Chapter 13

Measuring Exposure to Exchange Rates

We have established three important facts about the effect of exchange rate volatility on a firm's value. First, changes in the nominal exchange rate are not offset by corresponding changes in prices at home and abroad. That is, there are persistent and significant deviations from purchasing power parity, implying that there is real exchange rate risk (Chapter 3). Second, the forward rate is not successful in forecasting the exchange rate nor are other fundamental variables (Chapter 10). Third, given the market imperfections in the real world, hedging exchange rate risk can lead to an increase in the value of the firm (Chapter 12). We may conclude, therefore, that at least some firms may want to hedge their exposure to the exchange rate at least some of the time. The issue that is still unsettled is how much should be hedged. Specifically, one issue is whether hedging of contractual exposure, as discussed in Chapter 5, suffices: shouldn't we hedge all "expected" cashflows, whether contractual or not? And shouldn't we also think of the effect of exchange-rate changes on accounting values (as opposed to cash flows)?

In the first section of this chapter we distinguish between exchange-rate *risk* and *exposure to* the exchange rate. We next explain how one can classify the effects of exchange rate changes into two categories. First, exchange rate changes may have an impact on accounting values (known as *accounting exposure* or *translation exposure*). Second, the exchange rate may affect the firm's cash flows and market value (called *economic exposure*), either through its effect on existing contracts (labeled *contractual exposure* or *transaction exposure*) or through its impact on the future operating cash flows of the firm (known as *operating exposure*). Having already discussed the hedging of contractual exposures in Chapter 5, our discussion of this item here focuses on what it achieves, and where it stops, rather than on the mechanics (Section 2). The rest of the chapter then considers operating and translation exposure, in Sections 3 and 4, respectively.

13.1 The Concepts of Risk and Exposure: a brief survey

In general, we need to distinguish between the terms exchange risk and exchange exposure. (Some people use them interchangeably, which is not a good idea.)

- **Risk** We interpret *exchange risk* as synonymous with uncertainty about the future spot rate. Possible measures of exchange risk include the standard deviation or the variance of the future spot rate change.
- **Exposure** A firm is said to be *exposed* to exchange risk if its financial position is affected by unexpected exchange rate changes. A large exposure means that a given exchange rate change has a large impact on the firm. That is, by *exposure* we mean a numerical measure of how sensitive the financial position of a firm is to changes in the exchange rate.

This concept was already used in Chapter 5, where we generally defined exposure as a number that tells us by what multiple the HC value of an asset or cash flow changes when the exchange rate moves by ΔS, everything else being the same. We denoted this multiple by $B_{t,T}$:

$$B_{t,T} = \frac{\Delta \tilde{V}_T}{\Delta \tilde{S}_T}. \tag{13.1}$$

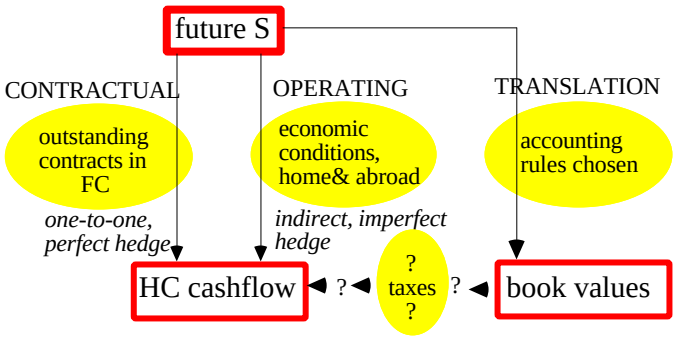
Note again the T subscripts to V and S: we have in mind values at T, so the delta's must mean that we compare two possible situations at the same (future) moment T, not two observations made at different moments in time. (We're so wont to interpret Δ as a change over time that explicit notation is in order, here.) Another way of saying this is that we have in mind a kind of *partial* derivative w.r.t. the exchange rate, holding constant other items (including time). We used this concept to price and hedge options (Chapter 9).

The above definition assumes that $\tilde{V}_T$ is an exact function of $\tilde{S}_T$. If the relation is known only up to noise or is otherwise imperfect—for instance because we willingly ignore non-linearities in the relation—a related concept of exposure crops up: the variance-minimizing hedge instead of the exact, perfect hedge. We looked at the variance-minimizing hedge already, notably in Chapter 6 on futures, and we'll use it again in this chapter. Recall that this hedge ratio is similar to the above exposure: a regression coefficient measures the sensitivity of $\tilde{V}_T$ to $\tilde{S}_T$, holding constant the regression residuals (which is "everything else", in a regression). So in that sense the general partial-derivative definition also covers the regression hedge-ratio measure of exposure.

We already showed that B has the dimension of a number of FC units. But what is meant by $\tilde{V}_T$? In the literature one typically lists three alternative possible specifications of what could be covered by this symbol:

- **Contractual exposure** In the case of contractual exposure, $\tilde{V}_T$ is defined as the HC value, at maturity, of a net contractual cash flow denominated in a

Figure 13.1: **Exposure Concepts: an Overview**



Key Contractual in- or outflows can be hedged peso-for-peso, if there really is no other risk. Operating exposures imply a noisy, convex relation between exchange rates and (HC-measured) cash flows, so the hedge is imperfect. Even getting a good idea of that relation is far from obvious: it requires a good understanding of the business and its environment. Translation exposure, lastly, primarily affects book values rather than cash flows—except indirectly if and when changed book values generate tax effects.

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FC that matures on that date. It includes, per currency and per date, all A/R, A/P, deposits and loans denominated in a given FC, forward currency contracts, and contracts to buy or sell goods in future at known FC prices (Chapter 5). (Note that not all required information is found in the accounting system: commodity contracts where no delivery has been made yet, have not yet given rise to A/P or A/R, but they do generate contractual flows.) The exposure B then is the FC value, which is assumed to be risk-free.

- **Operating exposure** In the case of operating exposure one looks at the firm not as a portfolio of FC contracts signed in the past and generating cash in- or outflows in the future, but as a set of activities that require constant decisions by management, customers, and competitors. These future decisions depend, among other things, on future exchange rates, so that the cashflows are exposed in both FC and HC terms. (In the case of contractual exposure, in contrast, the FC amount is by assumption fixed, and only the HC value depends on the exchange rate.) In short, here $\tilde{V}_T$ is the cash flow from future operations rather than from past contracts, and the FC cash flow, C^*, is not a constant but depends on the future spot rate, $\tilde{S}_T$, and possibly other variables $\tilde{X}_T$: $\tilde{V}_T = C^*(\tilde{S}_T, \tilde{X}_T) \times \tilde{S}_T$.

- **Translation exposure** (or, less aptly, *accounting* exposure) arises when a multinational company has to consolidate its financial statements. As all subsidiaries' balance sheets and income statements are originally drawn up in the local currency, they must be translated first, and the result of this inevitably depends on the exchange rate at the reporting date.

Note that in the case of translation exposure we are talking about accounting values, that is, numbers written into books rather than cash flows that enter or leave bank accounts. To stress the difference, contractual and operating exposure are often referred to as *economic* exposures, as opposed to translation exposure.

We provide a more in-depth discussion of each of these in the rest of this chapter. We start with a discussion of contractual exposure.

13.2 Contractual-Exposure Hedging and its Limits

In Chapter 5 we saw already how one can close a contractual exposure, primarily by manipulating the financial items in the above list. We also saw how one can pool exposures for "similar" dates and hedge the aggregate net exposure, but too much grouping may create an interest-rate exposure problem. What we want to add now is a discussion of the limits and limitations of contractual-exposure hedging. First we consider the limitations: we show that hedging contractual exposure can achieve less than the uninitiated may have hoped. We then discuss the limits: how firm and certain should a cash flow be for it to be "contractual"; and what happens if we are less strict about this and include near-certain or even just "expected" cash flows?

13.2.1 What does Management of Contractual Exposure Achieve?

You may remember the example of Slite, the shipping line that keeled over when the devaluation of the FIM had made its new ship unaffordable. This could have been avoided by buying forward DEM. But this example is rather specific in that it involved a one-shot, and huge, exposure. The situation for a committed exporter or importer is different: there is a steady stream of in- or outflows, each of which is relatively small. The message to take home from this subsection is that even if such a firm continuously hedges all its contractual exposures, the impact of the exchange rate will be far from completely eliminated. There will still be exposure to the exchange rate from two sources: (*i*) exposure to variations in the forward rate, and (*ii*) "operating" exposure through the effect of the exchange rate on the volume of sales. We explain these issues below.

Consider an Italian firm, Viticola, which exports its fine wines to the US. Viticola can choose between at least two invoicing policies: (a) invoice in USD at (in the short run) constant US prices, and hedge each invoice in the forward market; or (b) invoice in EUR at (in the short run) constant home currency prices. In either case, Viticola has zero contractual exposure. Still, the exchange rate affects its profits:

- **Invoicing constant USD prices and hedging forward** Assume that the Italian firm extends three months credit to its US customers. If the firm hedges its contractual exposure systematically every time a new invoice is sent, its EUR cash flows ninety days later will be proportional to the ninety-day forward

rate prevailing at the invoicing date. If, on the other hand, Viticola does not hedge its contractual exposure, its cash flows will be proportional to the spot rate prevailing when the invoice matures. In the long run, both series will have a similar variability, with the hedged version following the swings in the unhedged one with a three-month lag.

Example 13.1

Suppose that Viticola sets the price of a bottle of wine at USD 10. If Viticola does not hedge its transaction exposure, the revenue in EUR from US sales is random, and depends on the EUR/USD spot rate prevailing in three months time: USD $10 \times \tilde{S}_{\text{t+3mo}}$. If, on the other hand, Viticola hedges each contract, the EUR cash flows from the sale of each bottle is USD $10 \times F_{t,t+3mo}$. You should realize, however, that even though the forward rate for three months from now is known today, future forward rates are as uncertain as future spot rates. Thus, the revenue from future sales is an uncertain number, equal to USD $10 \times \tilde{F}_{T_i,T_i+3mo}$. Every decrease in the EUR/USD spot rate means a virtually identical decrease in the forward exchange rate, which then is reflected in lower revenue for Viticola three months later.

Thus, even perfect hedging of contractual exposure does not reduce the long-run variability of cash flows; it merely facilitates three-month budget projections.

- **Invoicing constant EUR prices** This means we let the exchange rate determine the USD price. From a contractual exposure point of view, Viticola is perfectly hedged since the contract is denominated in its home currency. Clearly, however, a policy of holding constant the domestic currency price may create huge swings in the USD price of the product and, therefore, may result in huge changes in the volume of Viticola's sales and profits, as illustrated below.

  Example 13.2

  Suppose that Viticola decides to set the price of each bottle of wine it sells at EUR 10. At the current spot rate of EUR/USD 1, this implies a price of USD 10, a price at which Viticola can sell 10,000 bottles in the US, and its total revenue from US sales is EUR 100,000. Assume that next month the USD depreciates to EUR/USD 0.95. Given that Viticola does not change its EUR price, the US price, translated at the new exchange rate, is now USD 10.53. At this new price, in the competitive wine market, Viticola can sell only 9,000 bottles. Thus, the export revenue of Viticola now declines to $9,000 \times 10 = 90,000$. True, the firm can now sell an extra 1000 bottles at home, but exports were the preferred solution (at the old rate, at least) and extra domestic sales probably require extra discounts too. Clearly, the total revenue of Viticola is exposed to the exchange rate.

The second policy, with its constant EUR prices, guarantees a stable profit per bottle sold but may cause big swings in volume. So the exposure is there, even if

contractually there is none. The first policy, with its constant USD price, should guarantee fairly stable volumes, everything else being the same, but it leads to volatile profit margins. It is not obvious which of the two is the riskier, even after hedging. Hedging the expected USD revenue, if pricing is in USD, merely postpones the effects of exchange-rate changes on EUR revenue. In statistical jargon, hedging reduces the *conditional* variance of the 90-day cash flow to zero: conditional on what we know today (incl. the 90-day forward), there is no exchange-rate-related uncertainty about the 90-day cashflow. But unconditionally there is not much of a change in the variability. In still other words, Viticola's three-month budgets are less uncertain, but the uncertainty is merely pushed back 90 days. We still have no idea how the next three-month budget will look.

The alert reader may already have concluded that, in the long run, the pricing policy is actually more important than the invoicing decision. For instance, the exporter may invoice in EUR but adjust the EUR prices every month to compensate for changes in the exchange rate so as to keep the USD price roughly constant. In terms of contractual exposure, there is no risk (as invoicing is in EUR), but the variability of the profit margins remains. At the other extreme, the exporter may invoice in USD and hedge forward, but also adjust the USD price every month in order to maintain roughly constant EUR prices. Again, there is no contractual exposure, but the variability of the USD price and, hence, of the sales volumes remains. Whatever the policy, or whatever combination of policies a firm uses, future profits will remain exposed to exchange rate changes. Therefore, to hedge against changes in the exchange rate, one has to go beyond simply hedging contractual exposure.

13.2.2 How Certain are Certain Cashflows Anyway?

The other way to get to the same conclusion starts from the notion that the certainty seemingly implied by the word "contractual" is often illusory. There is always a non-zero probability of default on the counterpart's behalf, and occasionally the credit risk can be so big that one hesitates whether hedging is even a good idea.

Example 13.3

You signed a big export contract some time ago (time t_0), but now you hear that the company is in deep trouble. In fact, you estimate your chances of seeing the promised money to be about even. The deal is hedged and this forward sale has a current market value of $(F_{t_0,T} - F_{t,T})/(1 + r_{t,T})$. What to do now?:

- You could close out, "betting" on default by the customer. But if he survives and does pay, you have a open long spot position, the receivable.
- Alternatively, you could carry on, hoping for a happy end. The risk then is that there is default after all; and then you'll find yourself saddled with an open short forward position, this time the hedge.

Clearly, it is not obvious which alternative is more attractive: you are potentially damned if you do hedge and potentially damned if you don't. The only way to avoid dilemmas like this is to take out some form of credit insurance, which comes at a cost too.

While credit risk can be insured, other uncertainties about execution of a contract cannot. For instance, some contracts have built-in uncertainty, like cancellation clauses under certain conditions, or marking-to-market clauses if the exchange-rate change exceeds certain limits. In short, many contractual in- or outflows are not really certain.

On the other hand, some non-contractual positions are quite close to contracts, once one realizes that contracts offer no certainty anyway. What about a memorandum of understanding, or a letter of intent? What about a verbal deal—legally a contract as there is consensus, but hard to prove and, therefore, hard to enforce? What about near-certainty about future sales contracts based on experience from the past? Many committed exporters or importers would be tempted to go beyond pure contractual positions, and hedge also near-certain forex revenue, hoping to thus postpone the impact of exchange-rate changes beyond the credit period.[1]

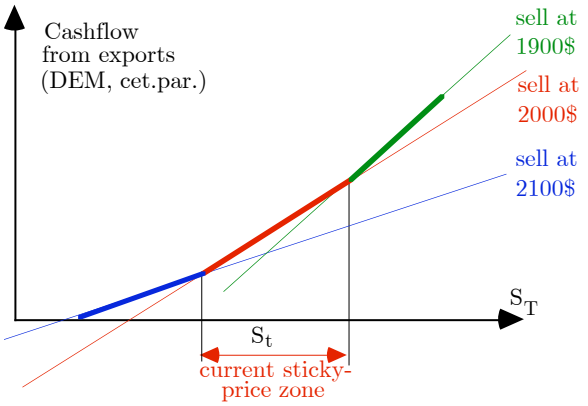
13.2.3 Hedging "Likely" Cashflows: what's new?

One should realize that the hedging of "likely" cash flows has two implications. First, noise creeps in, stemming from other variables than future exchange rates. Second, abstracting from noise, the relation between the HC cash flow and the exchange rate is likely to be convex. That is, we go from an exact linear relation (like $\tilde{V}_T = B_{t,T}\tilde{S}_T$) to a noisy and non-linear one: $\mathrm{E}(\tilde{V}_T|S_T) = f_{t,T}(\tilde{S}_T)$. How come?

The *noise* comes from the fact that the final decision still is to be taken by the customer (or the exporter), and this decision will inevitably depend on other variables than the exchange rate. A car exporter's foreign sales, for instance, will depend on other producers' prices and promotions, on interest rates for personal loans, the level of consumer confidence, etc. The *convexity*, on the other hand, stems from optimal reaction to exchange-rate changes. The exporter does have the option to sell at a constant FC price, in which case the translated revenue would rise or fall proportionally with the exchange rate, everything else being the same. But this passive policy will be abandoned if the exchange-rate change is sufficiently big and if reaction does improve the situation. Thus, in 1974 VW might have been exporting its beetles to the US at USD 2,000 apiece, but with a falling dollar and shrinking profit margins they would surely increase the USD price if that beats the passive policy. (This should probably have come with further changes in the marketing mix.) Even

[1] Recall that pure A/P hedging just postpones the impact of shifts by the credit period, like three months in the Viticola example.

Figure 13.2: **How Convexity Arises in Operating Exposure**



Key The lines show an exporter's HC cash flows for a given FC sales price, everything else being constant. The optimal price depends on the exchange rate. A policy of always choosing the best price leads to a convex relation between S and the expected cash flow.

abandoning exports would be an option: zero cash flows are better than negative ones. In the case of a rising dollar, similarly, VW might have considered lowering its USD price below 2,000, giving up some profit margin in exchange for more market share. Again, this will be adopted if it beats the passive policy. The final picture is one of a piecewise-linear, convex relation (Figure 13.2: passive sticky-prices policies for exchange rates close to the current level, but switching to new and better policies if the change has become sufficiently big.

In fact, in the above paragraph we have actually wandered from the realm of contractual exposure into that of short-term operating exposure. Before we proceed with this, let's point out one major implication of the fact that the effect of exchange-rate changes now is of a general non-linear form, $\mathrm{E}(\tilde{V}_T|S_T) = f_{t,T}(\tilde{S}_T)$, rather than a contractual-exposure type relation $\tilde{V}_T = B_{t,T}\tilde{S}_T$. The implication is that exposure is no longer some number of FC units that can be found in the balance sheet, or a FC cash flow as stated in a pro forma P&L. Rather, exposure has to be computed—notably from a comparison of two or more possible outcomes for the firm at time T, one outcome per possible exchange rate. As a colleague put it, "the idea is completely foreign to accounting-tied CFOs". Here's your chance to get ahead.

13.3 Measuring and Hedging of Operating Exposure

While contractual exposure focuses on the effect of the exchange rate on future cash flows whose value in foreign currency terms is contractually fixed in the past, operating exposure analyzes the impact of future exchange rates on *noncontractual* future cash flows. These FC cash flows that are likely to be random even in terms

of the foreign currency, partly as a result of other factors than exchange rates and partly because of the exporter's endogenous response to the exchange-rate change. Thus, the complicating factors relative to contractual exposure are that the relation between the HC cash flow $\tilde{V}_T$ and the exchange rate $\tilde{S}_T$ has become noisy and non-linear. Worse, the relation has become hard to identify, as it depends on the economic environment that the firm competes in, and on how the firm reacts to changes in the exchange rate, given its competitive environment.

13.3.1 Operating Exposure Comes in all Shapes & Sizes

There are at least two misconceptions about the source of operating exposure. The first misconception, already discarded in the previous section, is that if a firm denominates all of its sales and purchases in terms of its own currency, it faces no exposure to the exchange rate. We know better, now. The second misconception is that only those firms that have foreign operations are exposed to the exchange rate; that is, only those firms that buy or sell goods abroad or use imported inputs are exposed to the exchange rate, while firms that have only domestic operations are not exposed to the exchange rate. This is usually wrong too. For instance, an exchange-rate change can turn a potential foreign exporter into an active competitor:

Example 13.4

Consider a firm located in the US. Assume that the firm's production is based in the US, and that the firm uses only inputs that are produced in the US and that the firm's entire sales are in the US. The naive view would suggest that this firm's operations are not exposed to the exchange rate. This view is false if the firm faces competition from abroad. Every time the USD appreciates, the foreign competitors gain; they can lower their USD prices and still obtain the same amount of their own home currency. US firms that faced this type of situation include Caterpillar, Kodak, General Motors, and Chrysler. In the early 1980s, when the USD appreciated against the JPY, all of these firms lost market share to their Japanese competitors, Komatsu, Fuji, Honda, and Toyota respectively. This erosion of market share led to large decreases in profits for the US firms.

The second way an apparently non-international player may be affected by exchange rates is indirectly, at a remove: the firm may buy from local firms that, in turn, do import; or it may sell to local firms that, in turn, do export. Or, even more indirectly: in an economy with a large open sector, the general level of economic activity may depend on the state of health of the export and the import-substituting industries.

Example 13.5

A UK firm has set up a subsidiary in our favorite country, Freedonia. Assume, for simplicity, that the subsidiary's cash flow, in terms of the Freedonian crown (FDK),

can take on one of two (equally probable) values, FDK 150 or FDK 100, depending on whether the Freedonian economy is booming or in a recession. Let there also be two equally probable time-T spot rates, GBP/FDK 1.2 and 0.8. Thus, measured in terms of the home currency, the GBP, there are four possible outcomes for the future cash flows, as shown in Table 13.1. In each cell, we also show the joint probability of that particular combination of outcomes for the exchange rate and the state of the economy. When the FDK is expensive, a recession is more probable than a boom because an expensive currency means that Freedonia is not very competitive. The inverse happens when the crown is trading at a low level. Thus, we assume that the probability of the exchange rate being high and the economy booming is fairly low: 0.15 not 0.25,[2] and likewise for the unexpected combination of a cheap Krone and a slumping economy. The more expected outcomes get probabilities 0.35.

One step towards quantifying the impact of the exchange rate is to first compute the conditional expected cash flow for each level of the exchange rate—each row, in the table. These numbers are added in the right-most column of the table and amount to 138 when the rate is high, and 108 when the rate is low. Thus, the expected impact of the exchange rate change is 30 (million) pounds.

In the example, there is more risk than just the uncertainty about the exchange rate (with its differential impact of 30): here, there is no one-to-one relation between the state of the economy and the level of the exchange rate, so the the firm's cash flow is not yet fully certain once you observe (or hedge) the exchange rate. In regression parlance, this would be called a residual uncertainty.

The example also illustrates how the relation between the HC cash flow (or the FC cash flow) and the exchange rate can be noisy. Below, we give a simple example where a convexity arises from the exporter's optimal reaction.

Example 13.6

A French niche producer of bottled mineral water can export its output to the US, where it sells at USD 1.25 per bottle (the market price minus the shipment costs etc). But it can also sell at home, at EUR 1.00. Obviously, for $\tilde{S}_T < 0.80$, they better sell at home, while for higher rates the wiser solution is to export:

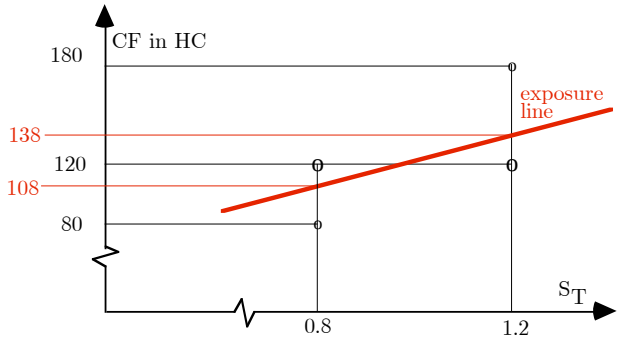
$$\tilde{V}_T = \begin{cases} 1.00 & , \quad \text{if } \tilde{S}_T \leq 0.80 \\ 1.25 \times \tilde{S}_T & , \quad \text{if } \tilde{S}_T > 0.80 \end{cases} \tag{13.2}$$

So the function is a piecewise linear one. (Figure 13.3).

[2] If the health of the Freedonian economy had been independent of the level of the spot rate, the probability of each cell would be $0.5 \times 0.5 = 0.25$.

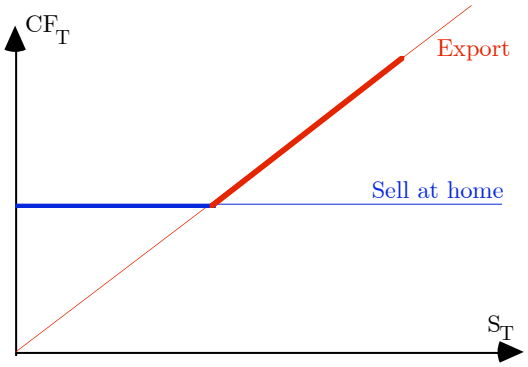
Table 13.1: **Joint distribution of $\tilde{S}_T$ and $\tilde{CF}_T$ for the Freedonian Subsidiary**

	boom: CF*= 150	bust : CF*= 100	$E(\tilde{V}_T\|S_T)$
$S_T = 1.2$	$150 \times 1.2 = 180$ $p = 0.15$	$100 \times 1.2 = 120$ $p = 0.35$	$\frac{180\times0.15+120\times0.35}{0.15+0.35}$ = GBP 138 $p = 0.50$
$S_T = 0.8$	$150 \times 0.8 = 120$ $p = 0.35$	$100 \times 0.8 = 80$ $p = 0.15$	$\frac{120\times0.35+80\times0.15}{0.35+0.15}$ = GBP 108 $p = 0.50$
	$p = 0.50$	$p = 0.50$	



The above examples are all about short-term exposures. By short term we mean, like in micro-economics, that the investments (P&E) are given; no major expansion or downsizing or relocation is being considered. Recall the example where VW was revising its marketing and pricing policies in light of the DEM/USD exchange rate. These were short-term reactions. But VW's reaction did become "long-term" when it considered moving its production abroad. In the late 70s, it effectively built factories in Brazil, Mexico and the US.

Figure 13.3: ***Bourbonnaise des Eaux*'s Option to Export Mineral Water**



Thus, operating exposure comes in all kinds of shapes & sizes. How, then, can one still hedge it? What is the measure of exposure? This depends on the type of hedge instrument one has in mind. When hedging is done with a linear tool like a spot or forward position, we have to approximate the (noisy, non-linear—remember?) relation by a linear one, using regression. If a non-linear hedge is used, for instance a portfolio of options, things are different. We begin with linear hedges.

13.3.2 The Minimum-Variance Approach to Measuring and Hedging Operating Exposure

Note from the definition of operating exposure given in Section 3 that exposure tells us by how much the cash flows of the firm change, for a unit change in the exchange rate. Adler and Dumas (1983) suggest the use of simulations to compute the economic exposure. The simulation requires that we come up with a number of possible future values for the spot exchange rate and compute the value, in home currency, of the cash flows for each possible future exchange-rate value. The exposure of the firm to the exchange rate can then be computed by decomposing the HC value of the asset or cash flow, $\tilde{V}_{T,s}$ in scenario $s = 1, ...n$, into a part linearly related to the spot rate in that scenario and a part uncorrelated with the spot rate—a technique commonly called linear regression:

$$\begin{aligned} \tilde{V}_{T,s} &= A_{t,T} + B_{t,T}\tilde{S}_{T,s} + \tilde{\epsilon}_{t,T,s}, \\ &= \underbrace{A_{t,T} + \tilde{\epsilon}_{t,T,s}}_{\substack{\text{uncorrelated} \\ \text{with } \tilde{S}}} + \underbrace{B_{t,T}\tilde{S}_{T,s}}_{\substack{\text{exactly linear} \\ \text{in } \tilde{S}}} . \end{aligned} \tag{13.3}$$

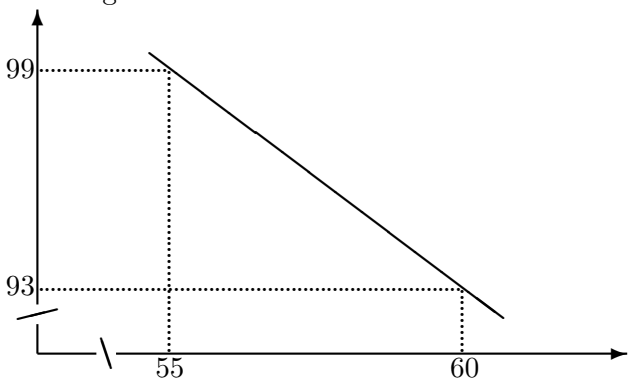
If $\tilde{V}$ were truly linear in $\tilde{S}$, we could have used the familiar conditional-expectation equation, $\mathrm{E}(\tilde{V}_{T,s}|S_{T,s}) = A_{t,T} + B_{t,T}S_T$, but that is usually not appropriate: the above is just a linear approximation or linear decomposition or linear projection of something that is really non-linear. But we need the linear approximation rather than the true relation because our hedge instrument is linear anyway. We start with a number of examples where the situation is so simple that the regression can be done naked-eye, almost. In the first illustration there isn't even any noise ($\tilde{\epsilon}$):

A Problem with just two Possible Exchange Rates, no Noise

Example 13.7

Belgium's Android MetaProducts NV/SA wishes to hedge its exposure to the exchange rate stemming from its ownership of a marketing affiliate located in UK. This is 1992, and the GBP has just formally joined the ERM after maintaining a constant rate for two years. Still there is risk: what worries Android is that, in the past few years, inflation has been substantially higher in the UK than on the continent, raising the question whether the current exchange rate, BEF/GBP 60, is sustainable. After discussion with its bankers, Android ends up with two possible outcomes:

Figure 13.4: **Android and the Pound**



- The UK government may switch to a strongly deflationary policy and stabilize the exchange rate at 60. Such a deflationary policy is expected to depress sales and would decrease the net cash flow of the marketing affiliate to GBP 1.55m.
- Alternatively, the UK government may let the GBP depreciate and follow a moderately deflationary policy. In this case, the exchange rate would be BEF GBP 55, and management expects a cash flow of GBP 1.8m. ———————

How can we hedge this? Obviously, as we have an asset denominated in pounds, the exposure seems bound to be positive—but should we hedge the lower amount, or the higher one, or something in between? The message below will be that the above "obvious" diagnosis is totally off the mark: the exposure is nowhere near the 1.55-1.80m range. In fact, it is massively negative. We see this by computing the two possible HC values:

$$\begin{aligned} \text{(no devaluation:)} \quad V_T &= 1.55m \times 60 = \text{BEF}\, 93m, \\ \text{(devaluation:)} \quad V_T &= 1.80m \times 55 = \text{BEF}\, 99m. \end{aligned}$$

This tells us that we win if the pound loses value, which means the exposure is negative. Figure 13.4 illustrates this. It is quite easy to compute the slope of the line connecting the two possible outcome points:

$$\text{slope} = \frac{93m - 99m}{60 - 55} = \frac{-6m}{5} = -\text{GBP}1.2m. \tag{13.4}$$

This slope is, of course, none other than our exposure, B: if there are just two possible points, the regression is the line through those two points. We now show that if Android takes a position in the forward market with the opposite sign—minus minus 1.2m, that is, buying forward 1.2m—it is hedged. Suppose that the forward rate is 58. The outcomes are analyzed as follows:

case	raw cash flow	outcome of hedge	hedged cash flow
S=60	93m	$1.2m \times (60 - 58) = +2.4m$	$93m + 2.4m = \text{BEF}95.4m$
S=55	99m	$1.2m \times (55 - 58) = -3.6m$	$99m - 3.6m = \text{BEF}95.4m$

DoItYourself problem 13.1

Verify that if the forward rate had been different, the level of the hedged cash flow would be affected but not the fact that the investment is hedged. For instance, with a forward rate of 57 instead of 58 the hedged asset would have been 1.2m higher, at 96.6m. Show it.

Remember two things from the example. First, exposure is computed from a comparison of alternative future outcomes, not from one single number found in a balance sheet or a pro forma cash flow statement for next year. Second, the size and (here) even the sign of exposure can be very different from what gut feeling would suggest. Here, an accounting-tied CFO would have taken for granted that exposure is positive: we talk about a GBP asset, don't we? Wrong; the position behaves like a 1.2m liability.

DoItYourself problem 13.2

We just showed that exposure defined as a slope of the line linking the two points does work: in this (overly simple) example, all risk is gone. Show that if you would have followed your intuition and had hedged (sold forward) GBP 1.55m, or GBP 1.8m, or in fact any positive number, the uncertainty after such "hedging" would have been higher than before.

A Problem with two Possible Exchange Rates and Noise

Let us generalize. The fact that the regression hedge always succeeds in taking away all exchange-related risk can be proven in just two lines:

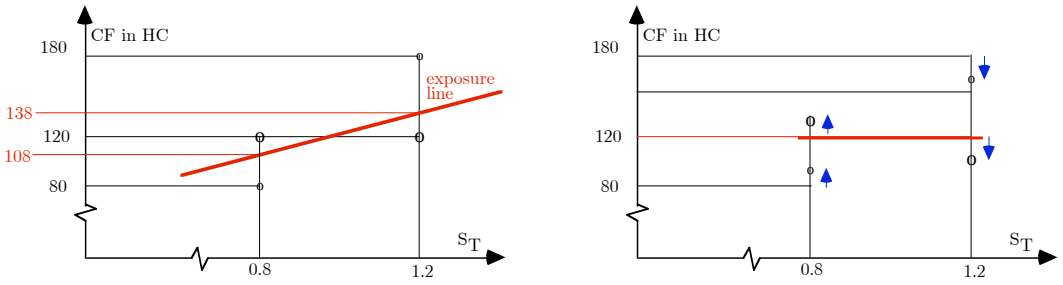
$$\begin{aligned}\tilde{V}_T^{\text{hedged}} &= \underbrace{A_{t,T}+B_{t,T}\tilde{S}_T+\tilde{\epsilon}_{t,T}}_{\text{value unhedged}}+\underbrace{[-B_{t,T}]}_{\substack{\text{size of}\\ \text{hedge}}}\underbrace{\left[\tilde{S}_T-F_{t,T}\right]}_{\substack{\text{expiry value}\\ \text{per GBP}}}, \\ &= \underbrace{A_{t,T}+\tilde{\epsilon}_{t,T}}_{\substack{\text{uncorrelated}\\ \text{with } \tilde{S}}}+\underbrace{B_{t,T}F_{t,T}}_{\text{risk-free}} . \end{aligned} \tag{13.5}$$

Thus, what regression-based hedging generally achieves is eliminating all uncertainty that is linearly related with the exchange rate: $B_{t,T}F_{t,T}$ has taken the place of $B_{t,T}\tilde{S}_T$. The uncertainty that is *not* correlated with the exchange rate, in contrast, cannot be picked up by the forward contract, so it remains there. It can be shown that this regression hedge ratio is also the one that reduces the variance of the remaining risk to the lowest possible level. This is why this section is called Minimum-Variance hedging and why ordinary regression is called Least Squares (=minimal residual variance).

In the Android example there was assumed to be no residual risk, which is hard to believe. Our earlier Freedonia example, in contrast, does have this feature: the state

Table 13.2: **Joint distribution of $\tilde{S}_T$ and $\tilde{CF}_T$ for the Freedonian Subsidiary**

	boom: CF*= 150	bust : CF*= 100	$E(\tilde{V}_T\|S_T)$
unhedged cash flows			
$S_T = 1.2$	$150 \times 1.2 = 180$ $p = 0.15$	$100 \times 1.2 = 120$ $p = 0.35$	$\frac{180\times0.15+120\times0.35}{0.15+0.35}$ = GBP138 $p = 0.50$
$S_T = 0.8$	$150 \times 0.8 = 120$ $p = 0.35$	$100 \times 0.8 = 80$ $p = 0.15$	$\frac{120\times0.35+80\times0.15}{0.35+0.15}$ = GBP108 $p = 0.50$
hedged cash flows			
$S_T = 1.2$	$180 - 18 = 162$	$120 - 18 = 102$	$\frac{162\times0.15+102\times0.35}{0.15+0.35}$ = GBP120
$S_T = 0.8$	$120 + 12 = 132$	$80 + 12 = 92$	$\frac{132\times0.35+92\times0.15}{0.35+0.15}$ = GBP120



of the economy (and, therefore, the cash flow) is not fully know once the exchange rate is observed, so there is only an imperfect correlation between the HC cash flow and the exchange rate. Table 13.2 repeats the Freedonia data and then shows the hedged cash flows. To find the hedged cash flows we of course need the exposure. In the case with just two possible values of $\tilde{S}_T$, the regression line runs through the points representing the conditional expectations. We identified these expectations as 138 when $S_T = 1.20$ and 108 when $S_T = 0.80$. So the exposure now equals

$$B_{t,T} = \frac{138 - 108}{1.20 - 0.80} = \frac{30}{0.4} = \text{FDK}75. \tag{13.6}$$

Note, in passing, that even though the cash flow, in FC, is either 150 or 100, the exposure is not even in the range [100, 150]: it equals 75. The only way to come with a meaningful exposure number again is to compare the two scenarios; neither scenario in itself gives you a reliable answer, nor does any accounting number. Let's show that our FC 75 does make sense. Assuming the forward rate is 0.96, the pay-offs from the hedges would be

$$\begin{aligned} \text{when } S_T = 1.20\text{:} \quad & -B_{t,T}(S_T - F_{t,T}) = -75 \times (1.20 - 0.96) \quad = \quad -18, \\ \text{when } S_T = 0.80\text{:} \quad & -B_{t,T}(S_T - F_{t,T}) = -75 \times (0.80 - 0.96) \quad = \quad +12. \end{aligned}$$

From the table, we see that now not all uncertainty is gone: the deviations between

cash flow and conditional expectations remain as large as before. That is because these deviations are the $\tilde{\epsilon}$'s, about which nothing can be done—at least not with currency forwards. But the conditional expected cash flows have been equalized, and as a result total risk is down. Again, this is the best reduction in the variance one can achieve, with these data.

General Minimum-Variance Hedging

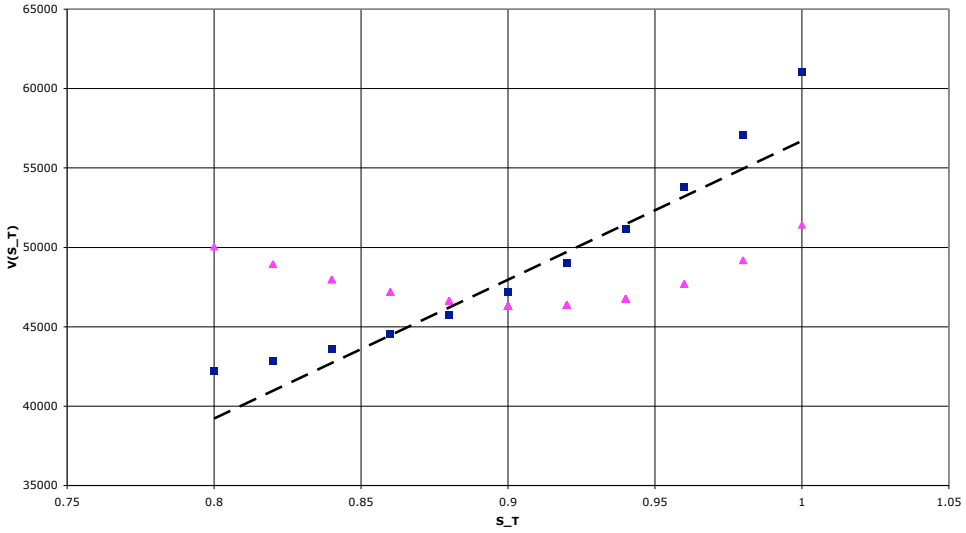
When, realistically, the exchange rate can assume many more values than just two, it is generally the case that all conditional expected values no longer lie on a line. In fact, on the basis of our optimal-response argument we would expect cash flows to be convex in the exchange rate. Table 13.3 gives an example. It shows eleven possible exchange rates, the corresponding expected cashflows (in HC), and the probabilities of each. The slope of the regression is 87370, and the R^2 0.92. Figure 13.5 shows the original expectations for each exchange rate (the upward-sloping array of little squares); the regression line; and the hedged expected cash flows (the little triangles in a smile pattern).

Two remarks about these results, for the statistically initiated reader. First, note that since the data do not contain deviations from the conditional expectations, this is not the usual R^2: it tells you that the regression captures 92 percent of the variability of the conditional expected cash flows, not of the potential cash flows themselves. So this tells you that the non-linearity is not terrible, but you cannot conclude that hedging reduces risk by 92 percent since the residual risk is being ignored, here. Second, you may be wondering how the hedged-expectations series, which shows quite some curvature, still only contains just 8 percent of the variability of the original data. The answer is that the data are probability-weighted. The "distant" ends of the hedged series contain low-probability events that have only a minor impact on the variance. We are not used to this: our typical regression data in other applications are never weighted this way, or rather, we always let the sample frequencies proxy for the probabilties. Thus, our eye is trained to see each dot on the graph as equally probable, whereas here the central dots represent many observations. (In fact, the low-tech way to weigh the data is to repeat the observations such that their frequencies in the data matrix become proportional to the probabilities.) The weighting also explains why the regression line looks like mostly "below" the data. This is just because the regression line is heavily attracted by the central data, where most of the probability mass is.

Table 13.3: **Data for a non-linear exposure example**

S	0.80	0.82	0.84	0.86	0.88	0.90	0.92	0.94	0.96	0.98	1.00
V	42181	42821	43607	44572	45754	47203	48977	51148	53805	57054	61026
p	0.02	0.04	0.06	0.10	0.16	0.24	0.16	0.10	0.06	0.04	0.02

Figure 13.5: **Results for the non-linear exposure example**



General Issues in Minimum-Variance Hedging

The above problems were kept simple, which is fine if the purpose is to explain the concept. Still, in fairness it must be added that the hedging of operations exposure is a bit of a minefield once you go to reality. Here is a list of the steps to be taken, and the issues to be solved:

- **Getting data** One can either go for data from the past, or numbers about possible future scenarios.
  - *Past data* One can proceed the way one estimates a market beta: collect past data on stock prices and exchange rates, and regress. We see the following problems. (*i*) This allows you, at best, to estimate the risk of the firm as a whole, not a new project or a separate business. (*ii*) The assumption is that the future is like the past, which is often not true: PPP deviations come in long swings, for instance, and exposure during a period of dollar overvaluation is a poor guide to exposure in the subsequent period of undervaluation. (*iii*) Even past exposure is estimated poorly because, for most firms, exchange risk is only a weak determinant of returns, which means that estimates are imprecise. (*iv*) If you nevertheless go for this data-mining approach, you should realise that, with time-series data, there is a problem of unit roots (ask your statistics teacher). This means that one has to use return data (percentage changes in values), not the value data themselves. The regression coefficient one gets from a returns regression is an elasticity (that is, $(\partial V/\partial S)(S/V)$) whereas the B we need is a partial derivative, $\partial V/\partial S$. So one would need an adjustment, multiplying the slope coefficient by V/S. Then a decision needs to

be made whether this correction will be based on the time series means, or the most recent values, or something else. We have no good guide to solve this issue.

– *Alternative scenarios for future cash-flows* The alternative to using time series of past data is to work with a cross section of alternative scenarios about the future. In principle this makes more sense. The only issue is the quality of these data in a real-world situation. The finance staff should know that the sales and cost data they get from Marketing and Operations, respectively, are crucial: if these are worthless, your hedge will be worthless too. Question them. Make sure the costs are not accounting COGS with mark-ups for overheads, for instance, but truly marginal cash outlays. Ask the marketing people how they would change their four or five P's under what scenario, thus forcing them to actually *think*.

- **Identifying the distribution of the future spot rate(s)** If you decide to work with scenarios, then you almost surely need to know how to weigh the possible pairs of possible future spot rates and associated expected cash flows. There are only three exceptions to this: weights are not needed if either it is reasonable to consider just two possible rates, like in the Android example, or if the expectations are linear in S, or if you go for a non-linear hedge (see below). But a two-point situation is exceptional; and if you get expected-cashflow data that are linear in S, that probably means the people who gave you the data were lazy: *a priori*, one expects convexity.

  Option traders typically start from a lognormal and then thicken the tails somewhat. You could get a standard deviation from them: ask for the "Implied Standard Deviation" or ISD. The mean, on the other hand, can be infered from the forward rate: we know there is, in principle, a risk correction that intervenes between CEQ()'s and E()'s, but it is small, both empirically and theoretically, and the choice of the mean has little impact on the regression anyway. Using forwards and ISDs, your forecasts for different horizons will be mutually compatible too. If you use a more wet-finger approach, compatibility over time is not guaranteed.

- **Linear or non-linear hedges?** When, realistically, the exchange rate can assume many more values than just two, it is generally the case that all conditional expected values no longer lie on a line. You then need to make up your mind as to whether you are happy with a static, linear hedge like we have discussed so far, or you prefer to go for a non-linear hedge. If, like in our example, the regression captures 92 percent of the expectations, you might be happy with the linear approximation and the associated hedge.

  The alternative is to go for a portfolio of options. In that case you construct a piecewise linear approximation to the data, using either your common sense

(helped by pencil and ruler) or a regression with linear splines.[3] You start with a forward hedge whose size is, for instance, equal to the slope in the first linear section. With options you then let the exposure of your hedge portfolio change wherever you want, mirroring the changing exposures of your expectations. Alternatively, you can use dynamic replication of the options, but this introduces model risk: the dynamic replication will not do as well as the option itself, and how badly it deviates depends on the adequacy of the model chosen. Dynamic hedging is described in Chapter 9, on the Binomial Model.

The advantages of the non-linear hedge are twofold. First, you do not need the probability distribution of S: you leave this to the market, which then builds its perceptions about the density into the option prices. Second, there is a better fit with the data. The drawbacks include higher complexity, higher transaction costs, and perhaps over-reliance on expectations data that are more seat-of-the-pants than you may wish.

- **Hedging other risks?** If cash flows depend on other variables beside the exchange rate, and if for these other variables one also has forward or futures contracts, then you have the option to hedge the other exposures too. For instance, the oil price could be such a variable. We denote the additional variable by X, and there could of course be more than one extra X. The mean-variance hedge now requires that you run a multiple regression, $V = A + B \cdot S + C \cdot X$. For this, you'll need far more scenarios, and a joint probability distribution for X and S, which is not easy.[4]

13.3.3 Economic Exposure: CFO's Summary

Let us conclude this review of economic exposure by summarizing a few crucial results and integrating them with ideas mentioned in earlier chapters.

We can divide economic exposure into two categories—contractual exposure (aka

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[3]First decide at what values of S you want a change of slope. These points are called knot points; for instance, in our example you may want a single change of slope, at $S = 0.90$ (right in the middle). Then make dummies $I_{k,j}$ indicating whether observation S_j is beyond the k-th knot point K_k; for instance, with one knot at $S = 0.90$, all observations with $S_j \geq 0.90$ get $I_{1,j} = 1$, and all lower observations get $I_{1,j} = 0$. Then regress $V_j = A + B_0 S_j + D_1[I_{1,j}(S_j - K_1)] + D_2[I_{2,j}(S_j - K_2)] \ldots$. The coefficient D_k tells you how much the slope changes in knot point K_k.

[4]Note that this makes sense only if you really want to hedge the additional risk with a linear hedge instrument, like oil futures or forwards. The econometrician's knee-jerk reaction is to add as many possible variables to a regression to improve the R^2 and isolate the contribution of S from that of other variables Z that are correlated with S. But if there is no hedge instrument for Z, sorting out the separate contributions of the two does not make sense. In fact, the difference between a multiple B and a simple-regression B is that the latter includes the effect of Z to the extent that Z resembles S. This is good, because then we at least do hedge the effect of Z (to the extent that Z resembles S).

transactions exposure) and operating exposure. Managers typically focus on contractual exposure, which arises from accounts receivable, accounts payable, long-term sales or purchase contracts, or financial positions expressed in foreign currency. This is because if one's source of information is accounting data, as it typically is, then transaction exposure is very visible and easy to measure. In contrast, operating exposure is much harder to quantify than contractual exposure; it requires a good understanding of competitive forces and of the macroeconomic environment in which the firm operates. For many firms, however, operating exposure is more important than contractual exposure, and it is critical that you make an attempt to identify and measure the exposure of operations to exchange rates.

Also, it is incorrect to assume that a firm with no foreign operations is not exposed to the exchange rate. For example, if a firm's competitors are located abroad, then changes in exchange rates will affect that firm's competitive position and its cash flows. Another common fallacy is the presumption that a policy of systematic hedging of all transaction exposure suffices to protect the firm against all exchange rate effects. As explained above, even if a firm perfectly hedges all contractual exposure, its operations are still exposed to the exchange rate.

Whether one considers transaction or operating exposure, one can use a forward contract (or the equivalent money-market hedge) to hedge the corresponding uncertainty in the firm's cash flow. Recall, however, that a forward or spot hedge is a double-edged sword. It is true that bad news about future operations is offset by gains on the forward hedge. However, you would likewise lose on the forward hedge if the exchange rate change improves the value of your operations. For example, in 1991, the Belgian group Acec Union Minière had hedged against a "further drop" of the USD. Instead, the USD rose, causing losses of no less than BEF 900m on the forward contracts. Four managers were fired. If you dislike this symmetry implicit in the payoff of a forward contract, you may consider hedging with options rather than forwards, to limit the downward risk without eliminating potential gains from exchange rate changes. As one banker once put it, "with a forward hedge you could end in the first row of the class or in the last; with an option, at worst you end somewhat below the middle."

A second potential problem that a treasurer needs to be aware of, when using short-term forward contracts to hedge long-term exposure, is the possibility of ruin risk, that is, liquidity problems that arise when there is a mismatch between the maturity of the underlying position and the hedging instrument. These liquidity concerns already came up in our discussion about hedging with futures contracts that are marked to market, but they arise any time the hedge triggers cash flows that come ahead of the exposed cash flow itself, for instance if a five-year exposure is covered by five consecutive one-year contracts.

Third, remember that, unlike many contractual exposures, operating exposure cannot be obtained from a balance sheet or a pro forma P&L statement. It has to be deduced from a cross-sectional analysis of possible future outcomes—cash flows, typically. The level of the true exposure can be totally out of the ballpark of the sizes

of the exposed cashflows themselves, and can even have a different sign: remember the Android example.

Fourth, it is important to keep in mind that the estimate of exposure that one calculates changes over time, and may not be very precise at any given moment. However, this measure is useful—even if it gives us only an approximate indication of the sign and size of a firm's exposure—because it forces us to think about the way exchange rates affect the firm's operations.

Finally, hedging is like an aspirine—quite useful for short-term headaches but not a long-run remedy for most serious diseases. It does provide you with a financial gain that is intended to offset operating losses, but it does not reduce the operating losses themselves. One can live with operating losses as long as they are temporary; and the point of hedging, in such a case, is that it does provide the cash that tides you over a bad patch. But if the problem is likely to be more than just temporary, you need strategic changes in operations—for example, revising the marketing mix, reallocating production, choosing new sourcing policies to reduce exposure, and so on. Again, financial hedging just provides cash that eases the pain and helps financing the adjustments; it does not solve the underlying problem.

In this respect, when making scenario projections about the possible future exchange rates, we should also make contingency plans for various possible future exchange rates, including less likely ones. One can win crucial time if the response has been talked through before; otherwise one wastes too much time deciding what exchange-rate changes are "big" and "structural" or not, what the available options are, not to mention who should be on the "task force" that ruminates on all this, and so on and so forth.

This finishes our discussion of economic exposures. We now turn to translation exposure.

13.4 Accounting Exposure

The $\tilde{V}_T$ entry in the exposure definition has been interpreted, thus far, as the portfolio of contractual FC-denominated undertakings inherited from the past, or a portfolio of activities that need continuous decisions influenced by, amongst other things, exchange rates. The third definition we discuss is the firm's accounting value. This accounting value may be affected by exchange rates in two ways. First, the firm may have contractual exposures which the firm is also *marking to market*, thus adjusting their book values to the rates that prevail on the valuation date. Second, the firm may have foreign subsidiaries, and the HC value of their *net worth*, in the accounting sense of the word, probably depends to some extent on the exchange rate that prevails on the consolidation date.

13.4.1 Accounting Exposure of Contractual Forex Positions

The issue of how to book contractual exposures has been brought up already in Chapter 5, where we argued that translation at the then prevailing forward rates makes more sense. Still, many firms use the spot rate. The issue here is different, though. Notably, if the firm has booked a contractual position in the past, should it adjust the book value on the reporting date, and, if so, how?

A/P, A/R, deposits, loans For these items, both US GAAP and the IFRS rules would agree, sensibly, that marking to market is recommendable; in the case of IFRS, that even is the general rule. Our earlier logic would then imply that the current forward rate be used to translate the values of A/R, A/P, deposits, loans, etc. into HC. (Ideally, one would also correct for time value and changes therein by PV'ing all numbers, but this is still too rarely done even though IFRS supports this). Any increase of the value of an asset would be balanced by an increased "liability", the unrealized capital gain that adds to the shareholders' net worth. (Similar statements can be made for losses, and for short positions, of course.) Being unrealized, many managers would prefer that the gain would not pass through Profit&Loss first, but IFRS begs to differ.

Futures For futures hedges and the like, the same logic holds. Instead of mentioning a zero value off balance sheet for a futures contract, one can add a capital gain or loss $f_{t,T} - f_{t_0,T}$. This entry is the counterpart, on the liability side, of all net marking-to-market cash flows that have been received from the Clearing Corporation since the initial value date t_0 (or the beginning of the accounting period if there has been at least one earlier financial report, which presumably contains the gains/losses prior to that date) and, therefore, have already shown up in "bank account", on the assets side of the balance sheet. If the marking-to-market cash flows have the character of a final payment rather than adjustments to security posted—the tell-tale symptom would be that there is no interest earned on outward payments, nor due on inward payments—then one could argue that the gain or loss is realised and, therefore, should be shown as part of P&L rather than just as an unrealized item among the shareholders' funds. This is the FASB position. The IAS position, as reflected in IFRS, is that all gains or losses have to be shown, whether realized or not.

Note that, if the firm has taken out a futures contract to hedge another position, and if that other position is not being marked to market and if the firm has to book its marking-to-market cash flows on the futures as a profit or loss, then realized profits become more volatile even though the hedging aims to reduce variability. In that case, the FASB would waive the requirement to book the gains and losses via P&L, provided the futures position was immediately designated as a hedge of a well-identified balance-sheet item. There is no such rule for forwards (where, by FASB rules, marking-to-market does not have to go through P&L) or cash hedges (where, presumably, the firm's marking-to-market rules for hedge and hedgee are always in agreement). But there is no similar rule either for exposures that are not

Table 13.4: Valuation using IFRS, pure spot, and pure forward rules

		balance-sheet items						gains (+) or losses (-) on marking to market of ...		
		Cash & bank	Invntry	A/P	*budgeted asset*	*budgeted liability*	forward	cmmtmnt	A/P	forward
CURRENT IFRS										
15-Oct S=1.000; F=1.018	order	n.a.	n.a.	n.a.	*1,018*	*1,018*	0		n.a.	
15-Nov S=1.020; F=1.035	book invoice a S			1,020		*1,018*		-2		
	book goods at S-dF		1,003		*-1,018*			-15		
	marking to market of hedge						17			17
	subtotals		1,003	1,020	*0*	*0*	17	-17		17
31-Dec S=1.040; F=1.045	marking to market of A/P			20					-20	
	marking to market of hedge						10			10
	subtotals		1,003	1,040	*0*	*0*	27	-17	-20	27
15-Jan S=1.015=F	marking to market of A/P			-25					25	
	marking to market of hedge						-30			-30
	pay bill, close A/P \& forw	-1,018		-1,015			3			
	subtotals	-1,018	1,003	0	*0*	*0*	0	-17	5	-3

Key The entries shown in italics are not actually used in IFRS but help explain what is done. A good is ordered at t_o for a foreign-currency price 1,000. At the time of ordering, the firm is assumed to record the future goods and the future A/P into its budget at the initial forward rate, 1.018. It closes these budget accounts and makes genuine accounting entries when the goods are actually delivered. At t_b, the invoice is entered at spot (1.020), leaving a loss of 2 relative to the initial valuation of 1.018. At t_b, the interim gain on the forward purchase is recognized (+17 pips). The cost of of the good is recognized to be only 1003, namely, the A/P value 1.020 minus the gain on the hedge, 17. The total result on the commitment consists of –2 (when the liability is entered as 1.020 instead of the initial entry, 1.018) and –15 when the asset is booked at 1.003 instead of its initial valuation, 1.018.

At year end, all positions are marked to market. The bookings for the date the invoice is paid start by marking everything to market again and then realizing the total loss on the forward contract (3, when currency worth 1.015 is bought at the original forward price of 1.018. The three lines can. of course, be merged into two or even one line.

yet in the balance sheet, which is anomalous, economically. Also, while the rule says that "speculative" futures positions should be fully marked to market, there is no such requirement for speculative positions in forward or spot markets.

Forwards For forwards there is no cash movement prior to expiry, so the accounting entries in case of a gain on a long position would be (*i*) a revaluation of an asset with original book value zero, and (*ii*) an upward adjustment in shareholders' funds, possibly as an unrealized and undistributable item. Again, almost surely the time value part that we showed in Chapter 4 would be missing: only the un-PV'ed part $F_{t,T} - F_{T_0,T}$ would be reported.

IFRS prescribes that all forward positions be shown—initially at zero value, and later marked to market using the change in the forward rate (undiscounted). The A/R or A/P position is to be booked at the spot rate, and marked to market at the spot rate. So the marking-to-market (M2M) of hedge and hedgee will roughly match but the difference between initial spot and forward is treated as a capital gain or loss—a bad idea, I argued in Chapter 5, because laypersons will think it actually *means* something.

The rule that forwards need to be M2M-ed creates a problem if the hedge is undertaken before the invoice is written or received: then, pending the invoice, the

forward contract would already trigger M2M cashflows while there are no roughly-matching M2Ms for a hedgee yet. Thus, again, the hedge would add uncertainty to the reported results even though it actually stabilizes cash flows. To solve this, IFRS could have decided to start booking the hedgee transaction at the date of *firm commitment*—presumably also the date the hedge is undertaken—rather than the date of the invoice or transfer of ownership, but that would have been a major change in accounting practices. For this reason, IFRS concocts an account 'firm commitments', which just absorbs any gains and losses in the forward contract during this initial period. For this to be possible, the hedge must be immediately designed as such, and linked to the specific transaction.

Example 13.8

Kayblan Whyer US orders glass fiber cables worth EUR 1m on October 15. The wares are shipped and invoiced on November 15. On December 31 the A/P is marked to market, and it is paid on January 15. In Table 13.4 I show the entries—as numbers in columns that stand for accounts, not as debits and credits, because columns are easier to follow. The columns on forwards and firm commitments are relevant only if Kayblan does hedge.

* * *

This finishes our brief discussion on updating the book values of contractual exposures. But these are only part of the balance-sheet items that might be affected. As mentioned already, also a subsidiary's P&L and A&L statements may have to be translated, for consolidation of the accounts, for instance. We first list some of the reasons why the financial statements of a subsidiary need to be translated into the currency of the parent firm. Next we describe the four main translation methods. We conclude with a discussion of the relevance of translation exposure.

13.4.2 Why Firms Need to Translate Financial Statements

If some of the subsidiaries of a firm are located abroad, their financial statements are typically maintained in terms of the local currency, which is foreign to the parent. There are a number of reasons why the financial statements of the subsidiary may need to be translated into other currencies—most often, the parent company's home currency:

- **Taxes** Translation is often necessary for tax purposes, notably if the tax authorities of the parent's home country have to review the subsidiaries' financial statements to establish the tax basis (as explained in Chapter 20). Taxes in the parent's home country, on income earned by the foreign subsidiary are, of course, payable in home currency. This means that the foreign income has to be translated into the home currency. Also, capital gains arising from exchange rate changes may be taxable; if so, to compute the capital gain, one needs to translate the value of the foreign subsidiary into home currency terms. Thus,

translation exposure, even though it deals with accounting data, can have an impact on cash flows through its effect on the tax basis.

- **Consolidated Financial Statements** Most countries require consolidation of the parent's and subsidiaries' financial statements for reporting purposes. Consolidation here refers to the integration of the financial statements of the firm's subsidiaries into the parent's asset and liabilities (A&L) and profit and loss (P&L) statements. Of course, one needs to first translate the financial statements of the subsidiary before they can be consolidated with those of the parent.

- **Performance evaluation and budget allocation across subsidiaries** The parent firm itself may feel the need to translate the financial statements of foreign subsidiaries. This is because one needs to compare data in order to allocate investment budgets or to evaluate the performance of the subsidiary. For example, even to get some idea about the importance of a foreign unit, one needs to determine its value in terms of a common currency. Of course, importance cannot be determined on the basis of a single figure and surely not on the basis of just backward-looking accounting data. Still, translated accounting data give a first impression of the relative importance of the foreign activities.

- **Bonuses** In order to make performance measures comparable, foreign data need to be translated into a common currency. For example, many firms have bonus plans that link their managers' compensation to their performance. Decisions to promote or fire managers are also based on performance. To make such decisions, one needs to translate the financial statements of the foreign subsidiaries into the currency of the parent.

- **Valuation** To value the entire firm (as an outside investor or financial analyst), one needs far more than just accounting data. Still, valuation is often partially based on accounting values; or, at the very least, the accounting value serves as a benchmark. For instance, if the discounted cash flow value of the entire firm turns out to be four times its book value, one would surely take a closer look at both types of information. Again, the book value of the firm as a whole cannot be computed unless assets and liabilities of foreign subsidiaries are first translated into a common currency.

In the next section we first discuss the general objectives that any method used to translate the accounts of the subsidiary into the currency of the parent firm tries to accomplish, and then the details of the various methods that are used for translation.

13.4.3 The Choice of Different Translation Methods

Accounting exposure arises because the outcome of translating a subsidiary's balance sheet from foreign currency to home currency depends on the exchange rate at the date of consolidation, an exchange rate that is uncertain. Firms may like to hedge this exposure to reduce or eliminate the swings in reported profits that arise simply due to these translation effects. This exposure, of course, depends on the rules used to translate the accounts of the subsidiary into the currency of the parent firm. There are a variety of approaches that one can adopt to translate the income statement and balance sheet items of the subsidiary into the currency of the parent firm.

Example 13.9

Suppose a Canadian firm buys a competitor in England for GBP 1m, when the exchange rate is CAD/GBP 2.0. A year later, the exchange rate is CAD/GBP 2.1. Thus, assuming that the subsidiary is still worth GBP 1m and translation is done at CAD/GBP 2.1, its translated value in terms of the currency of the parent is CAD 2.1m. One question is whether one *should* translate the GBP value at the new rate at all; and, if the answer is positive, the next question is how to report this increase in the value of the British subsidiary in the accounts of the parent firm. For example, should the exchange rate effect be shown as part of the reporting period's income, or should it just be mentioned on the balance sheet, as an unrealized gain?

If the decision is to translate at the historical exchange rate—the one prevailing when the asset was purchased—then there is no translation exposure. Otherwise there is, but its size depends on how one translates; for example, one could opine that real assets do not really lose value following a devaluation, etc.

The above example illustrates what the controversy between accountants is all about. Accountants do not agree which assets and liabilities should be translated at the historical exchange rate and which at the "current" or "closing" exchange rate, that is, at the rate prevailing at the date of consolidation. There is also some disagreement about whether and when exchange rate gains or losses should be recognized in income. A major criterion of accountants in devising the translation rules is whether these rules are consistent with the rules for domestic accounting. However, from a firm's point of view, the principal requirement is that the rules be such that they provide accurate information about the performance of the subsidiary. Lastly, firms also wish that the rules be such that they do not lead to wide swings in the figures reported in the financial statements.

In the rest of this section, we describe four different translation methods and the philosophy underlying each method. Each method has a set of rules for translating items in the balance sheet and the income statement. The rules for translating items in the income statement are quite similar across the different methods; hence, we will focus on the rules for items reported in the balance sheet. To illustrate the differences between these methods, we shall consider the example of an Australian

Table 13.5: **Translating the Australian Balance Sheet into MTL**

	Value in AUD	values in MTL after translation at 0.333 or 0.300					
		curr/noncurr		mon/nonmon		closing rate	
		(at .333)	(at .3)	(at .333)	(at .3)	(at .333)	(at .3)
Assets							
cash, securities	1,000	333	300	333	300	333	300
A/R	1,000	333	300	333	300	333	300
inventory	1,000	333	300	*325*	*325*	333	300
plant, equipment	5,000	*1,625*	*1,625*	*1,625*	*1,625*	1,665	1,500
Total assets (a)	8,000	2,624	2,525	2,616	2,550	2,664	2,400
Liabilities							
A/P	500	166.5	150	166.5	150	166.5	150
Short-term debt	2,000	666.0	600	666.0	600	666.0	600
Long-term debt	2,400	*780.0*	*780.0*	799.2	720.0	799.2	720.0
Total Debt (b)	4,900	1,612.5	1,530	1,631.7	1,470	1,631.7	1,470
Net worth (a)–(b)	3,100	1,011.5	995.0	984.3	1,080.0	1032.3	930.0
of which:							
Retained	0	*0*	*0*	*0*	*0*	*0*	*0*
Equity	3,100	*1002.0*	*1002.0*	*1002.0*	*1002.0*	*1002.0*	*1002.0*
Eq Adjustment	—	9.5	7.0	17.7	78.0	30.3	72.0
exposure of net worth		$\frac{1011.5-955.0}{0.333-0.300}$ = AUD 500 = nt wrkng cptl		$\frac{984.3-1080.0}{0.333-0.300}$ = AUD–2,900 = nt mon. assets		$\frac{1032.3-930.0}{0.333-0.300}$ = AUD 3.100 = net worth	

Key Items deemed to be non-exposed are printed in italics.

subsidiary of a Maltese firm. A simplified balance sheet of the subsidiary is shown in the second column (value in AUD) of Table 13.5. We shall explain the notion of accounting exposure by considering translation on December 31, 2007, at two different exchange rates, MTL/AUD 0.333 and MTL/AUD 0.300, and by seeing how the value of the subsidiary changes depending on the accounting method being used. Throughout this discussion, our focus will be to study what the different translation methods imply for the firm's accounting exposure.

The four methods all share the following steps: (*i*) translate assets and debt, using the method's rules as to what items are exposed or not; (*ii*) compute net worth (assets minus debts, in HC); (*iii*) subtract equity at historic valuation (including past retained earnings, each at its own historic valuation) to identify the balancing item, Equity Adjustments.

The Current/Non-Current Method

The Current/Non-Current Method for translating the financial statements of foreign subsidiaries is one that was commonly used in the US until the mid-1970s. As its name suggests, whether an item is translated at the closing exchange rate or the historical rate depends on its time to maturity. Thus, according to this method, current (*i.e.* short-term) assets and liabilities in the balance sheet are translated at the closing exchange rate, while non-current items, such as long-term debt, are translated at the historical rate. The logic underlying this is that the value of short-term assets and liabilities is fixed, or at least quite sticky, in AUD terms, so that its HC value changes proportionally with the exchange rate. For example, the future value of a AUD T-bill is fixed in AUD nominal terms; and, in the short-term, goods prices are sticky and therefore quasi-fixed in AUD terms, too. Long-term assets and liabilities, in contrast, will not be realized in the short run—and by the time they are realized, the closing exchange rate change may very well turn out to have been undone by later, opposite changes in the spot rate. That is, the effect of a closing exchange rate change on the realization value of long-term assets and liabilities is very uncertain. As accountants hesitate to recognize gains or losses that are very uncertain, the Current/Non-Current Method simply prefers to classify the long-term assets and liabilities as unexposed.

Thus, under the Current/Non-Current Method, translation at the closing rate is restricted to only the short-term assets and liabilities. Thus, exposure is given by the difference in short-term assets and liabilities, that is, Net Working Capital.

Example 13.10

In Table 13.5, we assume that long-term debt was issued and long-term assets (plant and equipment) were bought in early 2007, at which time the exchange rate was MTL/AUD 0.325. Thus, these items are recorded at their historical values (indicated as italicized text) and are not affected by the exchange rate. It follows that net exposure equals short-term assets minus short-term liabilities, or net working capital—AUD 500. The effect of the exchange-rate change from 0333 to 0.300 is a drop in net worth of AUD $500 \times (-0.033) = -$MTL 16.5.

Evaluation

- The assumption underlying this method seems to be that there is mean-reversion in exchange rates; that is, exchange rate fluctuations tend to be undone in the medium run, which (if true) means that they affect short-term assets only. However, as discussed in Chapter 11, there is little empirical support for this view (except for the small movements of exchange rates around a central parity): typically, changes in exchange rates are not undone in the medium run, and floating exchange rates behave like random walks.
- Most firms have positive net working capital and would therefore be deemed to be positively exposed (losing value, that is, following a devaluation of the host currency). Yet economic logic says that the true effect on economic value

should be hard to predict in general, depending, for instance, on whether the firm is an exporter or an importer, a price taker or a price leader, in a small open economy or in a large, closed one, or competing against locals or versus foreign companies, etc. Thus, there is little hope that this method will capture the true value effect except by pure serendipity.

- The consolidated accounts are not compatible with the subsidiary's original accounts. The relative values of items differ according to whether one uses HC or FC numbers, and many of the standard ratios will be affected. This is not good news if e.g. performance analysis is based on ratios.
- The resulting translated balance sheet is a mixture of actual and historic rates and, therefore, hard to interpret.

To translate the subsidiary's income statement, the Current/Non-Current Rate Method uses an average exchange rate for the period, assuming that cash flows come evenly over the period—except for incomes or costs corresponding to non-recurrent items (like depreciation of assets): these are translated at the same rate as the corresponding balance sheet item. This creates another inconsistency between the AUD and MTL P&L figures, and between the translated P&L and A&L figures.

The Monetary/Non-monetary Methods

The Monetary/Non-Monetary Method and its close kin, the Temporal Method are said to be ideally suited if the foreign operation forms an integral part of the parent. The idea is that, accordingly, the translation should stay as close as possible to what would have happened if the operation had been run as a branch, that is, just a part of the main company that happens to be active abroad and has assets abroad but does not have a separate legal personality.

If the foreign business had been a branch indeed, without any separate accounting system, the translation issue would not have arisen: everything would have been in the parents' books already, in HC, except for monetary assets whose value by definition is fixed in FC terms and needs to be translated. For instance, if the parent firm held forex cash or other monetary assets expressed in forex, any value change would have been recorded and probably included into the parent's P&L; but its machines and buildings would have been unaffected, in terms of book value, by exchange-rate changes. Since by assumption the subsidiary is really a part of the parent, the subsidiary's monetary A&L are translated at the closing rate, and the non-monetary items at the historic rate. Any resulting gains or losses are mentioned among the reserves, as unrealized gains or losses.

The above argument assumes that domestic assets are valued at historic cost, which principle is becoming less and less popular. But there exist another angle to justify the rule. It is sometimes argued that, in the long run, inflation differentials should undo exchange rate changes (PPP). So in the long run the real value of real

assets will not be affected. Thus, according to this method, we should adjust only the monetary (not the real) assets and liabilities for changes in the exchange rate. It follows that only the net foreign-currency monetary position, financial assets minus debt, is exposed.

Example 13.11

In Table 13.5, the Net Worth figures under each of the two possible year-end exchange rates differ by MTL +95.7. The exposure was $2000 - 4900 = -2900$ (AUD), under this method.

Evaluation

- The Purchasing Power Parity view of the world has received little empirical support, except vaguely in the never-arriving long run.[5] Accountants usually do not rely on highly uncertain prospects.
- In addition, PPP just says that translated values of assets abroad tend to be equal to values at home. If true, this would mean that changes in values of foreign and domestic assets are equal to each other; but there is no claim that the value change at home is zero.
- Likewise, in the "closely related operations" versions of the story the non-monetary assets are treated like they would have been treated if they were at home and, therefore, left unchanged. But that's historic costing. In many cases, under replacement value or fair value the value of the foreign-based asset would differ from one at home, and the argument would break down.
- This measure of exposure, financial assets minus debts, is likely to be negative for most firms. Thus, under the Monetary/Non-Monetary Method, a devaluation will typically lead to an accounting gain rather than to a loss. But, from our earlier discussion on a related point in the Current/Noncurrent method, economic reality should be very different for different firms, so the hope that this method produces the true number is, again, slim.
- Also here, HC relative values differ from FC ones, affecting ratios; there is no consistency.
- Finally, the resulting mixture of actual and historic translations is again hard to interpret.

To translate the subsidiary's income statement, the Monetary/Non-Monetary Method uses an average exchange rate for the period, except for incomes or costs

[5] Recall that all we know is that uncertainty about future real exchange rates does not grow proportionally with the length of the horizon, which is a far cry from uncertainty somehow disappearing entirely the longer one waits.

corresponding from non-monetary sources (like depreciation of assets). These are translated at the same rate as the corresponding balance sheet item. This again creates an inconsistency between the AUD and MTL P&L figures, and between the translated P&L and A&L figures.

The Temporal Method

The Temporal Method of translating the financial statements of a foreign subsidiary is similar to the Monetary/Non-Monetary Method. One difference between the two methods arises if "real" items have been marked to market in HC. As we saw, under the monetary system, inventory is always translated at the historical exchange rate, since it is a non-monetary asset. Under the Temporal Method, in contrast, inventory may be translated at the current (*i.e.* closing) exchange rate if it is recorded in the balance sheet at current market prices. The advantage of this approach is that it is less inconsistent with the accounting rules used for the parent firm if the parent marks to market its domestic inventory too. Another aspect of the temporal method is that it makes translation effects part of reported income, which can lead to large swings in reported earnings. Thus, under this method CFOs tried to hedge exposures that were just arbitrary paper results, not real cash flows.

The US accounting directive that was used from 1976 to 1981, FASB 8, was based on the Temporal Method. (Prior to that, the US imposed the Current-Noncurrent method.) The Closing Rate Method, introduced by FASB 52 in the US, is designed to overcome some of these problems.

The Current- or Closing-Rate Method

This is the simplest approach for translating financial statements. According to the Current Rate Method or Closing Rate Method, all balance sheet items are translated at the closing exchange rate. Typically, exchange gains are reported separately in a special equity account on the parent's balance sheet, thus avoiding large variations in reported earnings, and these unrealized exchange gains are not taxed.

Example 13.12
For the Australian subsidiary's simplified balance sheet, the exposed amount is net worth, AUD 3,100.

Evaluation

- The main advantage is consistency between the parent's and subsidiary's relative numbers. Likewise, using one rate produces a number that is easier to interpret than one resulting from mixtures of closing and historic translations.[6]

[6] If the subsidiary's accounts themselves mix historic costs—some of them possibly very dated—

- Under this method, a 15% devaluation means a 15% decrease in the net value of the investment. Economically, one expects that a devaluation of, say, 15 percent leads to a value loss of 15 percent only if all subsequent cash flows are unaffected (in HC terms), which assumes a very closed economy. So, again, this method is unlikely to capture the true economic effect.

To translate the income statement, one translates all items at either the closing exchange rate or the average exchange rate of the reporting period. The first method is chosen for consistency with the balance sheet translation. The second method is based on the argument that expenses that have been made gradually over the year should be translated at the average exchange rate. (Curiously, this argument does not seem to apply to expenses that end up capitalized into balance-sheet items.) Profits, the argument goes, are realized gradually over the year, and should be translated at an average rate. This, of course, contradicts the translation of the balance sheet at a single exchange rate.

13.4.4 Accounting Exposure: CFO's Summary

As we have seen, there are various methods to translate a subsidiary's balance sheet into the parent's currency. Many regulating bodies favor the Closing Rate Method. For example, the US Financial Accounting Standards Board has essentially imposed this method (FASB #52, 1982) for most operations, and allows the old Temporal Method only for foreign operations closely integrated with the domestic headquarters. Similar rules were issued soon thereafter in the UK and Canada. The International Accounting Standards Committee has likewise come out in favor of the Closing Rate Method (IASC #21, 1983—a text that, unlike FASB #52, is well-written, lucid, and short), again except for closely related operations, where the Temporal Method is imposed.

However, the IASC can provide recommendations only; it has no statutory power to impose accounting rules anywhere. In continental Europe there is no consensus as to what method is to be followed. For example, in many countries (including, until the early nineties, Italy and Belgium), consolidation was not mandatory and, therefore, not regulated, while in other countries (including Germany), the obligation to consolidate was not extended to foreign subsidiaries. The EC 7th Directive, passed in 1983 and implemented in most member states by the early nineties, imposes consolidation but does not prescribe any particular translation method. The only requirement is that the notes to the accounts should disclose the method that was used. Only under IFRS, the IAS rules do apply; but in the EU IFRS is mandatory only for listed companies and financials. Other companies can use traditional local GAAP, which typically leaves considerable discretion.

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with true(er) recent valuations, the result remains hard to interpret. But at least the translation procedure no longer adds to that problem.

Given the wide choice that is offered in many cases, one could wonder which method is best. And even where one particular method is imposed, one could consider whether it is useful to adopt a different method for internal reporting purposes. Even more fundamentally, one could ask whether accounting exposure matters at all. Let us briefly dwell on this before we close this chapter.

From the discussion of the various translation methods, we see that the question of which translation method to choose is similar to the issue of whether the firm should use the method of last-in/first-out (LIFO), or first-in/first-out (FIFO), or some average cost, for the purpose of valuing its inventory. One could argue that the accounting method for inventory valuation does not matter, since a shift from, say, LIFO to FIFO will change neither the firm's physical inventory nor its cash flows (except possibly through an effect on taxes). Moreover, one could argue that neither LIFO nor FIFO nor average cost is correct; only replacement value is theoretically sound. In the same vein, one could argue that the choice of the translation method does not affect reality—except possibly through its effect on taxable profit—so that the whole issue is, basically, a non-issue. Furthermore, while in the case of inventory valuation, one could argue that LIFO, being generally closer to replacement value, is the least of all evils, it is not obvious which of the translation methods generally corresponds best to economic value. The whole issue is, perhaps, best settled on the basis of practical arguments. Accounting data are already complicated enough, so that the Current Rate Method is probably a good choice, given its simplicity and internal consistency.

In Table 13.6 we compare economic and accounting exposures. Perusal of the list will reveal that economic exposure is the one to watch, not accounting exposure. But although accounting exposure suffers from the limitations described above, often accounting data are the only data that are readily available to a firm. Thus, it is important that treasurers and CFO's, when using these data to make hedging decisions, be aware of these limitations when using accounting data.

* * *

Let is recapitulate the results obtained thus far in the current part. We first argued that hedging adds value at least for some firms some of the time. We then discussed exposure, that is, the size of the forward hedge that should be added to minimize uncertainty. But the decision whether or not to hedge was hitherto discussed in isolation from other risks the firm incurs, many of which are not hedgeable at all. So perhaps the question should be what the total risk of the company is, and by how much this total risk goes down if exchange risk is being hedged. Such a holistic, portfolio view is taken by Value at Risk (VaR), the issue of the next chapter.

Table 13.6: **Economic v Translation Exposure: summary**

1. Economic exposure relates to changes in genuine cash flows and their PV.	Accounting exposure focuses on book values with, usually, no cashflow repercussions. (One possible exception is through taxes, if translation gains are taxed.)
2. Economic exposure is forward looking: it relates to future cash flows.	Accounting exposure is backward looking: it relates to past decisions on assets and liabilities as recorded on the balance sheet.
3. Economic exposure covers all cash flows, whether or not they can be found in the current financial statements.	Accounting exposure is confined to A&L and P&L items.
4. Economic exposure exists for virtually all firms.	Accounting exposure only exists when there are FC-denominated A&L items or subsidiaries whose accounts need to be consolidated.
5. Economic exposure depends on economic facts, like the contracts the firm signed or the economic environment it operates in.	Accounting exposure depends on the translation method chosen or prescribed, without reference to the economic framework.

13.5 Test Your Understanding: contractual exposure

13.5.1 Quiz Questions

True-False Questions

1. Exchange risk describes how volatile a firm's cash flows are with respect to a particular exchange rate.
2. Exchange exposure is a measure of the sensitivity of a firm's cash flows to a change in the spot exchange rate.
3. Hedging exposure means eliminating all risk from a net position in a foreign currency.
4. If you need to hedge a series of exposures with different maturities and you use duration hedging, it is best to hedge the negative exposures separately from the positive exposures.
5. Contractual exposure is the absolute change in the firm's cash flows for a unit change in the spot exchange rate.

6. Operating exposure is the exposure that results when the forward rate is at a discount with respect to the spot rate at the moment you sign a sales or purchase contract.
7. Contractual exposure is additive for one maturity and one currency.
8. Options are undoubtedly the best choice for hedging foreign currency exposure because the possibility of profiting from a favorable change in the exchange rate remains open without the losses from an unfavorable change in the exchange rate.
9. Reverse exchange risk is the risk that arises when you receive a foreign currency A/R that you left unhedged, and the exchange rate at the time of receipt is unexpectedly low.
10. When interest rates are zero, we can aggregate exposures of a given currency across time.
11. If interest rates are positive but certain, and exchange rates are uncertain, we can aggregate the exposure of one currency across time once we take time value into account.
12. By pooling the aggregate exposure of one currency across time, we can ignore time value, because we have arbitraged away interest rate risk. The only risk that remains is exchange rate risk.

Matching Questions

Suppose that you are a manager at a British firm, and you are responsible for managing exchange rate exposure. Determine whether the following statements are related to accounting exposure, operating exposure, or contractual exposure.

1. Your German subsidiary has recently made new investments.
2. You bought a call option on EUR to hedge an EUR accounts payable.
3. You have just sold goods to an American customer. The customer has ninety days to pay in USD.
4. You have just developed an exciting new product. The success of this product depends on how it is priced in the local currencies of your export markets.
5. You have made a bid to deliver your exciting new product to schools in France during the next academic year. You will learn whether or not the bid has been accepted in three months.
6. You sell wool but face potential competition from Australia. If there are no imports, the price of your wool will be GBP 1. However, Australians enter your market once the exchange rate falls below GBP/AUD 2.

13.5.2 Applications

1. The American firm, American African Concepts, has a one-year EUR A/P totaling EUR 100,000 and a one-year Senegalese A/R totaling CFA 120,000,000. The CFA/EUR exchange rate is fixed at 655.957.

   (a) Can AAC offset its EUR A/P with its CFA A/R?

   (b) If so, how much exposure remains?

2. The Dutch manufacturer Cloghopper has the following JPY commitments:

   - A/R of JPY 1,000,000 for thirty days.
   - A/R of JPY 500,000 for ninety days.
   - Sales contract (twelve months) of JPY 30,000,000.
   - A forward sales contract of JPY 500,000 for ninety days.
   - A deposit that at maturity, in three months, pays JPY 500,000.
   - A loan for which Cloghopper will owe JPY 8,000,000 in six months.
   - A/P of JPY 1,000,000 for thirty days.
   - A forward sales contract for JPY 10,000,000 for twelve months.
   - A/P of JPY 3,000,000 for six months.

   (a) What is Cloghopper's net exposure for each maturity?

   (b) How would Cloghopper hedge the exposure for each maturity on the forward market?

   (c) Assume that the interest rate is 5 percent (compound, per annum) for all maturities and that this rate will remain 5 percent with certainty for the next twelve months. Also, ignore bid-ask spreads in the money market. How would the company hedge its exposure on the spot market and the JPY money market? Describe all money-market transactions in detail.

   (d) If the interest rate is 5 percent (compound, per annum) for all maturities and will remain 5 percent with certainty for the next twelve months, how would the company hedge its exposure on the forward market if only one forward contract is used?

   (e) Assume that Cloghopper prefers to use traded options rather than forward contracts. The option contracts are not divisible, have a life of either 90, 180, 270, or 360 days, and for each maturity the face value of a contract is JPY 1,000,000. How could Cloghopper hedge its exposure? Do the options offer a perfect hedge for each maturity?

   (f) Drop the assumption of a flat and constant term structure. If Cloghopper wants to hedge its exchange rate exposure using one forward contract and its interest rate exposure using FRA contracts, how would the analysis of parts (c) and (d) be affected? A verbal discussion suffices.

(g) The term structure is flat right now (at 5 percent p.a., compound), but is uncertain in the future. Consider the spot hedge of part (c). If, instead of FRAs, duration is used to eliminate the interest risk, how should Cloghopper proceed?

13.6 Test Your Understanding: Operating exposure

13.6.1 Quiz Questions

True-False Questions

1. A firm that has no operations abroad does not face any operating exposure.
2. Only firms with exports, or firms that compete against foreign exporters, face operating exposure.
3. A firm that denominates all of its contracts in home currency, or hedges all of its foreign currency contracts, faces no operating exposure.
4. Almost every firm faces some operating exposure, although some firms are only exposed indirectly (through the country's general economic activity).
5. As large economies have a big impact on world economic activity, companies in such countries tend to be very exposed to exchange rates.
6. Small economies tend to fix their exchange rate relative to the currency of larger economies, or tend to create currency zones (like the EMS). Therefore, companies in small economies tend to be less exposed to exchange rates.
7. The smaller a country, the more open the economy. Therefore, exposure is relevant for most of the country's firms.
8. Everything else being the same, the larger the monopolistic power of a firm, the smaller its exposure because such a firm has more degrees of freedom in adjusting its marketing policy.
9. Consider an exporting firm that has substantial monopolistic power in its product market. Everything else being the same, the more elastic foreign demand is, the more an exporting firm will profit from a devaluation of its own currency. Similarly, the less elastic foreign demand is, the less an exporting firm will be hurt by an appreciation of its own currency.
10. Most information needed to measure operating exposure can be inferred from the firm's past export and import contracts.

Multiple-Choice Questions

Choose the correct answer(s).

1. In a small, completely open economy,
   (a) PPP holds relative to the surrounding countries.

(b) A 10 percent devaluation of the host currency will be offset by a 10 percent rise in the host country prices.

(c) The value of a foreign subsidiary, in units of the foreign parent's home currency, is unaffected by exchange rate changes.

(d) The real value of a foreign subsidiary to an investor from the host country is unaffected by exchange rate changes.

(e) In the absence of contracts with a value fixed in the host currency, the real value of a foreign subsidiary to an investor from the parent's home country is unaffected by exchange rate changes.

(f) In the absence of contracts with a value that is fixed in foreign currency, the real value of a foreign subsidiary to an investor from the host country is unaffected by exchange rate changes.

(g) There is little or no advantage to having one's own currency: exchange rate policy has virtually no effects.

2. In a completely closed economy,

(a) PPP holds relative to the surrounding countries.

(b) A 10 percent devaluation of the host currency will be offset by a 10 percent rise in the host country prices.

(c) The value of a foreign subsidiary, in units of the foreign parent's home currency, is unaffected by exchange rate changes.

(d) The real value of a foreign subsidiary to an investor from the host country is unaffected by exchange rate changes.

(e) In the absence of contracts with a value fixed in host currency, the real value of a foreign subsidiary to an investor from the parent's home country is unaffected by exchange rate changes.

(f) In the absence of contracts with a value that is fixed in foreign currency, the real value of a foreign subsidiary to an investor from the host country is unaffected by exchange rate changes.

(g) There is little or no advantage to having one's own currency: exchange rate policy has virtually no effects.

3. In an economy that is neither perfectly open nor completely closed,

(a) Consider a company that produces and sells in this economy. Apart from contractual exposure effects, its value in terms of its own (local) currency is positively exposed to the value of other currencies.

(b) The value of an importing firm located in this economy could either go up or go down when the local currency devalues: the effect depends on such factors as the elasticity of local demand and foreign supply.

(c) Consider a company that produces and sells in this economy. Apart from contractual exposure effects, its value in terms of a foreign currency is positively exposed to the value of its currency expressed in terms of other currencies.

4. Suppose that the value of the firm, expressed in terms of the owner's currency, is a linear function of the exchange rate up to random noise.

   (a) The firm's exposure is the constant $a_{t,T}$ in $V_T(i) = a_{t,T} + b_{t,T}\, S_T(i) + e_{t,T}(i)$.

   (b) The exposure is hedged by buying forward $b_{t,T}$ units of foreign currency.

   (c) Hedging means that all risk is eliminated.

5. Suppose that the value of the firm, expressed in terms of the owner's currency, is a nonlinear function of the exchange rate up to random noise. Suppose that you fit a linear regression through this relationship, and you hedge with a forward sale with size equal to the regression coefficient.

   (a) All risk will be eliminated.

   (b) There is remaining risk, but it is entirely independent of the realized value of the exchange rate.

   (c) There is remaining risk, but it is uncorrelated to the realized value of the exchange rate.

   (d) There is no way to further reduce the variance of the firm's hedged value.

   (e) There is no way to further reduce the variance of the firm's hedged value if only exchange rate hedges can be used.

   (f) There is no way to further reduce the variance of the firm's hedged value if only linear exchange rate hedges can be used.

13.6.2 Applications

SynClear, of Seattle, Washington, produces equipment to clean polluted waters. It has a subsidiary in Canada that imports and markets its parent's products. The value of this subsidiary, in terms of CAD, has recently decreased to CAD 5m due to the depreciation of the CAD relative to the USD (from the traditional level of USD/CAD 0.85 to about 0.75). SynClear's analysts argue that the value of the CAD may very well return to its former level if, as seems reasonable, the uncertainty created by Canada's rising government deficit and Quebec's possible secession is resolved. If the CAD recovers, SynClear's products would be less expensive in terms of CAD, and the CAD value of the subsidiary would rise to about 6.5m.

1. From the parent's (USD) perspective, is the exposure of SynClear Canada to the USD/CAD exchange rate positive or negative? Explain the sign of the exposure.

2. Determine the exposure, and verify that the corresponding forward hedge eliminates this exposure. Use a forward rate of USD/CAD 0.80, and USD/CAD 0.75 and 0.85 as the possible future spot rates.

3. SynClear's chairman argues that, as the exposure is positive and the only possible exchange rate change is an appreciation of the CAD, the only possible change is an increase in the value of the subsidiary. Therefore, he continues, the firm should not hedge: why give away the chance of gain? How do you evaluate this argument?

   In the remainder of this series of exercises, SynClear Canada's cash flows and market values are assumed, more realistically, to depend on other factors than just the exchange rate. The Canadian economy can be in a recession, or booming, or somewhere in between, and the state of the economy is a second determinant of the demand for SynClear's products. The table below summarizes the value of the firm in each state and the joint probability of each state:

State of the economy	Boom	Medium	Recession
S_T=0.85:Joint probability	0.075	0.175	0.25
Value$_T$ (USD)	5.25	4.75	4.50
S_T=0.75:Joint probability	0.25	0.175	0.075
Value$_T$ (USD)	4.25	3.857	3.50

4. What are the expected cash flows conditional on each value of the exchange rate?

5. Compute the exposure, the optimal forward hedge, and the value of the hedged firm in each state. The forward rate is USD/CAD 0.80.

