “root-T” rule:

\[ P_{t+5} = P_t \exp \left( 5 \mu + \sigma \sqrt{5} \varepsilon_{t+1} \right) \]
Comparing VaR approaches

- Nonlinearity refers to the price change not being at linear function of the change in the risk factors. This is especially important for options.
- Non-Normality refers to the ability to calculate the potential changes in risk factors without assuming that they have a Normal distribution.
## Comparing VaR approaches

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<td>Easy</td>
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<tr>
<td>Reliability of result</td>
<td>Flexible</td>
<td>Rely on historical return</td>
<td>Flexible</td>
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<tr>
<td></td>
<td>Tend to underestimate under high confidence level</td>
<td>Good under high confidence level</td>
<td>Good</td>
</tr>
</tbody>
</table>
Comparing VaR & Beta or STD

Measured by
VAR

Stand-Alone Risk
Or
Total Risk

Measured by
\( \beta \)

- Systematic Risk + Unsystematic Risk
- Non-Diversifiable Risk + Diversifiable Risk
- Market Risk + Company-Specific Risk
Sensitivity analysis (scenario and stress testing)

- Subject your current portfolio to ‘extreme’ adverse historic events and see how much you lose.

  - For example:
    - 2000-2002 Stock market crash
    - 1995 Rise in bond yields
    - 1997 Asian crisis where FX rates changed dramatically
    - 1998 Russian bond crisis where spreads between low-grade and high-grade bonds widened
    - 2007/8 Credit crunch, where MBS, CDOs plummeted in value and liquidity was “thin”
Sensitivity analysis (scenario and stress testing)

- Problems:
  - In the next crisis would the fall in exchange rate and their correlations (e.g. between individual exchange rates or between stock and bond returns and exchange rates, in these “extreme scenarios” be
  - Exactly the same as in the crash of 1997?
  - Exactly same as in crash of 1987 or an average of the two crash periods?
  - Depends on what you think is most realistic as a ‘forecast’ of the future.
  - The scenario outcome depends crucially on the correlations you assume
  - Stress testing is not really a VaR analysis as there are (usually) no probabilities involved and its not and average of the past’ but an analysis of extreme specific event(s) from the past and maybe “possible gut feelings” about the future.
  - You (or the regulator) can choose your own alternative “1000 year storm”, extreme loss scenarios.
Exchange Rate Risk Management
Discussion about Forecasting FX

- Fundamental Approach
- Technical Approach
- Financial Econometrics
- Artificial Intelligence and Machine Learning Approach (Algorithm Trading)
Management of Transaction Exposure

- The sensitivity - due to unexpected changes in exchange rates - of the domestic currency value of a firm’s contractual cash flows that are denominated in foreign currencies.

- Unlike economic exposure, transaction exposure is well-defined, transaction-specific and short-term.

- **Contractual Hedges**
  - Forward Market Hedge
  - Money Market Hedge
  - Options Market Hedge
  - Futures Market Hedge

- **Financial Hedges**
  - Swaps

- **Operating Strategies**
  - Risk Shifting
  - Price adjustment clauses
  - Exposure Netting
  - Risk Sharing
Derivatives in Foreign Currency (Forward, Futures, Options, Swap)

- Forward Market
- Contract made today for delivery in the future
- Forward rate is “price” agreed, today
- eg. One-year Forward rate = 1.5 $ / £
- Agree to purchase £100 ‘s forward
  - In 1-year, receive £100
  - and pay-out $150
If you are going to owe foreign currency in the future, agree to buy the foreign currency now by entering into long position in a forward contract.

If you are going to receive foreign currency in the future, agree to sell the foreign currency now by entering into short position in a forward contract.

Example: You are a Canadian importer of British woolens and have just ordered next year’s inventory. Payment of £100M is due in one year.

Question: How can you fix the cash outflow in dollars?

Answer: One way is to put yourself in a position that delivers £100M in one year—a long forward contract on the pound.
Suppose the forward exchange rate is $1.50/£.

If he does not hedge the £100m payable, in one year his gain (loss) on the unhedged position is shown in green.

The importer will be better off if the pound depreciates: he still buys £100 m but at an exchange rate of only $1.20/£ he saves $30 million relative to $1.50/£.

But he will be worse off if the pound appreciates.
If he agrees to buy £100m in one year at $1.50/£ his gain (loss) on the forward are shown in blue.

If you agree to buy £100 million at a price of $1.50 per pound, you will make $30 million if the price of a pound reaches $1.80.

If you agree to buy £100 million at a price of $1.50 per pound, you will lose $30 million if the price of a pound is only $1.20.
## Forward Rates (Quotes)

<table>
<thead>
<tr>
<th></th>
<th>Yen / $</th>
<th>Yen / $</th>
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<tbody>
<tr>
<td><strong>Spot</strong></td>
<td>131.05-13</td>
<td>spot spread</td>
</tr>
<tr>
<td></td>
<td>1.15</td>
<td></td>
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<tr>
<td><strong>1m forwd discount</strong></td>
<td>0.01-0.03</td>
<td>spread on discount</td>
</tr>
<tr>
<td><strong>1m forwd rate</strong></td>
<td>131.06-13</td>
<td>1m forwd spread</td>
</tr>
<tr>
<td></td>
<td>1.18</td>
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</tbody>
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- Rule of thumb. Here discount / premium should be added so that: forward spread > spot spread
- Premium (discount) % = ( premium / spot rate ) x ( 365 / m ) x 100
Covered Interest Parity

- CIP determines the forward rate $F$ and CIP holds when:
- Interest differential (in favour of the UK)
  \[ \frac{r_{UK} - r_{US}}{1 + r_{US}} = \frac{F - S}{S} \]

  (or, forward premium on the $)

\[ \frac{r_{UK} - r_{US}}{1 + r_{US}} = \frac{F - S}{S} \]
Let $S =$ spot rate (£/$)  $F =$ forward rate - 1 year (£/$)  £$r =$ UK interest rate - decimal. (1 year)  $\$r =$ US interest rate

1) Invest £$A$ in UK  Return = $A(1 + £r)$

3) Invest in US  Return = $(A.S)(1 + \$r)(F)$

Equating the two riskless returns:

$(£r-\$r)/(1+£r) = (F-S)/S$

OR

$F = S(1+£r)/(1+\$r)$

If interest rates are constant $F$ and $S$ move together over time this is useful in hedging using forwards/futures.
Bank Calculates Forward Quote

- CIP implies, banks quote for F (£/$) is calculated as
  \[ F(\text{quote}) = S \left[ \frac{1 + r_{UK}}{1 + r_{US}} \right] \]

  If \( r_{UK} \) and \( r_{US} \) are relatively constant then
  F and S will move together (positive correlation)

  hence:
  **For Hedging with Futures**
  If you are long spot $-assets and fear a fall in the $ then go short
  (ie.sell) futures on USD
Creating a Synthetic FX-Forward Contract

- Suppose the actual quoted forward rate is: \( F = 1.5 \) (\$/£)
- Consider the cash flows in an actual forward contract

- Then reproduce these cash flows using “other assets”, that is the money markets in each country and the spot exchange rate. This is the synthetic forward contract

- Since the two sets of cash flows are identical then the actual forward contract must have a “value” or “price” equal to the synthetic forward contract. Otherwise riskless arbitrage (buy low, sell high) is possible.
Actual FX-Forward Contract: Cash Flows

Data: $F = 1.5 \ ($/£)$

- Will receive $150 and pay out £100 at $t=1$
- No “own funds” are used. No cash exchanges hands today (time $t=0$)
Synthetic Forward Contract: Cash Flows

- Using two money markets and the spot FX rate
  Suppose: ruk = 11%, rus = 10%, S = 1.513636 ($/£)
  Create cash flows equivalent to actual Forward Contract
  Begin by “creating” the cash outflow of £100 at t=1

Switch £90.09 in spot market and lend $136.36 in the US at r(US) = 10%.

Note: S = 1.513636 $/£ and no “own funds” are used.
Synthetic FX-Forward Contract

- Borrowed £100/(1+r_{uk}) = £90.09 at t=0
- Pay out £100 at t=1

- Convert to USD \[\frac{100}{(1+r_{uk})}\] S = $136.36 at t=0

- Lend in USA and receive \[\frac{100}{(1+r_{uk})}\] S (1+r_{us}) = $150 at t=1

- Synthetic Forward Rate SF:
  - Rate of exchange (t=1) = (Receipt of USD) / (Pay out £’s)
  - \[\frac{150}{100}\] = $150 / £100

  \[SF = \frac{\frac{100}{(1+r_{uk})} S (1+r_{us})}{100}\]
  - \[= \frac{S (1+r_{us})}{(1+r_{uk})}\]

- The actual forward rate must equal the synthetic forward rate
Risk Free Arbitrage Profits (F and SF are different)

- **Actual Forward Contract** with $F = 1.4 (\$/£)
  - Pay out $140 and receive £100 at t=1

- **Synthetic Forward (Money Market)**
  - Data: $r_{uk} = 11\%$, $r_{us} = 10\%$, $S = 1.513636$ (\$/£) so $SF = 1.5$ (\$/£)
  - Receive $150 and pay out £100

- **Strategy:**
  - Sell $140 forward, receive £100 at t=1 (actual forward contract)
  - Borrow £90.09 in UK money market at t=0 (owe £100 at t=1)
  - Convert £90.09 into $136.36 in spot market at t=0
  - Lend $136 in US money market receive $150 at t=1 (synthetic)

- **Riskless Profit** = $150 - $140 = $10
### Foreign Currency Futures

<table>
<thead>
<tr>
<th>Size</th>
<th>Margin Maintenance Margin</th>
<th>Tick Size [Value]</th>
<th>Initial Margin</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Pound Sterling</td>
<td>£62,500</td>
<td>0.02¢ per £[$12.50]</td>
<td>$2,000</td>
</tr>
<tr>
<td>2 Swiss Franc</td>
<td>SF125,000</td>
<td>0.01¢ per SFr</td>
<td>$2,000</td>
</tr>
<tr>
<td>3 Japanese Yen</td>
<td>Y12,500,000</td>
<td>0.01¢ per 100JY[$12.5]</td>
<td>$1,500</td>
</tr>
<tr>
<td>4 Canadian Dollar</td>
<td>CD100,000</td>
<td>0.001 ($/CD)[$100]</td>
<td>$900</td>
</tr>
<tr>
<td>5 Euro</td>
<td>125,000</td>
<td>0.01¢ per Euro [$12.50] varies</td>
<td></td>
</tr>
</tbody>
</table>
Futures: Hedging

- $S_0 = \text{spot rate} = 0.6700(\$/SFr)$
- $F_0 = \text{futures price (Oct. delivery)} = 0.6738(\$/SFr)$
- Contract Size, $z = \text{SFr 125,000}$
- Tick size, (value) $= 0.0001(\$/SFr)$ ($12.50$)

US Importer

$TVS_0 = \text{SFr 500,000}$

Vulnerable to an appreciation of SFr and hence takes a long position in SFr futures

$N_f = 500,000/125,000 = 4$ contracts
Futures: Hedging

Net $-cost = Cost in spot market - Gain on futures

= TVS0 S1 - Nf z (F1 - F0)
= TVS0 (S1 - F1 + F0) = TVS0 (b1 + F0)
= $ 360,000 - $ 23,300 = $ 336,700

Nfz = TVS0
Hedge “locks in” the futures price at t=0 that is F0, as long as the final basis b1 = S1 - F1 is “small”.
Importer pays out $336,700 to receive SFr 500,000 which implies an effective rate of exchange at t=1 of:

Net Cost/TVS0 = b1 + F0 = 0.6734 ($/SFr)

~close to the initial futures price of F0 = 0.6738($/SFr) the difference being the final basis b1 = -4 ticks.
Foreign Currency Options

<table>
<thead>
<tr>
<th>Contract</th>
<th>Size</th>
<th>K-Increments</th>
<th>Min Price</th>
<th>Chge</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBP</td>
<td>£31,250</td>
<td>$0.0250</td>
<td>$0.0001 = $3.125</td>
<td></td>
</tr>
<tr>
<td>DM</td>
<td>DM62,500</td>
<td>$0.050</td>
<td>0.0001 = $6.25</td>
<td></td>
</tr>
<tr>
<td>JY</td>
<td>JY6,250,000</td>
<td>$0.050</td>
<td>0.000001 = $6.25</td>
<td></td>
</tr>
<tr>
<td>Can $</td>
<td>CD50,000</td>
<td>$0.050</td>
<td>0.0001 = $5.00</td>
<td></td>
</tr>
</tbody>
</table>
Buy (long) call on sterling if you expect sterling to appreciate.
Profit a Long Call

\[ \mathbb{Y} = \text{Max}(S_T - K, 0) - C \]

\[ = -C \quad \text{if} \quad S_T \leq K \]

\[ = S_T - K - C \quad \text{if} \quad S_T > K \]

- **Break even spot rate is:** \( S_{T,\text{BE}} = K + C \)
- \( z_{op} = £31,250 \) at expiry
- \( K = 1.40 \, $/£ \)
- \( C = 4.0 \, \text{cents/£} = 0.04 \, $/£ \)
- \( S_T = 1.50($/£) \) (see figure 11.2):
- Gross profit = \((S_T - K) \cdot z_{op} = (1.50 - 1.40) \cdot £31,250 = £3,125\)
- Invoice price per contract = \( z_{op} \cdot C = £31,250 \cdot 0.04($/£) = £1,250\)
- **Net profit:** \( \mathbb{Y} = (S_T - K - C) \cdot £31,250 = (1.50($/£) - 1.40($/£) - 0.04($/£)) \cdot £31,250 \)

\[ = (0.06($/£)) \cdot £31,250 = $1,875\]
Buy long put on sterling if you expect sterling to depreciate.
Profit from Long Put

- **If** $S_T < K$ \[140 < 144\]
  - Exercise the option ("in-the-money")
  - **Gross profit** \[= (K - S_T) \times z = (1.44-1.40) \times 31,250 = $1250\]
  - **Net profit** \[= (K - S_T - P) \times z = 1.44-1.40-0.025 = $468.75 \text{ per contract}\]

- **If** $S_T > K$
  - Do not exercise the option ("out-of-the-money")
  - **Loss** \[= (2.5/100) \times 31,250 = $781.25\]
  - Loss is limited to put premium (insurance)
Pricing

Replace $q = \text{dividend yield}$ by $r_f$

\[
C = S \ N(d_1) - K \ N(d_2)
\]

\[
P = K \ N(-d_2) - S \ N(-d_1)
\]

\[
d_1 = \frac{\ln(S/K) + (r_d - r_f + \sigma^2/2)T}{\sigma\sqrt{T}}
\]

\[
d_2 = \frac{\ln(S/K) + (r_d - r_f + \sigma^2/2)T}{\sigma\sqrt{T}} = d_1 - \sigma\sqrt{T}
\]

$S$ is measured as $\$ \text{per £ (or cents per £)}$, \ldots
Pricing: Alternative Representation

\[ S = F e^{-(r_d-r_f)T} \]

\[ C = [F N(d_1) - K N(d_2)] \]

\[ P = [K N(-d_2) - F N(-d_1)] \]

\[ d_1 = \frac{\ln(F/K) + (\sigma^2 / 2)T}{\sigma \sqrt{T}} \]

\[ d_2 = \frac{\ln(F/K) - (\sigma^2 / 2)T}{\sigma \sqrt{T}} \]
Outset of a currency swap

French Bondholders
FRF500m

US Bondholders
$100m

Effel
FRF 500m
$ 100m

Swap Dealer
FRF 500m
$ 100m

Uncle Sam
FRF 500m
$ 100m

12%
Interest flows on currency swap

Swap Dealer: USD Gain = 9.2 - 8 = 1.2%
FRF loss = 12 - 11.2 = 0.8%.
Net position = 1.2 - 0.8 = 0.4%
General Hedging Rule

- Future foreign currency cash outflow
  - Certain: Go long futures or forwards
  - Uncertain: Buy a call option

- Future foreign currency cash inflow
  - Certain: Go short futures or forwards
  - Uncertain: Buy a put option
A multinational firm should not consider deals in isolation, but should focus on hedging the firm as a portfolio of currency positions.

As an example, consider a U.S.-based multinational with Korean won receivables and Japanese yen payables. Since the won and the yen tend to move in similar directions against the U.S. dollar, the firm can just wait until these accounts come due and just buy yen with won.

Even if it’s not a perfect hedge, it may be too expensive or impractical to hedge each currency separately.

Many multinational firms use a reinvoice center. Which is a financial subsidiary that nets out the intrafirm transactions.

Once the residual exposure is determined, then the firm implements hedging.
Discussion about Hedging in Islamic Finance

- Financial Instrument and Derivatives in Islamic Finance
Management of Economic Exposure

- Changes in exchange rates can affect not only firms that are directly engaged in international trade but also purely domestic firms.
- Consider a Canadian bicycle manufacturer who sources and sells only in Canada.
- Since the firm’s product competes against imported bicycles it is subject to foreign exchange exposure.
Recognizing Operating Exposure

- Where is the company selling? [domestic v. foreign]  
  Who are the key competitors? [domestic v. foreign]
- How sensitive is demand to price?  
  Where is the company producing? [domestic v. foreign]
- Where are the company’s inputs coming from? [domestic v. foreign]

- Volvo produces most of its cars in Sweden, but buys most of its inputs from Germany.
- The U.S. is an important export market for Volvo.
- Volvo management believed that a depreciating Swedish krona versus the $ and an appreciating Swedish krona versus the DM would be beneficial to Volvo.
- But researchers found that statistically
  - A depreciating krona relative to the Deutschemark improved Volvo’s cash flow!
- These results reflect the fact that Volvo’s major competitors are the German firms BMW, Mercedes and Audi.
Channels of Economic Exposure

- Asset exposure
- Exchange rate fluctuations
- Operating exposure

Home currency value of assets and liabilities

Future operating cash flows

Firm Value
How to Measure Economic Exposure

- Economic exposure is the sensitivity of the future home currency value of the firm’s assets and liabilities and the firm’s operating cash flow to random changes in exchange rates.

- There exist statistical measurements of sensitivity.
  - Sensitivity of the future home currency values of the firm’s assets and liabilities to random changes in exchange rates.
  - Sensitivity of the firm’s operating cash flows to random changes in exchange rates.
If a Canadian MNC were to run a regression on the dollar value ($P$) of its British assets on the dollar-pound exchange rate, $S(\$/£)$, the regression would be of the form:

$$P = \alpha + bS + e$$

Where

- $\alpha$ is the regression constant
- $e$ is the random error term with mean zero.

- The regression coefficient $b$ measures the sensitivity of the dollar value of the assets ($P$) to the exchange rate, $S$.
- Exposure is the regression coefficient $b$. 

How to Measure Economic Exposure
How to Measure Economic Exposure

The exposure coefficient, $b$, is defined as follows:

$$ b = \frac{\text{Cov}(P,S)}{\text{Var}(S)} $$

Where $\text{Cov}(P,S)$ is the covariance between the dollar value of the asset and the exchange rate, and $\text{Var}(S)$ is the variance of the exchange rate.
Example

- Suppose a Canadian firm has an asset in Britain whose local currency price is random.
- For simplicity, suppose there are only three states of the world and each state is equally likely to occur.
- The future local currency price of this British asset \( (P^*) \) as well as the future exchange rate \( (S) \) will be determined, depending on the realized state of the world.
Operating Exposure: Definition

- The effect of random changes in exchange rates on the firm’s competitive position, which is not readily measurable.
- A good definition of operating exposure is the extent to which the firm’s operating cash flows are affected by the exchange rate.

Example: A Canadian company operates a French subsidiary that assemble and sells computers throughout Europe. The French sub imports Intel microprocessors from US. A depreciating Euro will have two effects:

1. Competitive Effect: A euro depreciation may affect OCF in Euros by altering the firm’s competitive position in the marketplace.

2. The conversion Effect: A given OCFs in Euros will be converted into a lower dollar amount after depreciation.
Determinants of Operating Exposure

- Recall that operating exposure cannot be readily determined from the firm’s accounting statements as can transaction exposure.

- The firm’s operating exposure is determined by:
  - The *market structure* of inputs and products: how competitive or how monopolistic the markets facing the firm are.
    - Generally speaking, a firm is subject to high degrees of operating exposure when *either* its cost or its price is sensitive to exchange rate changes. When *both* the cost *and* the price are sensitive or insensitive to exchange rate changes, the firm has no major operating exposure.
  - The firm’s ability to adjust its markets, product mix, and sourcing in response to exchange rate changes.
Managing Operating Exposure

- Selecting Low Cost Production Sites
- Flexible Sourcing Policy
- Diversification of the Market
- R&D and Product Differentiation
- Financial Hedging
Selecting Low Cost Production Sites

- A firm may wish to diversify the location of their production sites to mitigate the effect of exchange rate movements.

  - e.g. Honda built North American factories in response to a strong yen, but later found itself importing more cars from Japan due to a weak yen.
Even if all production is domestic, the firm can take advantage of changes in ex-rates if it has flexibility in sourcing.

Sourcing does not apply only to components, but also to “guest workers”.

- e.g. Japan Air Lines hired foreign crews to remain competitive in international routes in the face of a strong yen, but later contemplated a reverse strategy in the face of a weak yen and rising domestic unemployment.
Diversification of the Market

- Selling in multiple markets to take advantage of economies of scale and diversification of exchange rate risk.

- Diversify by:
  a) selling the same product in more than one country, and
  b) selling several different product lines in more than one foreign market.

- As long as ex-rates don't move together perfectly against the dollar, and as long as ex-rates don't affect each product line the same, the diversification will mitigate operating exposure to currency risk.
R&D and Product Differentiation

- Successful R&D that allows for
  - cost cutting
  - enhanced productivity
  - product differentiation.

- Successful product differentiation gives the firm less elastic demand which may translate into less exchange rate risk.
Financial Hedging

- The goal is to stabilize the firm’s cash flows in the near term.
- Financial Hedging is distinct from operational hedging.
- Financial Hedging involves use of derivative securities such as currency swaps, futures, forwards, currency options, among others.
Managing Translation Exposure

- The main technique to minimize translation exposure is called a *balance sheet hedge*.
- A balance sheet hedge requires an equal amount of exposed foreign currency assets and liabilities on a firm’s consolidated balance sheet.
- If this can be achieved for each foreign currency, net translation exposure will be zero.
- These hedges are a compromise in which the denomination of balance sheet accounts is altered, perhaps at a cost in terms of interest expense or operating efficiency, to achieve some degree of foreign exchange protection.
References:

Thanks for your patience ;)