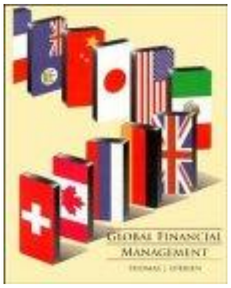

II-5. CORPORATE REVENUES AND FX RISK

The measurement and management of a firm's risk exposure to FX variability is a central issue in global financial management. The uncertainty of future FX rates creates risk for many firms. Not surprisingly, firms that conduct international business face a serious challenge in dealing with FX risk. We'll also see that firms that do not conduct business abroad may also face FX risk.

The focus in this section of the text is on a firm's *long-term FX exposure*, defined to be the variability in the firm's value, or in its anticipated future cash flow stream, caused by unexpected FX changes. Long-term FX exposure is a more complex problem than the *transaction exposure* of a single, already-arranged receivable or payable. The emphasis here is on the numerical measurement of long-term FX exposure, which will in turn serve as a guide to a firm on how to hedge or otherwise manage its risk due to FX changes.

Long-term FX exposure may be dissected into components: The long-term FX exposure of a firm's anticipated *revenue* steam is referred to as *FX revenue exposure*. This chapter covers the fundamental determinants of FX revenue exposure. The long-term FX exposure of a firm's anticipated *operating profit* stream (or operating cash flow stream) is referred to as *FX* *operating exposure*. Chapter 6 covers FX operating exposure and the notion of operational hedging. The FX exposure in a firm's *equity value* is a long-term exposure called *FX equity exposure*. Chapter 7 covers the relationship between operating exposure, capital structure, financial hedging, and equity exposure. Chapter 8 focuses on accounting issues, including *translation exposure* of a firm's accounts for foreign assets and the accounting rules for reporting FX hedging transactions under *FAS 133*.

FX REVENUE EXPOSURE

Consider a firm that produces widgets in the US and exports them overseas. At a given spot FX rate, $X^{\$/€}$, the firm expects an overall revenue level during the year, in US dollars, of $R^{\$}$. If the FX rate changes, then the company's overall revenue level in US dollars is likely to change.

For example, consider the pharmaceutical firm Merck, which produces in the US and sells roughly one-half of its produced drugs in overseas markets, according to a report in 1990. Assume for illustration that 20% of Merck's products are sold in "Euroland", the countries that use the euro as their currency. If the value of the euro depreciates, then the revenues that Merck generates in euros are worth less in US dollars.

A US firm's FX revenue exposure to the euro is denoted $B_{R€}^{\$}$. As usual, the superscript denotes the "pricing currency", so the \$ superscript indicates that the revenues are being measured in US dollars. The "R" subscript indicates "revenues", while the subscript indicates that it is changes in the FX value of the euro which affect the revenues. That is, the euro is the currency to which the firm's revenues, measured in US dollars, are exposed. $B_{R€}^{\$}$ is defined as the expected percentage change in its US dollar revenue level, denoted $\%\Delta R^{\$}$, given the percentage change in the spot FX value of the euro, $x^{\$/€}$. The definition of a firm's FX revenue exposure is shown symbolically in equation (5-1).

$$B_{R€}^{\$} = (\%\Delta R^{\$})/x^{\$/€} \qquad \textbf{(5-1)}$$

The symbol "B" is used to denote FX exposure, whereas "β" (beta) is symbolic of systematic risk. Conceptually, both are regression coefficient "sensitivities", but the independent variable is different. With "B" (FX exposure), the independent variable is FX percentage changes. With "betas", the independent variable is the market portfolio index. Like betas, FX exposures involve both theory and estimation with actual data.

For example, assume that the euro declines in value by 10%. If Merck's Euroland revenues in euros do not change, then Merck's Euroland revenues are worth 10% less in US dollars. That is, the FX revenue exposure of Merck's Euroland revenues, when measured in US dollars, is $(\%\Delta R^{\$})/x^{\$/€}$ = -0.10/-0.10 = 1. Assume further that Merck's revenues from Euroland make up 20% of overall worldwide revenues, including those produced in the US, and that the non-Euroland 80% of Merck's overall revenues are not exposed to changes in the FX value of the euro. Then a 10% depreciation in the FX value of the euro will result in a 2% drop in Merck's *overall* consolidated revenue level; Merck's overall FX revenue exposure to the euro is -0.02/-0.10 = 0.20. In this special case, Merck's overall FX revenue exposure to the euro is equal to the percentage of its overall revenues generated in Euroland, 0.20. The assumptions of this special case are that Merck's Euroland revenues *in euros* are not affected by FX changes, and neither are Merck's non-Euroland revenues, measured in US dollars.

If we think of a firm's FX revenue exposure as linear in FX changes, then equation (5-1) describes the general sensitivity of a firm's revenues, measured in US dollars, to changes in the value of the euro. If the euro appreciates by 15%, Merck can expect the percentage change in the US dollar equivalent of its Euroland revenues to be 15%, and the percentage change in its overall revenues in US dollars to be $\%\Delta R^{\$} = B_{R€}^{\$}(x^{\$/€})$ = 0.20(0.15) = 0.03, or 3%. That is, with an overall FX revenue exposure of 0.20 to the euro, Merck would expect it's overall revenue level in US dollars to rise by 3%, in response to a 15% appreciation of the euro (relative to the US dollar).

The FX revenue exposure of Merck's Euroland revenues is a case example of pure *conversion exposure*. As FX rates change, Merck's Euroland revenue stream *in euros* does not change, based on the assumption that neither product prices nor sales volume are affected by change in the FX value of the euro. Thus, the only FX influence on Merck's US dollar revenues is the impact on the conversion of the euro revenues into US dollars. Note that conversion exposure does not necessarily entail actual repatriation and exchange of the revenues from overseas back to the home country. The conversion can be the mental exercise of figuring what an amount in euros would be worth when measured in US dollars, i.e. if the revenue *were* to be converted.[1]

***Assume a firm has a base currency of US dollars and generates Swiss franc revenues of Sf 1 mm per year. Assume that the current spot FX rate is 1.60 Sf/$. Assume the firm has a FX revenue exposure to the Swiss franc of 1, a pure conversion exposure. What will be the firm's new revenue level in US dollars if the Swiss franc appreciates by 10% relative to the US dollar? What will be the new revenue level in Swiss francs?*** *Answers: The US dollar revenue level at the current FX rate is Sf 1 mm/(1.60 Sf/$) = $625K. If the Swiss franc appreciates by 10%, the US dollar revenues will increase by 10%, since* $B_{RSf}^{\$} = 1$. *Thus the new US dollar revenues are $625K(1.10) = $687.50K. The new spot FX rate will represent a 10% higher FX value of the Swiss franc or 1/[0.625 $/Sf(1.10)] = 1/(0.6875 $/Sf) = 1.4545 Sf/$. The*

[1] Merck's actual FX exposure is discussed in detail in Judy C. Lewent and A. John Kearney, "Identifying, Measuring, and Hedging Currency Risk at Merck," *Journal of Applied Corporate Finance*, Winter 1990, pp. 19-28.

new level of the Swiss franc revenues is $687.50(1.4545 Sf/$) = Sf 1 mm, the same as the old level. This is characteristic of exposure equal to 1, i.e., a pure conversion exposure: The foreign currency revenue level does not change while the home currency revenue level changes by the same percentage as the value of the foreign currency.

In many cases, the influence of FX changes may be more complex than the simple conversion effect of the Merck case. In general, the level of a firm's foreign revenues may be affected by FX changes. The changes in foreign revenues may be a combination of changes to a product's price in local currency and an impact on sales volume. When these possibilities occur, the FX revenue exposure may be different than 1. Thus one might see an FX revenue exposure scenario as in the next example.

Assume a firm's base currency is US dollars. Let the current spot FX rate be $X_0^{\$/£}$ = 1.50 \$/£, and assume that the firm's revenues, in US dollars, are currently at the level of \$500K (per year). Assume that if the spot FX value of the pound changes to $X_1^{\$/£}$ = 1.80 \$/£, the US dollar revenue level will increase \$750K per year. What is the firm's FX revenue exposure to the pound? *Answer: The spot FX value of the pound increases by (1.80 \$/£)/(1.50 \$/£) – 1 = 0.20, or 20%, whereas the firm's US dollar revenues increase by \$750K/\$500K – 1 = 0.50, or 50%. Thus, this firm's FX revenue exposure to the pound is $B_{R£}^{\$}$ = 0.50/0.20 = 2.50.*

FX PASS-THROUGH AND CURRENCY OF DETERMINATION

The influence of FX rate changes on a product's local-currency selling price is referred to as *FX pass-through*. At this point, we look at the impact of FX rate changes on price alone, without considering any collateral impact of the price change on sales volume. The idea of a simultaneous economic impact of FX changes on both price and sales volume is reviewed later in the chapter.

Consider the system of measuring FX pass-through used by Dow Chemical Corporation, as the firm attempts to assess the FX exposure of each of its products sold in Europe. Dow's point of view is its home currency, US dollars. The currency to which Dow's European revenues are exposed is the euro. The more that changes in the FX value of the euro are *passed-through* to Dow's European customers, in the form of changes in a product's local price in euros with no impact on sales volume, the *less* is the FX exposure Dow's revenues (measured in US dollars) to the euro.

The firm's marketing managers are interviewed and asked to rate the stability of the local-currency prices of each of Dow Europe's products, using a "stability index" of 0 to 100. A Dow rating of "100" means a product's price in euros is "100%" stable and is thus unaffected by changes in the FX rate, and thus that Dow cannot or does not pass-through FX changes to the customer. Thus the US dollar level of the foreign revenues bears 100% of the exposure to FX changes. Merck's drugs, for example, would have a rating of "100" in the Dow system, as Merck does not change drug prices in local currencies as FX rates change. Since all of the FX risk is retained by the seller, not passed through to the buyer, Dow's FX revenue exposure in US dollars to changes in the FX value of the euro is 1, for products with a rating of "100".

A Dow local-price stability rating of "0" implies that the product's price in euros has "no stability". Zero stability in local price is good in the sense that Dow is able to entirely pass-through FX changes into the product's local price in euros, and thus Dow's US dollars revenues are not exposed to changes in the FX value of the euro. For example, when the spot FX value of the euro rises, the euro price of a product rated "0" is dropped, and vice versa, in precisely the right amount to leave the Dow's revenues unaffected when viewed in US dollars. Thus a rating of "0" implies that "0%" of the euro price is stable, and thus that "0%" of US dollar revenues is exposed to FX changes. The "0" rating thus represents full pass-through. Full pass-through may be possible for a product where Dow had no competition and/or where demand for the product is relatively price-inelastic. Full pass-through is also referred to as "indexing" the product's price in local currency to FX changes.

The US firm Vulcan Materials Co. also illustrates the full pass-through case where overseas sales pose *no* FX revenue exposure to the US parent. Vulcan's UK subsidiary sells metals whose price is "indexed" with the $/£ FX rate in such a way that the price is essentially stable when viewed from the perspective of US dollars. Vulcan's UK subsidiary fully alters its products' prices in pounds to offset changes in $/£ FX rate, with no change in expected sales volume. Thus from the US dollar point of view, the sales of Vulcan's UK subsidiary have no FX revenue exposure to the pound, even though the subsidiary's revenues in pounds were volatile. In terms of Dow's system, Vulcan's UK metals prices in pounds would be rated "0" for price stability in pounds, and thus are entirely stable when viewed from the US dollar perspective.

Most of Dow's products rated in *between* "0" and "100". A Dow price stability rating of "60" means that 60% of the foreign-currency price is stable and not subject to the pass-through of FX changes, while 40% of any FX change is passed-through in the form of a partially offsetting change in local euro product prices. Some of Dow's products are rated "100", some are rated "70", some "25", etc. down to "0". Partial pass-through of prices is sometimes referred to as *risk-sharing*.[2]

FX pass-through is related to the concept of a product's *currency of determination* in a given market, which is the currency in which the product's price is 'stable' in that market. Many basic commodities have a

---

[2] For a discussion of indexing, risk-sharing and dual-currency pricing, see Frank Milley http://www.gtnews.com/articles3/2039.html. The Dow system is described in John J. Pringle, "Managing Foreign Exchange Exposure," *Journal of Applied Corporate Finance*, Winter 1991, pp. 73-82. The Vulcan Materials case is covered in C. Kent Garner and Alan C. Shapiro, "A Practical Method of Assessing Foreign Exchange Risk," *Midland Corporate Finance Journal*, Fall 1984, pp. 6-17.

single currency of determination throughout the world. For example, the currency of determination of metals is generally the US dollar in all markets. At one time, Swedish paper companies were so dominant, that the Swedish krone was the currency of determination for paper. For consumer products, the currency of determination is often the local currency in which it is sold. For example, the currency of determination of Merck's pharmaceuticals is the local currency in which they are sold, since their prices are held fixed in local currencies. Sometimes a product's price is determined by more than one currency. For example, auto prices are determined in part by the Japanese yen and in part by local currency.

If the currency of determination of an exporter's product is unambiguously the foreign currency, then the product's price is stable in that foreign currency. Hence, the exporter will have FX conversion exposure to the foreign currency. If the currency of determination is unambiguously the exporter's currency, the product's price will be stable in the exporter's currency, and the exporter will have no FX exposure to the currency as local price changes in the foreign currency offset the conversion impact of FX changes.

Consider a Danish firm, DRE Co., with a base currency of Danish kroner, that exports products to the US. DRE expects to do a volume of 500K units per year at $2.00 per piece, if the FX rate maintains its initial level, 7.50 Dk/$. Assume that the Danish kroner is the <u>currency of determination</u> for DRE's products in the US market, and that the US dollar price fully changes, with no change in sales volume, as the FX rate changes. Demonstrate that if the value of the US dollar depreciates by 15%, then DRE's expected revenues in Dk do not change, that is, that DRE's $B_{R\$}^{Dk}$ ***is 0.*** *Answer: The European terms quote is in direct terms from the point of view of the kroner. Thus, a 15% depreciation of the US dollar would imply a new FX rate of (0.85)(7.50 Dk/$) = 6.375 Dk/$. DRE's initial expected US dollar revenues are*

($2.00/unit)(500K units) = $1 mm per year. Initially, the expected US dollar revenues convert to a kroner equivalent of $1 mm(7.50 Dk/$) = Dk 7.50 mm per year. If the price in kroner is stable at Dk 15, then the new price in US dollars will be Dk 15/(6.375 Dk/$) = $2.353. The new US dollar revenue level is ($2.353/unit)(500K units) = 1.176 mm after the FX change, and the new expected kroner revenue level is $1.176 mm(6.375 Dk/$) = Dk 7.50K per year. Thus, the FX exposure of the kroner revenues to changes in the FX value of the US dollars is 0.

In many cases the currency of determination is ambiguous. If a Dow product in France has a rating of “60”, then the product’s price in euros responds to 40% of the FX change, and thus only 40% of the price is stable in US dollars. The product’s price in euros does not respond to 60% of an FX change and thus is 60% stable in euros. In this case, the product’s price is determined by both currencies, with the euro being the stronger determinant.

The currency (or currencies) of determination of a given product may be different in different markets. For example, if a US firm has no foreign competitor in the US, but its exports are sold into a foreign market where there exists a dominant firm, the currency of determination could be the US dollar in the US and the overseas currency in the foreign market.

ECONOMIC FX EXPOSURE

The effect of changes in foreign product *prices* on a firm’s revenues is one aspect of *economic FX exposure*. In general, a firm’s economic FX exposure will also involve sales *volume* responses to the price changes that are passed-through, and sometimes to “wealth effects” that might result from FX changes. There are a number of possible scenarios of such economic exposure, including an *indirect FX exposure* of a company that does not even have foreign sales! For example, consider the Canadian heavy equipment dealer, Finning. Finning’s Canadian customers, with base currency in Canadian dollars, sell their products primarily to US firms. Thus, when the US dollar appreciates relative to the Canadian dollar, Finning's Canadian customers experience increased revenues in Canadian dollars and are more likely to place orders with Finning, and vice versa. Thus Finning has a FX revenue exposure, *indirectly*, to a foreign currency, in this case the US dollar.[3]

The scenarios of FX revenue exposure covered thus far have all been cases of positive (or "long") exposure in the sense that revenues rise when the FX value of the foreign currency appreciates. That is, $B_R > 0$. However, it is possible for economic considerations to make a firm's FX revenue exposure negative. Consider the case of the now-defunct Laker Airways, a UK firm whose base currency was British pounds. Laker Air specialized in flying British vacationers to the US at a time when the pound was relatively "strong" in the sense of overseas purchasing power. However, when the US dollar appreciated relative to the pound, the expenses incurred in the US rose for British "holiday-makers", discouraging their use of the airline. Since Laker's revenues dropped as the foreign currency (the US dollar) appreciated, the firm's FX revenue exposure to the US dollar was negative. A negative (or "short") FX revenue exposure to foreign currencies, based upon the same reasoning, has also been observed by American Airlines.

In general, when the spot FX value of a foreign currency changes, an exporter into that country will tend to implement changes to *both* sales volume and prices simultaneously. Thus, the magnitude of the firm's FX revenue exposure depends on the elasticity of the demand for the products in the export market. When these economic effects are combined with the conversion exposure, a relatively large sensitivity to FX changes may result. This situation is illustrated in the following profit maximization scenario of an exporter, given the demand function for the firm's products.

---

[3] A description of Caterpillar-Finning is found in Gregory J. Millman, *The Floating Battlefield: Corporate Strategies in the Currency Wars* (New York: AMACOM, The American Management Association, 1990).

Consider UVM Inc., a hypothetical US exporter of widgets to France. UVM is assumed to produce the widgets in the US at a cost of $1400 per widget and to have no competitors in the French market, i.e is a monopolist. Assume that UVM faces the following *demand function* (relationship between the product's price and quantity sold): $p^{€} = 2900 – Q$, where $p^{€}$ is the price of a widget in France in euros and Q is the volume of widgets sold by UVM in France.

Thus UVM's total widget revenue in euros is $p^{€}Q = (€2900 – Q)Q$. Using calculus (now you know why you had to take it), UVM's marginal revenue can be found by taking the first derivative of total revenue with respect to output, Q. UVM's marginal revenue in euros is thus $MR^{€} = €2900 – 2Q$. The marginal revenue expressed in US dollars depends on the spot FX rate, $MR^{\$} = X^{\$/€}(€2900 – 2Q)$. By setting the marginal revenue in US dollars equal to the assumed marginal cost in US dollars, $1400, we can solve for UVM's optimal output decision for *Q,* given any assumed spot FX rate.

For example, if $X^{\$/€}$ = 1 $/€, then setting (1 $/€)$(€2900 – 2Q)$ equal to $1400, and solving for Q, we get a *Q* of 750 widgets. Using the demand function, $p^{€} = 2900 – Q$, we can find that if the firm produces 750 widgets, it will set a price per widget in euros of $p^{€}$ = €2150. The firm's revenue in euros, $R^{€}$, will thus be €2150(750) = €1,612,500. UVM's revenue in US dollars, $R^{\$}$, will thus be 1 $/€(€1,612,500) = $1,612,500.

What if the FX value of the euro depreciates to 0.80 $/€? Then setting the new marginal revenue in US dollars equal to the marginal cost of $1400, $MR^{\$}$ = 0.80 $/€$(€2900 – 2Q)$ = $1400, gives a solution for *Q* of only 575 widgets. The euro's FX value is lower, and in response UVM drops its US production of widgets exported to France from 750 to 575. Along with the lower production, however, the price charged for a widget in euros is higher. Using the demand function, $p^{€} = €2900 – Q$, we find that the firm will now set a price in euros of $p^{€}$ = €2325. At this price of €2325, and with a sales volume of 575, the firm's revenues in euros, $R^{€}$, will be €2325(575) = €1,336,875. UVM's revenue in US dollars, $R^{\$}$, will be 0.80 $/€(€1,336,875) = $1,069,500.

The FX pass-through for UVM's widgets has been neither 0 nor 100%. The FX value of the euro has dropped by 20% from 1 $/€ to 0.80 $/€, whereas the widget price response was from €2150 to €2325, an increase of about 8%. Thus, only about 40% of the FX change was passed-through in the form of a price adjustment in local currency. In addition, UVM will sell a much lower volume at this price, 575 widgets, down from 750.

What is UVM's FX revenue exposure to the euro, $B_{R€}^{\$}$? The euro depreciated by 20% from 1 $/€ to 0.80 $/€; in response, UVM's US dollar revenues changed by a percentage equal to $1,069,500/$1,612,500 - 1 = -0.337, or – 33.7%. Thus using equation (5-1), the FX exposure of UVM's US dollar revenues to the euro, $B_{R€}^{\$}$, is – 0.337/-0.20 = ***1.685***. Thus, if the euro drops in value by 20%, the firm's revenues in US dollars drop by 1.685x20%, or by 33.7%. The decline in the FX value of the euro has had a "double impact": UVM's euro revenues dropped due to the overall impact of the price/volume interaction (the economic FX exposure), and the revenues in US dollars dropped all the more due to the added effect of conversion exposure.

Because the demand function was assumed in this example to be linear, the FX revenue exposure here is technically "non-linear", meaning that if a change in the value of the euro other than 20% is assumed, the computed FX revenue exposure would be somewhat different than ***1.685***. The example below estimates UVM's revenue exposure to be 1.56 with a different "what if" assumption for the FX rate change, a 25% appreciation of the euro. Taking the average of these two estimates, about ***1.62***, seems like a reasonable answer if one were to boil UVM's estimated FX revenue exposure to the euro down to one number. This FX revenue exposure number may be higher than one observes for typical real-world companies, as in Table 5-1. The reason is that UVM is a hypothetical firm, with 100% of sales in the form of exports to a single area, Euroland. This assumption was made to clearly show the idea of economic FX exposure, whereas real companies generally will also have domestic sales and sales in other countries.

Find UVM's FX revenue exposure to the euro in a scenario where the FX rate begins at 1 \$/€ and the euro appreciates to 1.25 \$/€. *Answer: If the value of the euro is 1.25 \$/€, then setting $MR^{\$}$ = 1.25 \$/€(€2900 – 2Q) = \$1400 gives a solution for Q of 890 widgets. The euro's value is higher, and in response UVM increases its production of widgets sold in France. With the higher production, however, the price charged for a widget in euros will be lower. Using the demand function, $p^{€}$ = 2900 – Q, we find that $p^{€}$ = €2010. The firm's revenues in euros, $R^{€}$, will be €2010(890) = €1,788,900. UVM's revenue in US dollars, $R^{\$}$, will be 1.25 \$/€(€1,788,900) = \$2,236,125. The euro has appreciated by 25%; in response, UVM's US dollar revenue has changed by \$2,236,125/\$1,612,500 - 1 = 0.39, or 39%. Thus UVM's FX revenue exposure to the euro was 0.39/0.25 = 1.56.*

The nature of a firm's economic FX exposure depends on a firm's demand function, which may not be explicitly known to managers of complex firms in the real world. In general, if a product's demand function is relatively inelastic, then the firm can pass-through FX changes without a relatively significant impact on sales volume, the currency of determination is more closely related to the exporter's currency, and the exporter's FX revenue exposure will be low. On the other hand, if an exporter faces a relatively elastic demand curve for its products, then the customers' local currency plays a greater role in determining the product price, and the exporter's economic exposure will be higher.

Note that the economic exposure would be absent if UVM were to move its production to Euroland. In such a case, there would be no economic impact of FX changes on the optimal output and price of widgets. If the cost of producing a widget were €1400 in France, regardless of the FX rate, then

UVM would find it optimal to produce 750 widgets and sell them for €2150 per widget, regardless of the \$/€ FX rate. That is, the currency of determination of widgets sold in France would be unambiguously the euro, since all production and purchasing of widgets takes place in euros. The firm's revenues in euros would be stable, €1,612,500. The firm's US dollar revenues would be $X^{\$/€}$(€1,612,500), and thus would only have conversion exposure. Thus if the value of the euro were to depreciate by 10%, UVM's US dollar revenues would decline by 10%. The firm would have only a pure conversion exposure, and $B_{R€}^{\$}$ would be 1. The reduction in UVM's FX revenue exposure to the euro from 1.62 to 1, if UVM were to move its production to Euroland, is a feature that we will see again in the next chapter.

MULTI-MARKET EXPOSURE

Consider the case of a firm that sells in both domestic and foreign markets. Such a firm may have a combination of different FX revenue exposures in different markets. In the foreign market, the economic exposure--combined with the effect of conversion exposure--could be different than the economic exposure in the domestic market. Kodak and Caterpillar are two major examples of the many modern firms with FX revenue exposure in multiple markets.

The British firm Rolls-Royce, with a base currency of pounds, typifies this idea. Rolls-Royce reported that 41% of its revenues were derived from overseas sales in the US, with the dollar as the "currency of determination". Assuming the other 59% of revenues are from domestic UK sales and do not fluctuate with changes in the \$/£ FX rate, the firm's FX revenue exposure (to the US dollar) would be $B_{R\$}^{£} = 0.41(1) + 0.59(0) = 0.41$.

Suppose the hypothetical US firm SLM Co. sells products in both the UK and the US, and SLM's base currency is the US dollar. Assume SLM's British competition in England is significant, but in the domestic US market SLM is virtually a monopolist, and competition is insignificant. In this case, we assume that the currency of determination for the company's products in the UK is the pound, but in the US is the US dollar. If SLM generates 30% of its business in the UK and the other 70% in the US, find the firm's overall FX revenue exposure to the pound. *Answer: The US operation has a FX revenue exposure to the pound of 0, whereas the US dollar revenues from the UK operation have a FX revenue exposure to the pound of 1. SLM's overall FX revenue exposure to the pound is* $B_{R£}^{\$} = 0.30(1) + 0.70(0) = 0.30$.

EMPIRICAL ESTIMATION OF FX REVENUE EXPOSURE

This chapter has thus far covered some underlying theory of FX revenue exposure. Most real world firms, however, would have a difficult time measuring their FX revenue exposures analytically. Instead, a firm might estimate its aggregate FX revenue exposures with actual consolidated revenue data, as shown in Table 5-1 for the FX revenues exposures of Gillette, Merck and GE to the yen, the pound, the German mark (as a proxy for the euro).

The FX revenue exposure estimates are mixed for Gillette. The estimates are relatively unreliable, however, judging from the standard errors. The standard errors for Merck's estimated FX revenue exposures are much smaller. GE has fairly high estimates of FX revenue exposure to all three currencies. For example, GE's estimated FX revenue exposure to the yen is 1.245 with a standard error of 0.442.

TABLE 5-1
ESTIMATED FX REVENUE EXPOSURES

	GILLETTE		MERCK		GE	
	$B_R^{\$}$	*Std. Error*	$B_R^{\$}$	*Std. Error*	$B_R^{\$}$	*Std. Error*
Yen	***-0.234***	*0.759*	***0.079***	*0.141*	***1.245***	*0.442*
Pound	***1.561***	*0.998*	***0.211***	*0.188*	***1.348***	*0.622*
Mark	***0.516***	*0.934*	***0.111***	*0.173*	***1.111***	*0.573*

Table 5-2 (in the Appendix) shows the basic quarterly data from which the FX revenue exposure estimates are made. The currency columns show quarterly historical percentage changes in spot FX values, used as the independent variable in the regression analysis. The 3 firms' actual quarterly revenues (from Primark Disclosure Quarterly 10K Spreadhseets, 000s omitted) are shown in Table 5-2. The computed percentage changes in those revenues were employed as dependent variables.

COMPETITIVE FX REVENUE EXPOSURE: EXPORTER FACING A LOCAL COMPETITOR

Additional economic effects on FX revenue exposure may result from an exporter's competition with a local firm, or from the local firm's perspective, competition with a foreign importer. This form of economic FX exposure is termed *competitive FX exposure*.

Let us construct a scenario where UVC Co., a US-producing widget exporter, has a local French competitor, FN Corp, SA. The demand function for the widgets sold in France is an industry-wide concept, and thus must consider the widget output of both UVC and FN, denoted Q_U and Q_F, respectively. Thus assume the demand function in this competitive scenario is $p^€ = €2900 – Q_U – Q_F$. Assume that FN can produce widgets in France for €1400 per widget, while UVC can produce them in the US for $1400. FN's revenues in euros are $R_F^€ = p^€ Q_F = (€2900 – Q_U – Q_F)Q_F$, and (by taking the first derivative of the revenues in euros with respect to Q_F), FN's marginal revenue in euros is $MR_F^€ = €2900 – Q_U – 2Q_F$.

UVC's revenues in euros are $R_U^€ = p^€ Q_U = (€2900 – Q_U – Q_F)Q_U$. In US dollars, UVC's revenues are thus $X^{\$/€}(€2900 – Q_U – Q_F)Q_U$. UVC's marginal revenue in US dollars, found by taking the first derivative of US dollar revenues with respect to Q_U, depends on the FX rate, $MR_U^{\$} = X^{\$/€}(€2900 – 2Q_U – Q_F)$. Now we need to simultaneously equate marginal revenue and marginal cost for each firm. By setting FN's $MR_F^€$ equal to its $MC_F^€$ (€1400), and setting UVC's $MR_U^{\$}$ equal to its $MC_U^{\$}$ ($1400), we solve simultaneously for the optimal widget output of both firms in the duopoly, Q_U and Q_F.

For example, if $X^{\$/€}$ = 1 $/€, then it turns out that both firms share the market equally, and Q_U and Q_F are 500 widgets. To see this, solve simultaneously the two MR equations, $€2900 – Q_U – 2Q_F = €1400$, *and* 1 $/€ ($\$2900 – 2Q_U – 2Q_F$) = $1400. Simplify the second equation by dividing through by 1 $/€. Now the two equations to solve simultaneously are a) $€2900 – Q_U – 2Q_F = €1400$, and b) $€2900 – 2Q_U – Q_F = €1400$. Solve the two equations simultaneously by first multiplying equation (a) by -2 to get $- €5800 + 2Q_U + 4Q_F = - €2800$, and then adding this new equation to equation (b) to get $- €2900 + 3Q_F = - €1400$, from which you solve that Q_F = 500. Plug this solution for Q_F into either original simultaneous equation, and obtain that Q_U = 500. Finally, using the demand function, $p^€ = €2900 – Q_U - Q_F$, we find that the widget price in euros will be $p^€$ = €1900. Each firm generates revenues in euros of (500)(€1900) = €950K. UVC's revenue in US dollars is 1 $/€(500)(€1900) = $950K.

If $X^{\$/€}$ = 0.80 \$/€, then simultaneous solution of the two *MR* = *MC* equations yields that UVC will produce less, Q_U = 267 widgets, and FN will produce more, Q_F = 617 widgets.[4] Using the demand function, $p^{€}$ = *€2900* – Q_U - Q_F, we find that the widget price in euros will be $p^{€}$ = €2016. UVC's revenue in US dollars is 0.80 \$/€(267)(€2016) ≈ \$430K.

What is UVC's FX revenue exposure to the euro, $B_{R€}^{\$}$? The FX value of the euro depreciated by 20% from 1\$/€ to 0.80 \$/€; in response, UVC's US dollar revenue has changed by \$430K/\$950K -1 = -0.547, or –54.7%. Thus using equation (5-1), the exposure of UVC's US dollar revenue to the euro is $B_{R€}^{\$}$ = –0.547/-0.20 = ***2.735***. If the euro drops in FX value by 20%, the firm's revenues in US dollars drop by 2.735x20%, or by 54.7%.

The decline in the FX value of the euro has an even greater impact in the competitive scenario than in the case of monopolist scenario of UVM in the prior section. Thus, other things equal, we thus might expect an exporter to have greater FX revenue exposure to the local currency if it must compete against local firms. UVC's euro revenues dropped substantially when the FX value of the euro fell, due to the competitive exposure, and the impact of this drop on UVC's revenues in US dollars is compounded by the impact of conversion exposure.

Again, the linearity of the assumed demand function results in an FX revenue exposure that is non-linear. The next example shows the exposure to be 2.53 if the euro appreciates in value by 25%. On average, we might estimate UVC's FX revenue exposure to the euro at about ***2.63***.

---

4 Actual computations: set €2900 – Q_U – $2Q_F$ = €1400 and (0.80 \$/€)(€2900 – $2Q_U$ – Q_F) = \$1400. Simplify the two equations to (a) 2900 – Q_U – $2Q_F$ = 1400 and (b) 2900 – $2Q_U$ – Q_F = 1750. Solve the two simplified equations simultaneously by first multiplying equation (a) by –2 to get - 5800 + $2Q_U$ + $4Q_F$ = - 2800, and then adding this new equation to equation (b) to get –2900 + $3Q_F$ = - 1050, which simplifies to Q_F = 617. Substitution of Q_F = 617 into either (a) or (b) will yield that Q_U = 267.

Find UVC's FX revenue exposure to the euro in a scenario where the FX rate begins at 1 $/€ and the FX value of the euro appreciates to 1.25 $/€*. Answer: If the FX value of the euro is 1.25 $/€, then simultaneous solution of the two MR = MC equations yields that Q_U = 686 widgets and Q_F = 407 widgets (actual computations not shown). Using the demand function, $p^{€}$ = €2900 – Q_U - Q_F, we find that $p^{€}$ = €1807. UVC's revenue in US dollars is 1.25 $/€(686)(€1807) ≈ $1550K. The FX value of the euro appreciated by 25%; in response, UVC's US dollar revenue has changed by $1550K/$950K - 1 = 0.63, or 63%. Thus using equation (5-1), the FX exposure of UVC's US dollar revenues to the euro, $B_{R€}^{\$}$, is 0.63/0.25 = 2.53.*

Competitive FX exposure can be even more complex if firms from multiple countries are competing. For example, Caterpillar competes with the Japanese heavy equipment maker, Komatsu in many markets. This situation would make Caterpillar's revenues exposed to the $/¥ FX rate, even if Caterpillar exported no products to Japan.

Note that if UVC moves its production to France, the competitive FX exposure to the euro disappears. In such a case, there would be no economic impact of FX changes on the optimal output and price of widgets, *for either UVC or FN*. If the cost of producing a widget were €1400 in France, both UVC and FN would find it optimal to produce 500 widgets and sell them for €1900 per widget, *regardless of the $/€ FX rate*. Each firm's revenues in euros would be stable, €950K. UVC's US dollar revenues would be $X^{\$/€}$(€950K). Thus if the value of the euro were to depreciate by 10%, UVC's US dollar revenues would decline by 10%. UVC would have only a pure FX conversion exposure, and $B_{R€}^{\$}$ would be 1. Thus, moving production to Euroland would reduce UVC's FX revenue exposure from (about) ***2.63*** to 1. Again, this information will be useful in the next chapter when the issue of plant location is covered. [If Japanese exports were competing in the market, there would still be exposure to the yen, however.]

In the UVC/FN example, the cost of producing widgets is the same in either country (thus for either firm) at the FX rate of 1 \$/€, since the cost of producing a widget in France is €1400 and the cost of producing a widget in the US is \$1400. At any other FX rate, though, the cost of producing a widget is not the same when viewed in a common currency. If the FX value of the euro > 1 \$/€, then producing a widget in France is relatively more expensive than in the US, giving UVC an economic advantage, and vice versa.

FX REVENUE EXPOSURE: DOMESTIC FIRM WITH A FOREIGN COMPETITOR

What is the nature of the FX revenue exposure for a domestic company when there is competition from a foreign firm that exports from its country? This question may be examined by looking at the last scenario from the perspective of the French firm, FN. FN's home currency is euros, and both sales and costs are in measured in euros. Still, FN is exposed to a foreign currency, the US dollar, because its competitor UVC is exporting widgets produced in the US into FN's local French market.

We already know from the prior section that at an FX rate of 1 \$/€, FN produces 500 widgets and sells them for €1900 per widget for expected revenue of €950K. At 0.80 \$/€, which is 1.25 €/\$ in direct terms from FN's euro point of view, FN's output is 617 widgets, and revenues are €2016(617) = €1,244K. FN's revenues (in home currency, euros) rise from €950K to €1244K (an increase of 31%), when the value of the foreign currency (the US dollar) rises from 1 €/\$ to 1.25 €/\$ (an appreciation of 25%). Thus FN's FX revenue exposure to the US dollar is $B_{R\$}^{€}$ = 0.31/0.25 = ***1.25***.

Find FN's FX revenue exposure to the US dollar in a scenario where the FX rate begins at 1 \$/€ and the spot FX value of the euro appreciates to 1.25 \$/€*. Answer: Recall from the* *prior problem that if the Fx value of the euro is 1.25 \$/€, the simultaneous solution of the two MR = MC equations yields that Q_F = 407 widgets and $p^€$ = €1807. FN's revenue in euros is (407)(€1807) $\approx$ \$736K. The US dollar has depreciated by 20%; in response, FN's euro revenue has changed by \$736K/\$950K - 1 = - 0.225, or - 22.5%. Thus using equation (5-1), the FX exposure of FN's euro revenues to the US dollar, $B_{R\$}^€$, is -0.225/-0.20 = 1.125.*

Note that if UVC decides to move its production to Euroland, making UVC's cost of producing widgets fixed in euros, then FN no longer will have FX exposure, even though its competitor is technically a US firm.

As long as UVC and FN produce in different countries, the competitive FX exposure scenarios above depict situations where neither the euro nor the US dollar is the unambiguous "currency of determination" for widgets sold in France. However, the scenarios did not factor in the relative "power" of the competitors. If the competitor from a given country were to carry more "clout", then that currency is likely to most heavily determine product prices.

Competitive FX exposure exhibits itself very clearly in the US automobile industry, where the yen appears to be a primary "currency of determination". When the yen depreciates in FX value relative to the US dollar, Japanese auto manufacturers can afford to sell at lower US dollar prices, forcing the US automakers to lose revenues. Note that this situation also works in the other direction. When the FX value of the yen appreciates relative to the US dollar, and the Japanese raise the dollar prices of the autos that are sold in the US, the US auto producers raise their prices in the US and increase profits.

Competitive FX exposure can take other forms, too. Consider the case of a US company operating in Germany. Suppose the euro appreciates relative to the US dollar, and as a result more US companies become inclined to compete for business in Germany. The additional competition could result in a lower market share and a lower German sales volume. The competitive pressure could result in price changes as well.

In reality, a firm's competitive FX exposure may be too complex to understand with a theoretical model. Thus empirical estimation, like the kind represented in Table 5-1, is sometimes the only source of measurement of FX revenue exposure for many firms.

SUMMARY

This chapter has covered the topic of a company's FX revenue exposure and is potential sources. Conversion exposure is one relatively evident form of FX revenue exposure. In addition there are often more subtle economic effects of FX changes that depend of where production is located, whether there are competitors and where their production is located, the elasticity of product demand, the FX exposure of a firm's customers, and so forth. Compound FX exposure is covered in the Appendix. The next chapters extend the FX revenue exposure concepts to the "profit line" and to the "stock value". In addition, hedging strategies are discussed.

Glossary

Competitive FX Exposure: Long-term economic exposure due to the effects of changes in a firm's competitive environment on its operating cash flows, where the competitive changes are due to FX changes.

Compound FX Exposure: A form of FX revenue exposure cause due to the compounding effect different FX rates.

Conversion Exposure: FX exposure due to converting given foreign currency cash flows to base currency equivalent.

Currency of Determination: Term used to indicate the currency in which, due to the particular economic conditions, prices of goods are effectively set.

Inelastic Demand: A situation described when users of a product are willing to order the same volume of the product at virtually any price.

Long-term Exposure: The variability in a firm's value, or in its ongoing cash flows, caused by the effects of uncertain FX rate changes.

Pass-through: The change in an exporter's local currency price in response to FX rate changes, in attempt to pass along the impact of the changes to the local customers.

FX Revenue Exposure: The variability in a firm's ongoing revenues, caused by uncertain FX changes.

PROBLEMS

1. Consider a US company with revenues, measured in US dollars, of \$500K per year, given a current spot FX rate of 0.60 \$/A\$. The company has an FX revenue exposure to the Australian dollar of $B_{RA\$}^{\$}$ = 0.60. If the A\$ appreciates in value by 20% (relative to the US dollar), what will be the firm's new expected US dollar revenue level?

2. Assume a firm's home currency is *British pounds*. Let the current spot

FX rate be 1.50 \$/£ and the expected revenues be £500K per year. Assume that if the FX value of the pound changes to 1.80 \$/£, the expected revenues in pounds would change to £750K per year. Show the correct symbol for, and compute the company's FX revenue exposure to the US dollar?

3. Consider the US firm DFE Co., exporting to Denmark. Let the current FX rate be 6.60 Dk/\$ (Danish krones), and let the firm's expected future revenues, measured in US dollars, be \$500K per year. Assume that DFE has an FX revenue exposure to the Danish krone of $B_{RDk}^{\$}$ = 1.20. If the FX rate goes to 7.50 Dk/\$, by what percentage will the expected US revenues change? What will be the new level of future expected revenues in US dollar terms?

4. Your firm is a domestic firm in Japan with no overseas sales. The base currency is the yen. However, since your domestic market has a dominant US-based competitor, the currency of determination for the products in the Japanese market is the US dollar. Assume that your firm currently expects a sales volume of 1000 units at a selling price of ¥1000 per unit. Assume the US dollar appreciates by 15% from the current spot FX rate of 120 ¥/\$. What is the FX revenue exposure for your firm to the US dollar? If the US competitor raises its yen selling price, while maintaining its same US dollar revenues at the same volume, what will be the new expected yen revenues for your firm?

5. If 30% of a firm's expected revenues have an exposure of 1 to the euro, 20% have an exposure of -0.44 to the euro, and the other 50% have an exposure of 0 to the euro, what is the firm's overall FX revenue exposure to the euro?

6. Use the UVM scenario in the text, and find UVM's FX revenue exposure to the euro in the case where the original FX rate is 1 \$/€, if the new FX rate is 1.15 \$/€.

7. Use the UVC/FN scenario in the text. Find UVC's FX revenue exposure to the euro in the case where UVC competes with FN and the FX rate changes from 1 \$/€ to 1.15 \$/€.

8. Extending the prior problem, find FN's revenue exposure to the US dollar.

9. (Compound exposure—see Appendix.) Assume that the revenues that your US company generates in Euroland, in euros, have a revenue exposure of to the yen of $B_{R¥}^{€}$ = 0.80, due to Japanese competition in Euroland. Since your company is a US company, there is an FX conversion exposure of the revenues in US dollars to the euro, $B_{R€}^{\$}$ = 1. If the FX values of the yen and the euro both appreciate by 10% (relative to the US dollar), what is the percentage change in the US dollar level of the company's revenues generated in Euroland.

Answers to problems: 1. \$560K. 2. $B_{R\$}^{£}$ = - 3. 3. The percentage change in the FX value of the Dk is (1/7.50 Dk/\$)/(1/6.60 Dk/\$) - 1 = - 0.12, or – 12%. Given the FX revenue exposure of 1.20, the US dollar revenues should change by 1.20(- 0.12) = - 0.144, or – 14.4%, to \$428K per year. 4. $B_{R\$}^{¥}$ = 1; ¥1.15 mm. 5. $B_{R€}^{\$}$ = 0.212; $B_{C€}^{\$}$ = 0.25. 6. Sales = 841 units; euro revenue is €1.731 mm; US dollar revenue is \$1.99 mm; $B_{R€}^{\$}$ = 1.57. 7. Sales = 622 units; euro revenue is €1.143 mm; US dollar revenue is \$1.315 mm; $B_{R€}^{\$}$ = 2.56. 8. Sales = 439 units; euro revenue is €807K; $B_{R\$}^{€}$ = - 0.15/-0.13 = 1.15. 9. 18.8%.

COMPREHENSIVE SCENARIOS (See Other Chapters)

SCENARIO 1: AEM Inc.

AEM Inc. (“American Exporting Monopolist”) is an American exporter of widgets to Europe. There are no competitors. AEM is assumed to produce the widgets in the US at a cost of \$1300 per widget. AEM is assumed to face the demand function in the sales market in Europe: $p^{€} = 2700 – Q$, where $p^{€}$ is the price of a widget in Europe in euros and Q is the quantity of widgets demanded and sold by AEM. Assume the FX rate is currently $X^{\$/€}$ = 1 \$/€. Estimate AEM’s FX revenue exposure to the euro from its exporting operation, if the euro depreciates by 20% relative to the US dollar.

Answer: ***1.679***. Setting MR of 1 \$/€ (€2700 – 2Q) equal to MC of \$1300, results in Q = 700. Thus the price charged per widget is €2700 – 700 = €2000. In US dollars, the exporting revenue is 1 \$/€(€2000)(700) = \$1.4 mm. Now assume the euro depreciates by 20%. Setting MR of 0.80 \$/€ (€2700 – 2Q) equal to MC of \$1300, results in Q = 537.5. Thus the price charged per widget is €2700 – 537.5 = €2162.5. In US dollars, the exporting revenue is 0.80 \$/€(€2162.5)(537.5) = \$929,875. AEM’s revenue falls by \$929,975/1.4 mm – 1 = - 0.3358, or – 33.58%, when the euro depreciates by 20%. AEM’s FX revenue exposure to the euro is – 0.3358/-0.20 = 1.679.

SCENARIO 2: AWC/EWC

AWC ("American Widget Competitor") Inc., a US-producing widget exporter to Europe, has a local European competitor, EWC ("European Widget Competitor") Co. The demand function for widgets in Europe is $p^{€} = €2700 - Q_U - Q_E$, where Q_U and Q_E represent the quantity of widgets sold by AWM and EWC, respectively. Assume that ELC can produce widgets for €1300 per widget, while AWC can produce them for $1400. Assume the FX rate is currently $X^{\$/€}$ = 1 $/€. Estimate AWC's FX revenue exposure to the euro, and EWC's FX revenue exposure to the US dollar, if the euro depreciates by 20% relative to the US dollar.

Answers: ***3.225; 1.253.*** When the FX rate is 1 $/€, AWC's MR is 1 $/€($€2700 - 2Q_U - Q_E$) and MC = $1400. EWC's MR is $€2700 - Q_U - 2\,Q_E$, and MC = €1300. Setting each MR = MC and solving the 2 equations simultaneously, we get that Q_U = 400 and Q_E = 500. The price of a widget is €1800. AWC's revenue in US dollars is 1 $/€(€1800)(400) = $720K; EWC's revenues in euros is (€1800)(500) = €900K.

When the FX rate is 0.80 $/€, AWC's MR is 0.80 $/€($€2700 - 2Q_U - Q_E$) and MC = $1400. EWC's MR is $€2700 - Q_U - 2Q_E$, and MC = €1300. Setting each MR = MC and solving the 2 equations simultaneously, we get that Q_U = 166.67 and Q_E = 616.67. The price of a widget is €1916.67.

AWC's revenue in US dollars is 0.80 $/€(€1916.67)(166.67) = $255,560. The percentage change in AWC's revenues is $255.56K/720K – 1 = -0.6451. AWC's FX revenue exposure to the euro is –0.6451/-0.20 = 3.225.

EWC's revenue in US dollars is (€1916.67)(616.67) = €1,182K. The percentage change in EWC's revenues is €1,182K/9000K – 1 = 0.3133. EWC's FX revenue exposure to the US dollar, is 0.3133/0.25 = 1.253.

APPENDIX

Tuesday September 19 12:14 PM ET

Cisco CEO Says Weak Euro a 'Non-Factor'

BOSTON (Reuters) - The chief executive of Cisco Systems Inc (NasdaqNM:CSCO - news), the No. 1 maker of Internet networking equipment, said on Tuesday his company doesn't have euro worries hurting other U.S. companies doing business overseas.

”We do most of our business in U.S. dollars over there," John Chambers told Reuters at a Boston technology conference hosted by SG Cowen Securities Inc. ``It actually has a slight positive effect in terms of expenses. (The euro) is a non-factor in terms of our exposure versus what other companies do.''

The euro dropped on Monday to its lowest level ever, battering stock and bond prices. A weaker euro -- the common European currency -- normally hurts the profits of U.S. companies that sell their products there.

Boston-based Gillette Co (NYSE:G - news), for example, warned of flat third-quarter sales, putting some of the blame on a weak euro.

Chambers said Cisco has always done most of its overseas business in U.S. dollars.

”I wish I could tell you it was brilliant leadership, but it's not. We just started that way and continued,'' Chambers said.

TWO QUESTIONS:

1. Is Cisco maintaining stable product prices in US dollars? If so, is there an alternative product, with price set in euros, that European buyers can turn to as Cisco's become more expensive in terms of euros?

2. Even if Cisco has no competitor and maintains set prices in US dollars, is demand so inelastic that sales volume does not drop in the face of the higher prices in euros?

COMPOUND FX REVENUE EXPOSURE

Western Mining Co. is an Australian producer of minerals and metals. The firm exports to the United States, Canada, and Europe, and the currency of determination for the products in all three export markets is the US dollar.

For many years, the management at Western Mining believed that from the perspective of the home currency, A$, the company's only FX revenue exposure was the *conversion exposure* to the US dollar. However, during a period of an appreciation of the US dollar relative to the Australian dollar, Western Mining did NOT experience the increase in A$ revenues that had been expected. The reason, management discovered, was that the US dollar had also appreciated relative to European currencies (represented now in general by the euro), and as the metals prices increased in Europe in terms of euros, the demand by Europeans declined. Thus, Western Mining became aware of an additional exposure in its revenue stream, the economic exposure of the *US dollar* revenues to changes in the $/€ FX rate.

This scenario is a relatively complex situation of *compound FX exposure*. Let us illustrate Western Mining's compound FX exposure using a hypothetical Australian mining company, called Koala Mining Company. For clarity, assume that the firm sells products with a US dollar currency of determination and has sales *only* in Europe, so that 100% of the revenues are subject to the economic exposure to the $/€ FX rate.

For simplicity, assume initially that the spot FX rates are 1 $/A$ and 1 $/€. Thus, the initial FX rate between Australian dollars and euros is 1 A$/€. Assume that under the initial FX conditions, Koala Mining expects to ship 1000 tons to Europe per year. Assume that the going-price in the international metal markets with a US dollar currency of determination, is $1K/ton. This US dollar price means that the Europeans pay €1K/ton at the assumed time-0 spot FX rate of $X_0^{\$/€}$ = 1 $/€. Since Koala expects to receive $1K/ton, the original expectation for the future revenue stream in US dollars is $R_0^{\$}$ = $1 mm per year, and the expected Australian dollar revenue stream is $R^{A\$}$ = $1 mm/(1 $/A$) = A$1 mm per year.

Now consider the case where the FX market experiences a *unilateral change in the spot FX value of the Australian dollar*, relative to all other currencies, in the form of a 20% depreciation to 0.80 $/A$ and 1.25 A$/€, and thus the $/€ FX rate remains the same at 1 $/€. This situation implies a 25% appreciation of both the euro and the US dollar relative to the Australian dollar. If this unilateral change in the FX value of the Australian dollar occurs, the expected revenues in US dollars would be unchanged, since the stability of the $/€ FX rate would imply no economic demand changes by the Europeans. However, the FX conversion exposure of the A$ revenues to the US dollar would imply that the new expected A$ revenues would be $1 mm/(0.80 $/A$) = A$1.25 mm, an increase of 25%.

Now suppose that instead of the unilateral move in the Australian dollar, both the euro and the Australian dollar depreciate by 20% relative to the US dollar, a *unilateral change in the spot FX value of the US dollar* relative to the other two currencies. The new FX rates are $X_1^{\$/A\$}$ = 0.80 $/A$, $X_1^{\$/€}$ = 0.80 $/€, and $X_0^{A\$/€}$ remains the same at 1 A$/€. In this case, the A$/$ FX rate has taken the same time-1 value as it would in the case of the unilateral move in the Australian dollar, 0.80 \$/A\$. However, given a stable US dollar price of \$1K/ton, the new sales price in euros to Europeans is (\$1K/ton)/(0.80 \$/€) = €1250/ton, a pass-through resulting from the change in the \$/€ FX rate.

Assume that the elasticity of the demand function dictates that the price increase in euros causes the expected European demand to fall to 880 tons from the original demand of 1000 tons. Thus, Koala's new expected revenues in US dollars are lower, $R^{\$}$ = (\$1K/ton)(880 tons) = \$880K per year. The firm's revenues, in US dollars, drop by 12% (from \$1 mm to \$880K).

Since the expected US dollar revenues drop by 12% in response to a 20% depreciation of the € relative to the US dollar, the FX exposure of the US dollar revenues to the € is $B_{R€}^{\$}$ = 0.12/0.20 = 0.60. The new expected Australian dollar revenues are \$880K/(0.80 \$/A\$) = A\$ 1.1 mm. The 10% increase in the expected A\$ revenues, from A\$ 1 mm to A\$ 1.1 mm, is due to the combined impact of two exposures. The first is the economic exposure of the US dollar revenues to the \$/€ FX rate. The second is the conversion exposure to the A\$/\$.

Note, however, that Koala's exposure *cannot* be measured simply in terms of changes in the A\$/€ FX rate. In the case of a unilateral US dollar move, we saw that the expected A\$ revenues change even though the A\$/€ FX rate did not change. Thus, Koala's FX exposure problem cannot be described as an FX exposure of it's A\$ revenues to the A\$/€ FX rate. Instead, Koala's FX exposure problem must be measured in terms of *two* FX rates, the \$/€ FX rate (for the economic exposure) and the A\$/\$ FX rate (for the conversion exposure).

This FX exposure problem is a *compound FX exposure*, where the firm's US dollar revenues are exposed to changes in the \$/€ FX rate, an exposure that is compounded into the FX conversion exposure of the revenues in Australian dollars to the A\$/\$ FX rate. It turns out that the percentage change in Koala's A\$ revenues can be written in the following compound formulation as

$$\%\Delta R^{A\$} = [1 + B_{R€}^{\$}(x^{\$/€})][1 + B_{R\$}^{A\$}(x^{A\$/\$})] – 1 \qquad (5\text{-}2)$$

In the Koala example, $B_{R€}^{\$}$ is 0.60 and $B_{R\$}^{A\$}$ is 1. Thus, consider the situation when the US dollar FX move is unilateral (that is, when the € depreciates by 20% relative to the US dollar and the US dollar appreciates by 25% relative to the Australian dollar). From equation (5-2), the percentage change in the expected A$ revenues is [1 + 0.60(-0.20)][1 + 1(0.25)] - 1 = (0.88)(1.25) - 1 = 0.10, or an increase of 10%, as found earlier. Next, consider the situation when the Australian dollar move is unilateral (that is, when the value of the € is unchanged relative to the US dollar and the value of the US dollar appreciates by 25% relative to the Australian dollar). From equation (5-2), the percentage change in the A$ revenues is [1 + 0.60(0)][1 + 1(0.25)] - 1 = (1.00)(1.25) - 1 = 0.25, or an increase of 25%, as found earlier.

Thus, we see that the compound exposure measurement in equation (5-2) describes the situation for the two extreme cases involving unilateral FX changes in the U$ and A$, respectively. The following additional example addresses the case of non-unilateral currency moves and also provides some further analysis of the underlying fundamentals.

Find the percentage change in Koala's expected A$ revenues, assuming that the US dollar revenues have an exposure of 0.40 to the €, that the € appreciates by 20% relative to the US dollar, and that the US dollar depreciates by 5% relative to the Australian dollar. Given a time-0 FX rate of 1 A$/$ and an expected future US dollar revenue stream of $1 mm per year, find the original expected A$ revenues and the new expected A$ revenues. Show that the percentage change in the expected A$ revenues reconciles with the computed value for $\%\Delta R^{A\$}$ ***from the application of equation (5-2).*** *Answers: Using the* *compound exposure measurement formulation in equation (5-2),* $\%\Delta R^{A\$} = [1 + 0.40(0.20)][1 + 1(-0.05)] - 1 = (1.08)(0.95) - 1 = 0.026$*. Thus, the percentage change in the expected A$ revenues should be 2.60%. Let us examine this result in the form of fundamental details, given original expected future US dollar revenue stream of $1 mm per year. Note first that the new expected future US dollar revenues are 8% higher, given the FX exposure to the € of 0.40 and given the 20% appreciation of the € relative to the US dollar. Thus the new US dollar revenues are $1.08 mm per year. Given a time-0 FX rate of 1 A$/$ and a 5% depreciation of value of the US dollar relative to the Australian dollar, the new FX rate is 0.95 A$/$, and the new expected A$ revenues are $1.08 mm(0.95 A$/$) = A$ 1.026 mm per year, 2.60% higher than the original expected base revenues of A$ 1 mm.*

In reality, Western Mining Co. had sales elsewhere than in Europe. In particular, sales were also in the United States and Canada. Thus, a complete analysis would have segmented the operating revenues by market currency. The US revenues would be analyzed as having simple conversion exposure to the A$/$ exchange rate, while the European and Canadian portions would be analyzed with an equation for compound exposure, similar to the one just used, using the euro and the Canadian dollar as the foreign currencies, respectively.[5]

[5] See Peter J. Maloney, "Managing Foreign Exchange Exposure: The Case of Western Mining," *Journal of Applied Corporate Finance*, Winter 1990, pp. 29-34.

TABLE 5-2

	Yen	Pound	Mark	"Index"	GILLETTE		MERCK		GE	
					Revenue	%Change	Revenue	%Change	Revenue	%Change
Dec-89	0.010	0.016	0.122	0.049	1052000		1761100		18944000	
Mar-90	-0.063	0.018	0.019	-0.009	1047200	-0.005	1758400	-0.002	12599000	-0.335
Jun-90	-0.003	0.053	0.013	0.021	1029000	-0.017	1899300	0.080	14352000	0.139
Sep-90	0.110	0.099	0.072	0.094	1026300	-0.003	1914300	0.008	14050000	-0.021
Dec-90	0.034	0.023	0.048	0.035	1242100	0.210	2099500	0.097	16661000	0.186
Mar-91	-0.025	-0.052	-0.071	-0.049	1114700	-0.103	2048900	-0.024	13333000	-0.200
Jun-91	-0.017	-0.094	-0.096	-0.069	1088800	-0.023	2122400	0.036	14774000	0.108
Sep-91	0.041	0.047	0.053	0.047	1138000	0.045	2117400	-0.002	14578000	-0.013
Dec-91	0.049	0.058	0.083	0.064	1342400	0.180	2314000	0.093	16694000	0.145
Mar-92	-0.036	-0.057	-0.059	-0.051	1206800	-0.101	2223400	-0.039	13525000	-0.190
Jun-92	0.047	0.076	0.057	0.060	1198900	-0.007	2373700	0.068	15188000	0.123
Sep-92	0.035	-0.005	0.084	0.038	1249200	0.042	2464300	0.038	15450000	0.017
Dec-92	-0.012	-0.160	-0.083	-0.085	1507900	0.207	2601100	0.056	12111000	-0.216
Mar-93	0.060	-0.058	-0.039	-0.012	1216600	-0.193	2379600	-0.085	12700000	0.049
Jun-93	0.089	0.032	-0.005	0.039	1237300	0.017	2573600	0.082	14566000	0.147
Sep-93	0.017	0.011	0.020	0.016	1339700	0.083	2544100	-0.011	14669000	0.007
Dec-93	-0.039	-0.022	-0.052	-0.038	1617200	0.207	3000900	0.180	17892000	0.220
Mar-94	0.046	0.000	0.012	0.019	1361100	-0.158	3514300	0.171	14182000	-0.207
Jun-94	0.025	0.023	0.039	0.029	1406500	0.033	3792000	0.079	16196000	0.142
Sep-94	0.038	0.026	0.050	0.038	1503400	0.069	3792000	0.000	16153000	-0.003
Dec-94	-0.014	-0.005	-0.014	-0.011	1799200	0.197	3871500	0.021	13578000	-0.159
Mar-95	0.107	0.027	0.118	0.084	1536000	-0.146	3817300	-0.014	15126000	0.114
Jun-95	0.069	-0.003	0.003	0.023	1601000	0.042	4135700	0.083	17809000	0.177
Sep-95	-0.158	-0.022	-0.040	-0.074	1669800	0.043	4171100	0.009	17341000	-0.026
Dec-95	-0.013	-0.012	0.014	-0.004	1987900	0.191	4557000	0.093	19752000	0.139
Mar-96	-0.039	-0.009	-0.025	-0.024	1676900	-0.156	4530400	-0.006	17098000	-0.134
Jun-96	-0.028	0.009	-0.033	-0.017	1745700	0.041	4908800	0.084	19066000	0.115

Sep-96	-0.009	0.011	0.013	0.005	1803300	0.033	4983400	0.015	20021000	0.050
Dec-96	-0.036	0.067	-0.029	0.001	4471800	1.480	5406100	0.085	22994000	0.148
Mar-97	-0.072	-0.033	-0.084	-0.063	2180000	-0.513	5567900	0.030	19998000	-0.130
Jun-97	0.074	0.022	-0.019	0.026	2285200	0.048	5909200	0.061	21860000	0.093
Sep-97	-0.055	-0.027	-0.033	-0.038	2436700	0.066	5927700	0.003	21806000	-0.002
Dec-97	-0.068	0.036	0.004	-0.009	3160100	0.297	6232100	0.051	24876000	0.141
Mar-98	0.005	0.001	-0.026	-0.007	2025000	-0.359	6058800	-0.028	22459000	-0.097
Jun-98	-0.080	-0.007	0.019	-0.023	2325000	0.148	6470400	0.068	24928000	0.110
Sep-98	0.044	0.019	0.055	0.039	2531000	0.089	6838300	0.057	23978000	-0.038
Dec-98	0.149	-0.007	0.017	0.053	3175000	0.254	7530700	0.101	28455000	0.187
Mar-99	-0.020	-0.030	-0.071	-0.040	1939000	-0.389	7536700	0.001	24062000	-0.154
Jun-99	-0.010	-0.016	-0.047	-0.024	2414000	0.245	8018200	0.064	15857000	-0.341
Sep-99	0.129	0.019	0.012	0.053	2509000	0.039	8195700	0.022	27112000	0.710