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FINA 4360 – International Financial Management

10/7 – Chapter 10
Measuring Exposure to FX Changes

Three areas of FX exposure
- Transaction exposure: associated with specific transactions (in FC).
- Economic exposure: associated with futures cash flows –true exposure for owners.
- Translation exposure: associated with a firm's consolidated statements.

TE is simply to calculate: Value in DC of a specific transaction denominated in FC.

We can measure TE, and analyze the sensitivity of TE to changes in S_t.

Use a statistical distribution or a simulation.

The less sensitive TE is to S_t, the lower the need to pay attention to changes in S_t.

MNCs have measures for NTE for:
- A single transaction
- All transactions (Netting + taking into account co-movements of transactions. A portfolio approach)

The portfolio approach incorporates correlations.

Recall that the co-movement between two random variables can be measured by the correlation coefficient. The correlation between the random variables X and Y is given by:

$$Corr(X,Y) = \rho_{XY} = \sigma_{XY}/(\sigma_Y\sigma_Y).$$

Interpretation of the correlation coefficient ($\rho_{xy} \in [-1,1]$):
- If $\rho_{xy} = 1$, X changes by 10%, Y also changes by 10%.
- If $\rho_{xy} = 0$, X changes by 10%, Y is not affected --(linearly) independent.
- If $\rho_{xy} = -1$, X changes by 10%, Y also changes by -10%.

Figure 10.1: Co-movement by Major Currencies (1999-2012)

Note: As shown in Figure 10.1, currencies from developed countries tend to move together -i.e., positive correlations. But, there are periods where the correlations can be quite negative.

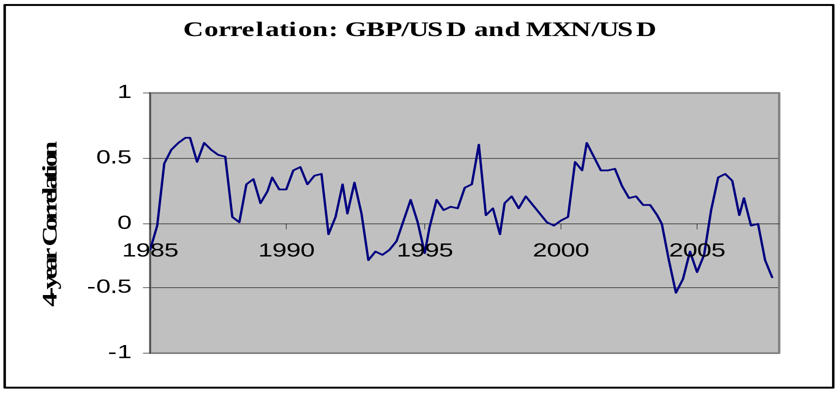
• MNC take into account the correlations among the major currencies to calculate NTE
$\Rightarrow$ Portfolio Approach.

A U.S. MNC: Subsidiary A with CF(in EUR)>0
Subsidiary A with CF(in GBP)<0
$\rho_{GBP,EUR}$ is very high and positive.
Net TE might be very low for this MNC.

Hedging decisions: Not made transaction by transaction. Rather, they are made based on the exposure of the portfolio.

Example: Swiss Cruises.
Net TE (in USD): USD 1 million. Payment: 30 days.
Loan repayment: CAD 1.50 million. Payment: 30 days.
S_t = 1.47 CAD/USD.
$\rho_{CAD,USD}$ = .924 (1990-2001)
Swiss Cruises considers the Net TE (overall) to be close to zero. ¶

Note: As seen in the previous graphs, currencies tend to move together, but not always. Correlations vary a lot across currencies. In general, regional currencies are highly correlated. From 2000-2007, the GBP and EUR had an average correlation of .71, while the GBP and the MXN had an average correlation of -.01. Correlations also vary over time.



• Sensitivity Analysis for Portfolio Approach
Do a simulation. That is, assume different scenarios (pay attention to the 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 (in USD) = EUR 120,000 * 1.05 USD/EUR + (GBP 75,000) * 1.60 USD/GBP =
= USD 6,000 (this is our baseline case)

Situation 1: Assume $\rho_{GBP,EUR} = 1$. (The correlation between the EUR and the GBP is high.)
Scenario (i): EUR appreciates by 10% against the USD ($e_{f,EUR}$=.10)

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 (in USD) = EUR 120,000*1.155 USD/EUR+(GBP 75,000)*1.76 USD/GBP =
= USD 6,600. (10% change)

Scenario (ii): EUR depreciates by 10% against the USD ($e_{f,EUR}$=-.10)

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 (in USD) = EUR 120,000*1.155 USD/EUR+(GBP 75,000)*1.76 USD/GBP =
= USD 5,400. (-10% change)

Now, we can specify a range for NTE $\Rightarrow$NTE $\in$ [USD 5,400, USD 6,600]

Note: The NTE change is exactly the same as the change in S_t. If a firm has matching inflows and outflows in different currencies –i.e., the NTE is equal to zero-, then changes in S_t do not affect NTE. That's very good.

Of course, we will draw more than 2 scenarios, say 10,000 draws for $e_{f,EUR}$ and then draw a histogram with the 10,000 NTEs. Finally, we can draw a (1-α)% Confidence interval.

Situation 2: Suppose the $\rho_{GBP,EUR}$ = -1 (NOT a realistic assumption!)
Scenario (i): EUR appreciates by 10% against the USD ($e_{f,EUR}$=.10)

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 (in USD) = EUR 120,000*1.155 USD/EUR+(GBP 75,000)*1.44 USD/GBP =
= USD 30,600. (410% change)

Scenario (ii): EUR depreciates by 10% against the USD ($e_{f,EUR}$=-.10)

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 (in USD) = EUR 120,000*0.945 USD/EUR+(GBP 75,000)*1.76 USD/GBP =
= (USD 18,600). (-410% change)

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

Note: The NTE has ballooned. A 10% change in exchange rates produces a dramatic increase in the NTE range. Having non-matching exposures in different currencies with negative correlation is very dangerous.

Again, we will draw more than 2 scenarios, say 10,000 and then draw a histogram with the 10,000 NTEs. Finally, we can draw a (1-α)% Confidence interval.

In both situations, given the high correlations, IBM only draws one variable ($e_{f,EUR}$). For the other situations, where the correlation is not very high, IBM will draw from the empirical distribution (ED). In this case, IBM will randomly draw pairs together –say, $e_{f,EUR}$ & $e_{f,GBP}$- and then calculate NTE's for each draw. ¶

Alternatively, IBM can assume a distribution (say, bivariate normal) with a given correlation (estimated from the data) and, then, draw many scenarios for the S_t's to generate an empirical distribution for the NTE. From this simulated distribution, IBM will get a range –and a VaR- for the NTE.

Real World: Walt Disney Company's *VALUE AT RISK (VaR)*
According to Disney's 2006 Annual Report:
The Company utilizes a VaR model to estimate the maximum potential one-day loss in the fair value of its interest rate, foreign exchange and market sensitive equity financial instruments. The VaR model estimates were made assuming normal market conditions and a 95% confidence level. Various modeling techniques can be used in a VaR computation. The Company's computations are based on the interrelationships between movements in various interest rates, currencies and equity prices (a variance/co-variance technique) These interrelationships were determined by observing interest rate, foreign currency, and equity market changes over the preceding quarter for the calculation of VaR amounts at fiscal 2006 year end.

The estimated maximum potential one-day loss in fair value, calculated using the VAR model, is as follows (unaudited ,in millions):

(in millions)	Interest Rate Sensitive Financial Instruments	Currency Sensitive Financial Instruments	Equity Sensitive Financial Instruments	Combined Portfolio
VaR (year end 05)	USD 22	USD 10	USD 1	USD 21
Average VaR	USD 19	USD 13	USD 0	USD 22
Highest VaR	USD 22	USD 15	USD 1	USD 24
Lowest VaR	USD 18	USD 10	USD 0	USD 18

2. Measuring 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.

Very general definition: It can be applied to any firm (domestic, foreign, MNC, exporting, importing, purely domestic, etc.).

Q: How can we measure the degree to which CFs are affected by *unexpected* $e_{f,t}$?
A: Remember Random Walk. All changes in S_t are unexpected.

Example: On February 2, 2015, Owens-Illinois (OI), the giant U.S. manufacturer of glass containers, reported its fourth-quarter results. OI reported that sales declined 9% year over year to USD 1.6 billion due to a stronger USD that adversely impacted sales by 6%. OI forecasted that, in 2015, earnings will be negatively impacted by the strong USD. The strong USD is expected to reduce translated sales by nearly 10%. This is *economic exposure.* ¶

• The degree to which a firm is subject to EE depends on:
  - The type and structure of the firm
  - The industry structure in which the firm operates.

In general, importing and exporting firms face a higher EE than purely domestic firms do.

Industry structure is also very important. In general, monopolistic firms will face lower EE than firms that operate in competitive markets will.

Example: Suppose a U.S. firm face almost no competition in the domestic market. This U.S. firm is able to transfer to its prices almost any increase of its costs due to changes in S_t. Thus, this firm faces no EE, since its CFs are unaffected by changes in S_t. ¶

But, the degree of EE for a firm is an empirical question.

• Economic exposure is: - Subjective.
- Difficult to measure.

Idea: To measure EE we need to relate future cash flows to changes in S_t.

1. A Measure Based on Accounting Data

It requires to estimate the net cash flows of the firm (EAT or EBT) under several FX scenarios. (Easy with an excel spreadsheet.)

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**

EBT (in USD) at S_t = 7 HKD/USD: **USD 130M**/7 HKD/USD = **USD 18.57M**
EBT (in USD) at S_t = 7.7 HKD/USD: **USD 180M**/7.70 HKD/USD = **USD 23.38M**

A 10% depreciation of the HKD, increases the HKD cash flows from HKD 130M to HKD 180M, and the USD cash flows from **USD 18.57M** to **USD 23.38** or a 25.9%.

Q: Is EE significant?
A: We can calculate the elasticity of CF to changes in S_t.
For example, in USD, a 10% depreciation of the HKD produces a change of 25.9% in EBT, for a 2.59 elasticity. It looks quite significant. But you should note that the change in exposure is USD 4.81M. This amount might not be very significant for IBM! A judgment call maybe needed here. ¶

2. An Easy Measure of EE Based on Financial Data

Sometimes, accounting data are not very relevant, since it measure the past. EE deals with futures cash flows. If available, changes in stock prices –i.e., returns- should be used –recall that stock prices measure discounted future cash flows.

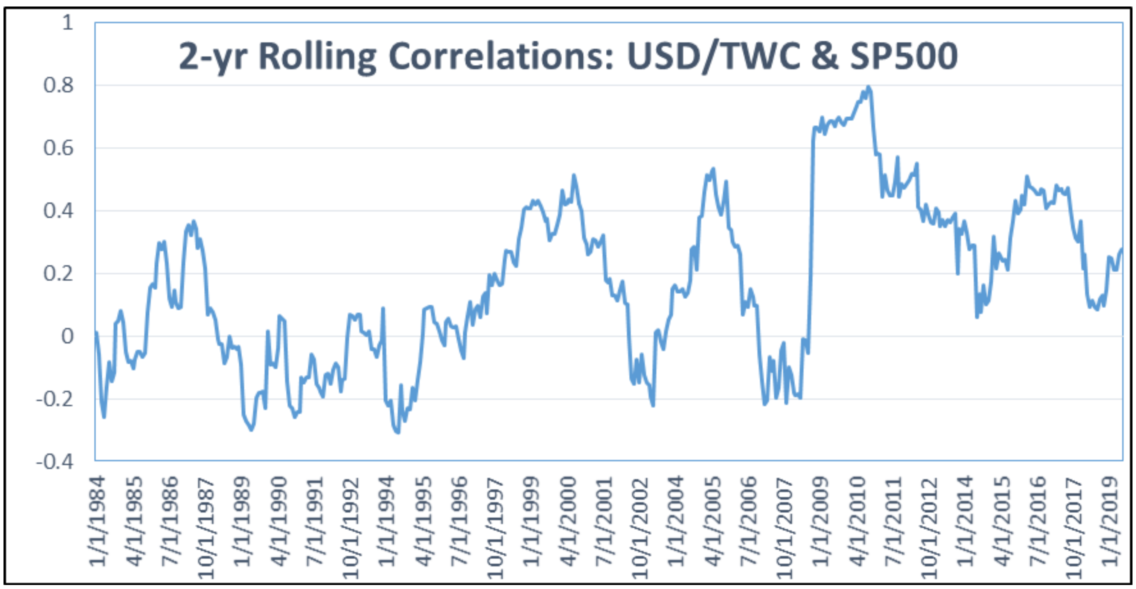
• We want to measure the correlation between ΔCF and $e_{f,t}$.

⇒ we can use the correlation coefficient between ΔCF and $e_{f,t}$.

Example: Kellogg's and AT&T's EE.
Using monthly stock returns for Kellogg's (Kret) and monthly changes in S_t (USD/TWC) from 1/1984-7/2019, we estimate $\rho_{K,e}$ (correlation between $Kret_t$ and $e_{f,t}$) = **0.102**. TWC represents a Trade Weighted Basket of Major Currencies. It looks small, but away from zero. We do the same exercise for AT&T (T), obtaining $\rho_{T,e}$ = **0.026**, small and close to zero. ¶

Interesting result: Correlations between returns and changes in exchange rates are time-varying. Recessions and crises affect the relation. Below, in Figure 10.2, we calculate the 12-month rolling correlation between the S&P returns and percentage changes in the USD/TWC, $e_{f,t}$, from 1991:Jan to 2019:Jan:

Figure 10.2: Correlation between S&P returns & changes in the USD/TWC 1984-2019



After the financial crisis of 2007-2008, there is a higher correlation between stock returns and changes in exchanges rates. The average correlation is **0.173**, which does not seem to be representative.

It is better to run a regression on ΔCF against unexpected $e_{f,t}$, it gives us a test.

Steps:

(1) Collect data on CF and S_t (available from the firm's past).

(2) Estimate the regression: $\Delta CF_t = \alpha + ß\, e_{f,t} + \xi_t$,

⇒ ß measures the sensitivity of ΔCF to changes in $e_{f,t}$.

⇒ the higher ß, the greater the impact of $e_{f,t}$ on CF.

$\Rightarrow$ the higher R^2, the greater the explanatory power of $e_{f,t}$.

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

H_1 (no EE): $\beta \neq 0$

(That is, evaluation of regression: t-statistic of ß and R^2.)

Note: One thing to do: Replace ΔCF_t by stock returns. A better measure.
Stock returns measure changes in discounted future cash flows.

Example: Kellogg's EE.
Now, using the data from the previous example, we run the regression: $Kret_t = \alpha + ß\, e_{f,t} + \xi_t$,

$R^2 = 0.0104$
Standard Error = 2.575
Observations = 424

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept (α)	0.3043	0.1263	**2.409**	0.0164
$e_{f,t}$ (β)	0.4787	0.2266	**2.112**	0.0353

We reject H_0, since $|t_\beta = \mathbf{2.11}| > 1.96$ (significantly different than zero).
Note, however, that the R^2 is low! (The variability of e_f explains 1% of the variability of Kellogg's returns.) ¶

Example: AT&T's EE.
Now, using AT&T data, we run the regression: $Tret_t = \alpha + ß\, e_{f,t} + \xi_t$,

$R^2 = 0.0007$
Standard Error = 2.714
Observations = 424

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept (α)	0.2005	0.1331	1.506	0.133
$e_{f,t}$ (β)	0.1299	0.2388	**0.544**	0.587

We cannot reject H_0, since $|t_\beta = \mathbf{-0.54}| < 1.96$ (not significantly different than zero).
The R^2 is extremely low: the variability of e_f explains less than 0.1% of the variability of AT&T's returns. ¶

• Sometimes the impact of ΔS_t is not felt immediately by a firm.
$\Rightarrow$ contracts and short-run costs (short-term adjustment difficult).

Example: For an exporting U.S. company a sudden appreciation of the USD increases CF in the short term. But, later, the export contract will be renegotiated.

Run a modified regression: $\Delta CF_t = \alpha + \beta_0\, e_{f,t} + ß_1\, e_{f,t-1} + ß_2\, e_{f,t-2} + ß_3\, e_{f,t-3} + \ldots + ß_Q\, e_{f,t-Q} + \xi_t$.
$\Rightarrow$ Sum of the β's measures the sensitivity of CF to changes in S_t ($e_{f,t}$). ¶

Practical issue: number of lags (Q in the modified regression)?

Usual practice: include at most two years of information.

Example: Kellogg runs the following regression to estimate EE with lags (t-stats in parenthesis):

$$\Delta CF_t = .006 + .478\, e_{f,t} + .264\, e_{f,t-1} + .180\, e_{f,t-2}. \qquad R^2 = .045.$$
$$(1.90) \quad (2.87) \qquad (1.97) \qquad (1.08)$$

K's CF (in USD) sensitivity to $e_{f,t}$ is 0.742 (= .478 +. 264).

$\Rightarrow$ a 1% depreciation of the USD increases CF (in USD) by 0.742%. ¶

• Note on regressions to measure EE

Changes in S_t ($e_{t,t}$) is not the only variable affecting a company's stock returns. A company grows, adds assets, then higher sales and EPS are expected. Also, the economy and the stock market grow over time. We need to be careful and "control" for these other variables, to isolate the effect of $e_{f,t}$.

A multivariate regression will probably be more informative, where we can include other independent ("control") variables (income growth, inflation, sales growth, assets growth, etc.), not just $e_{f,t}$ as determinants of the change in CFs (or stock returns).

We can also borrow from the investments literature and use the three popular Fama-French factors (Market, Size (SMB), Book-to-Market (HML)) as controls. Then, we can run a regression to check if a company faces EE:

$$\text{Stock Return}_t = \alpha + \beta\, e_{f,t} + \delta_1 \text{ Market Return}_t + \delta_2 \text{ HML}_t + \delta_3 \text{ SMB}_t + \varepsilon_t$$

Example: Using the Fama-French Factors to compute Kellogg's EE.

Now, using the data from the previous example, we run the regression:

$$\text{Kret}_t = \alpha + \beta\, e_{f,t} + \delta_1 \text{ Market Return}_t + \delta_2 \text{ HML}_t + \delta_3 \text{ SMB}_t + \varepsilon_t$$

$R^2 = 0.1291$
Standard Error = 2.424
Observations = 424

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	0.12321	0.12172	1.012	0.3120
Market (R_m-R_f)	0.21486	0.02864	**7.501**	3.79E-13
Size (SMB)	-0.08947	0.04086	**-2.190**	0.0291
B-M (HML)	0.03758	0.04338	0.866	0.3868
$e_{f,t}$ (β)	0.12455	0.21855	**0.570**	0.5690

Note: You can find this, the previous (K and IBM) and other (DIS) examples in my homepage: www.bauer.uh.edu/rsusmel/4386/kellogg-euro.xls

A higher R^2 is mainly due to the market factor. But, looking at EE, once we control for other factors (the FF factors), we cannot reject H_0, since $|t_\beta = \mathbf{0.57}| < 1.96$ (not significantly different than zero); that is, at the 5%, we cannot reject the null hypothesis of no economic exposure. ¶

Evidence: The above regressions have been done repeatedly for firms around the world. (Without the FF factors, we have already done it for AT&T and with the FF factors, we have already done it for Kellogg.) On average, for large firms (MNCs) EE is small –i.e., β is small– and not significant at the 5% level. See Ivanova (2014).

♦ **Real World Example: Economic Exposure - The Case of Ericsson**
Ericsson is very dependent on the behavior of the SEK and on economic conditions in Sweden. Around 40% of all employees and 25% of total production is located in Sweden, but Sweden accounts for just 3% of all sales. With this substantial cost base in SEK, for example, an appreciation of the SEK against the major currencies will have a negative impact on Ericsson's cash flows. As a matter of fact, during the year 2000, the depreciation of the EUR against the SEK had a negative impact on Ericsson compared to Ericsson's competitors with costs denominated in EUR. Usually, Ericsson does not hedge economic exposure. **Source**: Ericsson Annual Report 2000. ♦