

Chapter

9

Measuring and Managing Real Exchange Risk

In May 2009, the Australian mineral extraction company, Rio Tinto Ltd., contracted with Japan's largest steel company, Nippon Steel, on a U.S. dollar (USD) price that Nippon would pay for iron ore over the next year. Given the severity of the global recession, the USD price was 33% lower than the previous price. Exchange rates provided a benefit to both companies. Over the previous year, the Australian dollar weakened relative to the U.S. dollar by 18%, whereas the Japanese yen had strengthened relative to the U.S. dollar by 10%. Because Rio Tinto's extraction costs in Australian dollars were essentially constant, the exchange rate change mitigated its loss of profit from a lower export price. Similarly, although the yen prices of finished steel were down in Japan, the strengthening of the yen lowered Nippon's costs in addition to the reduced USD price of iron ore and thus mitigated its loss of profit. The situations of these two firms are examples of how changes in exchange rates can affect the profitability of a firm, in this case positively. This chapter examines how firms respond to this "real exchange risk" with their pricing, marketing, and production policies.

In general, such changes in profitability arise because of fluctuations in real exchange rates. We develop the concept of real exchange risk by first demonstrating how the real exchange rate arises naturally in understanding the profitability of exporters and importers. Then we examine how to share real exchange risk in a long-term contract. Whenever firms from different countries that do not share a common currency enter into a long-term contract, real exchange risk must be allocated in some way. Next, we examine why firms violate the law of one price when selling in the domestic and foreign markets; that is, they "price-to-market." We also explore how firms' prices should respond optimally to fluctuations in real exchange rates. Fluctuations in real exchange rates also make foreign subsidiaries more or less profitable. We explore how to design a compensation system for foreign subsidiaries that rewards good management and not just luck due to favorable movements in real exchange rates. The chapter ends with some general advice for how managers can respond to changes in real exchange rates.

9.1 HOW REAL EXCHANGE RATES AFFECT REAL PROFITABILITY

To understand how changes in the real exchange rate affect a firm's profitability, we consider the **real profitability** of a firm, which is the purchasing power of a firm's nominal profits. It is obtained by dividing the firm's nominal profits by the price level. A firm's shareholders

care only about the firm's real profits, not its nominal profits, because ultimately, they care only about how much they can consume—not how much money they have.

The Real Profitability of an Exporting Firm

Consider the real profitability of Apples Galore, a U.S. exporter that sells apples in both the United States and Britain. Suppose that Apples Galore produces apples in the United States and incurs only dollar costs. Let's begin by calculating its nominal profit.

Calculating a Firm's Nominal Profit

Apples Galore's nominal profit is the sum of its domestic sales and foreign sales minus its nominal costs:

$$\text{Nominal profit} = \text{Dollar revenue from U.S. sales} + \text{Dollar revenue from U.K. sales} \\ - \text{Dollar costs}$$

Dollar revenue from its U.S. sales is the dollar price of apples, $P(A, \$)$, multiplied by the quantity of apples the firm sold, $Q(A, \text{U.S.})$:

$$\text{Dollar revenue from U.S. sales} = P(A, \$) \times Q(A, \text{U.S.})$$

Dollar revenue from U.K. sales is the nominal exchange rate ($\$/\pounds$) multiplied by the pound price of apples, $P(A, \pounds)$, multiplied by the quantity of apples sold in the United Kingdom, $Q(A, \text{U.K.})$:

$$\text{Dollar revenue from U.K. sales} = S(\$/\pounds) \times P(A, \pounds) \times Q(A, \text{U.K.})$$

Apples Galore's dollar cost of production is the average dollar cost per apple, $C(A, \$)$, multiplied by the total quantity of apples it sold in both the U.S. and U.K. markets:

$$\text{Dollar cost of production} = C(A, \$) \times [Q(A, \text{U.S.}) + Q(A, \text{U.K.})]$$

Relative Prices and Components of Real Profit

Apples Galore's real profit is its nominal profit divided by the U.S. price level, $P(\$)$. We'll consider U.S. revenue, U.S. costs, and U.K. revenue, in that order. The first term is

$$\text{Real revenue from U.S. sales} = \frac{P(A, \$) \times Q(A, \text{U.S.})}{P(\$)} = \frac{P(A, \$)}{P(\$)} \times Q(A, \text{U.S.})$$

On the right-hand side is the **relative price** of apples in the United States multiplied by the quantity of apples. The relative price affects the **demand curve** for apples and determines, along with other variables like people's income, how many apples will be sold. Think of Apples Galore as setting its relative price to determine how much it will be able to sell. To keep the relative price of apples constant, the firm must ensure that the nominal price of the apples increases at the U.S. rate of inflation.

Next, consider Apples Galore's real costs. Divide dollar costs by the U.S. price level:

$$\text{Real costs} = \frac{C(A, \$)}{P(\$)} \times [Q(A, \text{U.S.}) + Q(A, \text{U.K.})]$$

Total real cost is the average real cost per apple, $[C(A, \$)/P(\$)]$, multiplied by the amount of apples sold in both countries. If its nominal average cost per apple increases at the U.S. rate of inflation, its real average costs are constant.

A Firm's Real Export Revenue

Now, consider Apples Galore's real export revenue. Divide its nominal export revenue by the price level in the United States:

$$\text{Real revenue from U.K. sales} = \frac{S(\$/\pounds) \times P(A, \pounds) \times Q(A, \text{U.K.})}{P(\$)}$$

If we multiply and divide the firm's real export revenue by the U.K. price level, $P(\pounds)$, and rearrange terms, we have

$$\text{Real revenue from U.K. sales} = \frac{S(\$/\pounds) \times P(\pounds)}{P(\$)} \times \frac{P(A, \pounds)}{P(\pounds)} \times Q(A, \text{U.K.})$$

Apples Galore's real export revenue involves three real terms. The first is the real exchange rate, $[S(\$/\pounds) \times P(\pounds)/P(\$)]$; the second is the relative price of apples in the United Kingdom, $[P(A, \pounds)/P(\pounds)]$; and the third is the quantity of apples sold in the United Kingdom, $Q(A, \text{U.K.})$.

When Apples Galore sets its U.K. relative price, the demand curve determines the amount of apples sold. Over time, if the U.K. demand curve does not change, Apples Galore will sell the same amount of apples if it keeps its relative price constant. This requires increasing the pound price of apples by the same percent as the U.K. rate of inflation. In this situation, if the real exchange rate is also constant, Apples Galore gets the same U.S. real revenue. Clearly, a real appreciation of the pound increases real revenue from the United Kingdom and allows the firm to become more competitive there because it can lower its relative price of apples.

How the managers of the firm choose to respond with their relative prices to changes in the real exchange rate is known as **exchange rate pass-through**. We will study more about pricing in the face of real exchange rate changes in Section 9.4. Now, though, let's consider the nature of risk that a firm faces from real exchange rate changes.

9.2 REAL EXCHANGE RISK AT EXPORTERS, IMPORTERS, AND DOMESTIC FIRMS

The phenomenon whereby the profitability of a firm can change because of fluctuations in the real exchange rate is called **real exchange risk** (or **operating exposure** or **economic exposure**). The Apples Galore example focuses on an exporting firm, but firms that sell products domestically and have imported costs also experience real exchange risk. Why is this so?

The value of a firm is represented by the present value of its expected future profitability. If there are changes in exchange rates that affect a firm's cash flows, either through changes in the demand for its products or through changes in the costs of its inputs, the firm faces a real exchange risk. Before we examine discounted profitability, let's examine how changes in real exchange rates cause changes in a firm's profitability.

In general, a real depreciation of the domestic currency hurts importing firms and helps exporting firms. A firm can even have an exposure to real exchange rates without having direct exposure to foreign currency cash flows because, for example, a real appreciation of the domestic currency hurts domestic import-competing firms who must then compete against less expensive imports. Because many firms have important imported parts and materials, real exchange rate changes can also affect the cost structure of a firm. Exactly how a firm is affected depends on the firm's type of business—that is, it depends on whether it is a net exporter, a net importer, or an import competitor. It also depends on the firm's competitive situation, by which we mean the degree of monopoly power that the firm commands for its products.

The Real Exchange Rate Risk of a Net Exporter

Suppose an exporting firm faces a nominal depreciation of the foreign currency. If the firm does nothing, the depreciation of the foreign currency lowers the nominal value of export revenue. The firm can avoid this decrease in profitability by increasing the foreign currency price of its product, but its ability to do so will be limited by the firm's competitive situation. Because the foreign demand for the firm's product depends on the product's relative price in the foreign country, we know that the firm will sell less of its product if it raises the price in the foreign country by more than the foreign rate of inflation. However, if the magnitude of the depreciation of the foreign currency *just equals* foreign inflation minus domestic inflation [that is, if relative purchasing power parity (PPP) holds], then increasing the nominal foreign price of the product in the foreign market by the same amount as at the foreign rate of inflation will cause the domestic currency value of the firm's foreign revenue to increase at the domestic rate of inflation. Thus, the firm's real revenue from exporting would not be affected.

Example 9.1 A Greek Cell Phone Exporter

Olympia Communication Exporters (OCE) manufactures cellular phones in Greece and sells them in the United States. This year, OCE priced its phone at \$79.00 and sold 2,000,000 phones at an average exchange rate of \$1.25/€. Hence, OCE's euro revenue this year is

$$\frac{\$79.00}{\text{phone}} \times (2,000,000 \text{ phones}) \times \frac{1}{\$1.25/\text{€}} = \text{€}126,400,000$$

Economists are forecasting 5.5% inflation for the United States and 1% inflation for Europe. They also expect the dollar to weaken to

$$\frac{\$1.3057}{\text{€}} = \frac{\$1.25}{\text{€}} \times \frac{1.055}{1.01}$$

and this change just offsets the inflation differential and leaves the real exchange rate unchanged. If the U.S. demand curve is constant, what dollar price should OCE charge if it wants to earn the same real revenue and sell the same quantity of phones in the United States?

The answer is that the price of a phone should increase by 5.5%, to

$$(\$83.35/\text{phone}) = (\$79.00/\text{phone}) \times (1.055)$$

in which case, the nominal revenue will increase to

$$\frac{\$83.35}{\text{phone}} \times 2,000,000 \text{ phones} \times \frac{1}{\$1.3057/\text{€}} = \text{€}127,670,981$$

Notice that €127,670,981 is 1% higher than €126,400,000. An increase of 1% in nominal revenue is required to keep the firm's real revenue constant.

A Competitive Dilemma

Any increase in the exchange rate above \$1.3057/€, the value that kept the real exchange rate constant in Example 9.1, creates a dilemma for Olympia Communication Exporters. If

the firm does not increase the price of its phone above \$83.35, the euro value of the company's revenue will decrease. However, if the company increases the price of its phone above the U.S. rate of inflation, the firm will sell fewer phones. Either way, though, a real appreciation of the euro hurts OCE's real profitability.

The choice that OCE should make in terms of raising its U.S. relative price depends on its competitive situation. We know that OCE will be less profitable after a real depreciation of the dollar, but we don't know by how much. A major factor determining the firm's response is the elasticity of its demand curve. **Elasticity** measures the percentage change in the quantity of the product demanded when the percentage relative price of the product changes. The more *inelastic* a product's demand curve, the less the quantity sold falls when its price rises. In contrast, the more *elastic* a product's demand curve, the more the quantity sold falls when the product's price rises. In other words, the more elastic the demand curve, the more likely it is that consumers will switch products or not buy the product at all when the relative price increases. In addition, the more competitive the market is for a product, the more elastic is the product's demand curve.

Because cellular phones are manufactured by many different companies around the world and because consumers are quite price sensitive, the market is quite competitive. Hence, it is unlikely that OCE would have much market power to raise its relative price without suffering a large fall in its sales. Thus, it is likely that OCE would not increase its price very much above what is warranted by U.S. inflation. However, if the OCE phone has some unique features that make the demand for its phone more inelastic (that is, less responsive to price changes), the company will not lose as much profitability because it can pass through more of the change in the exchange rate to the product's price.

The Real Exchange Risk of a Net Importer

The next example demonstrates how the real profits of a **net importer**—that is, a firm with more imported inputs than exports—are affected by a change in the real exchange rate.

Has Real Appreciation Hurt Chinese Exporters?

The November 6, 2010, U.S. edition of *The Economist* carried an article entitled “Nominally Cheap or Really Dear? The Yuan–Dollar Exchange Rate.” The article noted that U.S. officials complain about an undervalued yuan that gives Chinese exporters a competitive advantage. In comparing changes in costs across countries, however, *The Economist* argued that it is not the change in the nominal exchange rate that is important but, instead, the change in the real exchange rate. Furthermore, the article noted that measuring real appreciation of the yuan versus the dollar using relative nominal unit labor costs, defined as “the price of labour per widget,” makes good sense. Between 2005 and 2010, the nominal yuan appreciated by 24% versus the dollar, whereas Chinese unit labor costs increased by 21% relative to U.S. unit labor costs. The combination of the nominal appreciation and the relative increase in unit labor

costs implies a 50% real appreciation of the yuan. The profitability of Chinese exporters has surely been squeezed during this 5-year period.

The debate about the undervalued yuan continued in early 2011 during a state visit to the United States by Chinese President Hu Jintao. U.S. Treasury Secretary Timothy Geithner continued to argue for faster nominal appreciation of the yuan, while in Geneva, Heiner Flassbeck, Director of the United Nations Conference on Trade and Development's Division on Globalization and Development Strategies, held a press conference on January 19, 2011, stating that according to his calculations based on unit labor costs, the Chinese currency “is not undervalued” because it has appreciated in real terms by 100% since 1995. U.S. politicians remain unconvinced.

Example 9.2 A Malaysian Airline Company

Trans-Malaysian Airlines (TMA) flies mostly domestic routes within Malaysia. Its imported fuel costs \$3.50/gallon. Last year, TMA imported 250,000,000 gallons of fuel, and the Malaysian ringgit–U.S. dollar exchange rate was MYR4/USD. Thus, TMA’s nominal fuel costs were

$$\frac{\$3.50}{\text{gallon}} \times 250,000,000 \text{ gallons} \times \frac{\text{MYR4}}{\text{USD}} = \text{MYR3.5 billion}$$

Last year, TMA’s nominal revenues minus its other ringgit costs were MYR4.0 billion, and its profit was

$$\text{MYR4.0 billion} - \text{MYR3.5 billion} = \text{MYR0.5 billion}$$

Suppose TMA is regulated and cannot increase its MYR ticket price by more than the Malaysian rate of inflation, which is 15% this year. If holding the relative price constant results in the same demand for its flights, then TMA will have the same number of passengers this year, it will need the same amount of fuel, and its revenue will increase by 15%. Suppose that its other ringgit costs also increase by 15%. However, suppose the dollar price of fuel increases by the U.S. rate of inflation, which is 4%. By how much will real profits fall if there is a 10% real appreciation of the dollar relative to the ringgit?

Let’s first calculate the new nominal MYR/USD exchange rate implied by the 10% real appreciation of the dollar. Because Malaysian inflation (15%) is higher than U.S. inflation (4%), the dollar should appreciate in nominal terms even if there is no real dollar appreciation. One plus the warranted rate of nominal dollar appreciation due strictly to the inflation differential is (1.15/1.04). The new nominal exchange rate must be 10% higher than this to induce a 10% real appreciation of the USD, so the new nominal exchange rate will be

$$\frac{\text{MYR4}}{\text{USD}} \times \frac{1.15}{1.04} \times 1.10 = \frac{\text{MYR4.8654}}{\text{USD}}$$

The new price of fuel is \$3.50/gallon \times 1.04 = \$3.64/gallon. Because the same number of gallons will be required, new fuel costs will be

$$\frac{\$3.64}{\text{gallon}} \times 250,000,000 \text{ gallons} \times \frac{\text{MYR4.8654}}{\text{USD}} = \text{MYR4.428 billion}$$

TMA’s ringgit revenues and its other costs are now 15% higher, due to inflation in Malaysia. Because revenues net of other costs were MYR4.0 billion last year, this year, they will be MYR4.0 billion \times 1.15 = MYR4.6 billion. Hence, nominal profits will be

$$\text{MYR4.6 billion} - \text{MYR4.428 billion} = \text{MYR0.172 billion}$$

Recall that TMA’s nominal revenues last year were MYR0.5 billion. As you can see, instead of nominal profits increasing by 15% as they would have without the real depreciation of the ringgit, nominal profits have actually fallen by 65.6% because $-0.656 = [(0.172 - 0.5)/0.5]$. Notice also that real profits have fallen by 70.1% because $-0.701 = [((0.172/1.15) - 0.5)/0.5]$.

A real appreciation of the dollar clearly has a severe effect on the real profitability of TMA because it increases TMA’s costs, and the regulation prevents the company

from passing any of its increased costs due to a change in the exchange rate on to its customers in the form of higher prices.

Of course, an increase in the relative price of tickets decreases the demand for air travel. If TMA could increase its relative price, it would have to decide how much of the real appreciation of the dollar it could pass through to its customers in the form of higher ticket prices. The answer depends on the elasticity of TMA's demand curve. The less competitive the market, the less responsive consumers are to increased fares, and the more TMA's increased costs could be passed on to customers in the form of higher ticket prices.

The Real Exchange Risk of an Import Competitor

The firms we have described so far all engage in operational transactions that require the exchange of foreign currency. Therefore, each firm directly experiences a change in profitability with a change in the real exchange rate. It may seem surprising to you, however, that a firm can have an exposure to real exchange risk even though the company has no explicit cash flows denominated in foreign currency. Consider the following example of an **import competitor**.

Example 9.3 Miami Beach Restaurants

Restaurants in Miami Beach, Florida, accept only dollars from their customers. They buy all their food from suppliers who accept only dollars, and they pay their employees in dollars. Consequently, the restaurants have no explicit foreign currency cash flows and no foreign currency-denominated assets and liabilities. Nevertheless, the Miami Beach restaurants experience fluctuations in their profitability because the demand from their patrons depends on the value of the dollar on the foreign exchange markets.

For example, when the dollar is weak and European currencies are strong, more European tourists enjoy vacations in Miami Beach because U.S. vacations are relatively inexpensive from the European perspective. Likewise, when the dollar is weak on foreign currency markets, more U.S. residents vacation in Miami Beach because European trips are relatively more expensive. Hence, demand for the restaurants' services is high when the dollar is weak. In contrast, when the dollar is strong, Americans view European vacations as relative bargains, and Europeans view trips to the United States as relatively expensive. As a result, relatively fewer American and European tourists travel to Miami, and restaurant profitability falls when the dollar is strong. As you can see, changes in the real exchange rate can alter the demand for products that are neither exported nor imported, such as restaurant meals.

Measuring Real Exchange Risk Exposure

Most nominal exchange rate changes are large relative to the associated changes in the price levels of countries. Hence, most changes in the nominal exchange rate are highly correlated with changes in the real exchange rate, especially in the short run. Most large changes in the nominal exchange rate are therefore associated with changes in relative prices, and most nominal exchange rate changes generate a fair amount of real operating exposure. Real exchange rates affect a firm's operating cash and its current profitability, but they also affect

its future profitability. Thus, real exchange rate exposure must include future periods as well as the current period.

The Present Value of a Firm's Profits

Let $CF(j)$ represent the expected value of a firm's after-tax profits for j periods in the future, and let r represent the appropriate discount rate. Then, the present value of the firm's future after-tax profits is

$$V = \sum_{j=1}^{\infty} \frac{CF(j)}{(1+r)^j}$$

Real exchange risk measures the change in V in response to an unexpected change in the real exchange rate.

We focus on the unanticipated change in the real exchange rate because the effects of any anticipated change would already be incorporated into the market value of the firm. By considering the present value of the firm's profits, we recognize that changes in the exchange rate are persistent and thus have effects on future profitability. A real strengthening of the domestic currency is bad for a net exporter in the current period. Moreover, because changes are so persistent, next period's profits are also likely to be low because the domestic currency is expected to continue to be strong. The next example works through a case in which the change in the real exchange rate is expected to persist indefinitely.

Example 9.4 A French Cheese Exporter

Fromagerie du Provence exports sheep's milk cheese to the United States. Last year, Fromagerie du Provence sold 1.5 million kilos of cheese at \$10 per kilo, for total revenue of \$15 million. The company had dollar costs of \$1 million associated with its U.S. distribution network, which left it with \$14 million in net revenue earned from its U.S. exports. Because the average exchange rate was \$1.40/€, Fromagerie du Provence's net export revenue in euros was equal to

$$\$14,000,000 / (\$1.40/\text{€}) = \text{€}10,000,000$$

The company's euro-denominated costs were €8 million, and it has no sales outside the United States. Hence, its euro-denominated profits were €2 million = €10 million – €8 million.

Suppose financial analysts forecast a constant real exchange rate and recognize that if the company maintains a constant relative price in the United States, it will sell the same amount of cheese every year. Suppose nominal costs in the United States and France are also expected to rise at the respective rates of inflation, in which case real costs are constant.

In this situation, the purchasing power of real net revenue in today's dollars will be \$14 million every year in the future. With a constant real exchange rate, the real euro profits will be €2 million. If the real discount rate is 8%, the real value of the firm in terms of its discounted future profits will be the following infinite sum:¹

$$\frac{\text{€}2,000,000}{1.08} + \frac{\text{€}2,000,000}{1.08^2} + \dots = \frac{\text{€}2,000,000}{0.08} = \text{€}25,000,000$$

¹This particular infinite sum is a perpetuity, which is straightforward to evaluate. The appendix to Chapter 15 describes how the perpetuity formula is derived.

Suppose analysts also think that if the real dollar–euro exchange rate changes, the change will be permanent. In this situation, we can consider how a 1% appreciation of the euro would affect the value of the firm. First, let the new nominal exchange rate be $(\$1.40/\text{€}) \times 1.01 = \$1.414/\text{€}$, which we can consider to be a real appreciation of the euro as well because prices are being held constant as the company does not respond to real appreciations. If Fromagerie du Provence does not adjust its cheese price, the appreciation of the euro would lower the company’s net revenue by 1%, to

$$\$14,000,000/(\$1.414/\text{€}) = \text{€}9,900,990$$

and its euro profits would fall to

$$\text{€}9,900,990 - \text{€}8,000,000 = \text{€}1,900,990$$

which is a decrease of 5%.

An unanticipated 1% real appreciation of the euro that was expected to be permanent would therefore lower all future net revenues to $\text{€}1,900,990$. Thus, the value of the firm would decrease to $(\text{€}1,900,990/0.08) = \text{€}23,762,375$, or by 5%.

Notice that the real exposure of Fromagerie du Provence arises from its large net dollar revenues and the assumed permanence of the exchange rate change. Extrapolating from our 1% change, we see that a 10% real depreciation of the dollar, which is not an extreme event, would cause the value of the firm to decrease by 50%. Of course, this example treats the change in the real exchange rate as permanent. This assumption conflicts with the empirical evidence presented in Chapter 8, which shows that although changes in real exchange rates are highly persistent, they appear to reverse themselves slowly over time. Thus, the actual exposure would be less than what is calculated here.

POINT-COUNTERPOINT

On Producing BMWs in the United States

It is December, and Ante, Freedy, and Suttle are driving through South Carolina on their way to Florida for a quick vacation when Ante spots the BMW plant in Spartanburg. Ante blurts out, “Why on earth would a high-quality German company like BMW want to sully their reputation by producing cars in South Carolina? They must have gotten enormous tax breaks to induce them to locate there.”

Freedy steadies the steering wheel and replies, “What do you mean? American workers are every bit as good as German workers. They’re cheaper, too, at current exchange rates. From the German perspective, German workers cost over $\text{€}30$ per hour, while Americans work for $\text{€}24.50$. Obviously, BMW saw a cost advantage. BMW is also very zealous about its quality. It wouldn’t build a facility if it wasn’t sure that it could produce high-quality cars.”

Ante can hardly control himself as he shouts, “That cost advantage will quickly evaporate if the dollar strengthens versus the euro.”

Suttle, who had been sleeping in the backseat, says, “Guys, there are elements of truth in what both of you are saying. It is true that BMW looks at the costs of workers when making a plant location decision. It also tries to get as many tax breaks from the local authorities as possible. After all, it has invested over $\$1.7$ billion in the South Carolina plant during the past 10 years and is providing thousands of jobs directly, not to mention the jobs of parts suppliers. But Ante is certainly right that an appreciation of the dollar versus the euro would raise the perceived euro-denominated cost to BMW of producing products in the United States

because the workers there are unlikely to take a pay cut just because the dollar strengthens. Nevertheless, you're both missing a major point."

Suttle continues, "One of the main reasons BMW built the Spartanburg plant is foreign exchange risk. If BMW builds a car in Germany and exports it to the United States, BMW has euro costs and dollar revenues. BMW loses a lot of profit when the dollar weakens because BMW cannot increase the dollar price of the car to offset the depreciation of the dollar. The potential loss is huge because the entire dollar revenue of the car is exposed to the exchange rate. On the other hand, if BMW builds a car in the United States and sells it there, BMW incurs dollar costs and dollar revenues. A depreciation of the dollar still creates a loss of value when the profits are converted into euros, and there is still pressure to increase the dollar price of the car to offset dollar depreciation, but the real exchange rate exposure is only on BMW's profit, its dollar revenues minus its dollar costs."

Suttle finishes by saying, "Ante, you're also right that BMW took a big risk that the quality of the cars would be up to the standards of the cars produced in Germany. But that was a risk worth taking because of the enormity of the foreign exchange risk."

9.3 SHARING THE REAL EXCHANGE RISK: AN EXAMPLE

This section examines an extended case that is designed to help you understand how real exchange risk can be shared between firms that do not share a common currency.

Safe Air Evaluates an International Supply Contract

John Cromwell is the 54-year-old CEO of Safe Air, Inc., a U.S. corporation that sells compressed air tanks with face masks to U.S. fire departments. Safe Air's masks are the best available, and Cromwell has often stated that Safe Air has no expertise in manufacturing air tanks. It consequently has always purchased tanks from an external supplier.

Safe Air's board of directors has begun to question Cromwell's leadership because earnings have been declining. Cromwell thinks he is too young to retire and being forced out by the board would be humiliating. In order to cut costs, he solicited bids from potential suppliers of tanks. In particular, Metallwerke, A.G., a German firm that manufactures air tanks, submitted an attractive contract that offered dollar pricing. Cromwell is intrigued by the possibility of locking in long-term dollar prices from a low-cost foreign supplier. He has evaluated the quality of Metallwerke's tanks and thinks they are as good as, if not superior to, that of Safe Air's current U.S. supplier. If the Metallwerke air tank works better than his current tank, he knows that fire departments will probably pay more for the improved performance.

The Indexing Formula

Although Metallwerke quoted a dollar price, Gerhard Spiegel, the CEO of Metallwerke, wants to sign a 10-year contract that sets a base dollar price for the tank and provides an **indexing formula** that allows for annual changes in the base dollar price under certain contingencies: (1) The base dollar price will be increased at the annual rate of inflation, as indicated by the U.S. producer price index; and (2) if the euro appreciates relative to the dollar, the percentage change in the base dollar price will equal the U.S. rate of inflation plus an additional percentage equal to one-half the rate of appreciation of the euro versus the dollar.

In the past, Safe Air's cost of the basic air tank has mostly increased with the U.S. rate of inflation, and Safe Air has typically been able to pass this increased cost along to its fire

department customers by increasing its retail price at the rate of inflation. But occasionally, Safe Air's cost increases from its suppliers have exceeded the U.S. rate of inflation, resulting in several unprofitable periods. Cromwell knows that fire departments are quite sensitive to price, which limits his ability to pass along cost increases. He also does not think that the board of directors at Safe Air will tolerate another unprofitable period without a change in senior management.

The Consultant's Task

You are a consultant, trying to help Cromwell decide what to do. As he talked to you on the telephone yesterday about Metallwerke's offer, you could sense his concerns. While Spiegel's initial base price is quite attractive, Cromwell wonders if there is a way to redesign the contract to be more favorable to Safe Air, and he wants you to find it. You know that the profitability of both firms must be considered in any long-term contract. You also know that somebody must bear the risk that the euro will strengthen relative to the dollar. But something about the current contract seems fishy. If a strong euro is so bad for Metallwerke, shouldn't a weak euro be good? Why isn't this mentioned in any way?

As a consultant to Safe Air, your task is to evaluate the desirability of this contract, to redesign it to be more favorable to Safe Air, and to figure out some way of explaining the issues to Cromwell and possibly to the company's board of directors.

Basic Data and Analysis

Based on data from Cromwell, you have set out some basic prices and notations (the zeros indicate current-period values) related to the Metallwerke proposal:

Safe Air's contractual base purchase price = $B(0, \$) = \400 per tank

Safe Air's other variable production costs = $C(0, \$) = \313 per tank

Safe Air's retail sales price = $T(0, \$) = \856 per tank

Safe Air's profit margin = $M(0, \$) = 20\%$

U.S. price level = $P(0, \$) = \140 per U.S. general good

Exchange rate = $S(0, \$/\text{€}) = \$1.40/\text{€}$

German price level = $P(0, \text{€}) = \text{€}100$ per German general good

Metallwerke's profit margin = $M(0, \text{€}) = 20\%$

Metallwerke's production cost = $C(0, \text{€}) = \text{€}238$ per tank

Profitability Under a Simple Contract with Constant Prices

Let's first look at the profitability of the firms if they were to sign a long-term contract that simply fixes the dollar price of the tank at \$400, no matter what the exchange rate. This is a contract that Cromwell would like because he wants to lock in a dollar price. Assuming that the sales price of the tank is kept constant at \$400, Exhibit 9.1 shows the risks the two companies face under three alternative scenarios corresponding to three exchange rates: \$1.40/€, \$1.54/€ (which represents a 10% appreciation of the euro), and \$1.26/€ (which represents a 10% depreciation of the euro).

Because Exhibit 9.1 assumes that the nominal exchange rate is changing with nominal prices fixed, the real exchange rate is also changing by 10%. Exhibit 9.1 indicates that each firm earns a 20% profit margin at \$1.40/€. The ratio of Safe Air's retail sales price to its production costs is

$$\frac{\$856}{(\$400 + \$313)} = 1.20$$

Exhibit 9.1 Profitability When the Price per Tank Is Contractually Fixed

	Safe Air (dollars)			Metallwerke (euros)		
	\$1.26/€	\$1.40/€	\$1.54/€	\$1.26/€	\$1.40/€	\$1.54/€
Sales						
Exported				317	286	260
Local	856	856	856			
Costs of Goods Sold						
Imported	(400)	(400)	(400)			
Local	(313)	(313)	(313)	(238)	(238)	(238)
Operating Profit	143	143	143	79	48	22
Profit Margin	20%	20%	20%	33.2%	20%	9.2%

The ratio of Metallwerke's euro sales price to its production costs is

$$\frac{\$400/(\$1.40/\text{€})}{\text{€}238} = 1.20$$

We know that the profit margin of each firm will be constant if their sales prices increase at the same rates as their costs of production. But because the \$400 Metallwerke charges Safe Air doesn't change with the exchange rate in Exhibit 9.1, Metallwerke's profit margin falls to 9.2% when the euro strengthens by 10%. On the other hand, Metallwerke's profit margin rises 33.2% when the euro weakens by 10%. In other words, with a constant dollar price, if the euro strengthens, Safe Air won't suffer, but Metallwerke will see its profits decline drastically. By contrast, if the euro weakens, Safe Air won't be any more profitable, but Metallwerke will be very profitable. What should the two companies agree to do?

Exhibit 9.2 provides an analysis of the profitability of the two firms under Metallwerke's proposed contract. As in Exhibit 9.1, exchange rates can change, but nominal prices other than the tank price are held constant.

Now, Safe Air pays 5% more, or \$420 total, when the euro strengthens by 10%. This causes Safe Air's profit margin to fall to 16.8%, but it causes Metallwerke's profit margin to rise to 14.7% (from 9.2% in Exhibit 9.1). Notice, though, that the increased profitability of Metallwerke when the euro weakens is not shared with Safe Air.

Sharing the Exchange Rate Risk with Constant Prices

Let's examine a contract that shares the foreign exchange risk. Exhibit 9.3 demonstrates what happens if the firms share the exchange rate risk equally. As before, if the euro strengthens, the base price of the tank increases by one-half the percentage rate of the euro appreciation. If the euro depreciates, though, the base price of the tank decreases by one-half the percentage rate of euro depreciation.

Exhibit 9.2 Profitability Under Metallwerke's Proposed Contract

	Safe Air (dollars)			Metallwerke (euros)		
	\$1.26/€	\$1.40/€	\$1.54/€	\$1.26/€	\$1.40/€	\$1.54/€
Sales						
Exported				317	286	273
Local	856	856	856			
Costs of Goods Sold						
Imported	(400)	(400)	(420)			
Local	(313)	(313)	(313)	(238)	(238)	(238)
Operating Profit	143	143	123	79	48	35
Profit Margin	20%	20%	16.8%	33.2%	20%	14.7%

Exhibit 9.3 Profitability Under a Contract That Shares Real Exchange Risk

	Safe Air (dollars)			Metallwerke (euros)		
	\$1.26/€	\$1.40/€	\$1.54/€	\$1.26/€	\$1.40/€	\$1.54/€
Sales						
Exported				302	286	273
Local	856	856	856			
Costs of Goods Sold						
Imported	(380)	(400)	(420)			
Local	(313)	(313)	(313)	(238)	(238)	(238)
Operating Profit	163	143	123	63.6	48	35
Profit Margin	23.5%	20%	16.8%	26.7%	20%	14.7%

In this case, the price Safe Air pays per tank when the euro weakens by 10% is \$380, and Safe Air's profit margin increases to 23.5%. Metallwerke still has increased its profitability, but only to a margin of 26.7%.

Analyzing Contracts When Inflation and Real Exchange Rates Are Changing

Exhibits 9.1 through 9.3 hold the prices of labor and the retail price of the tank constant. In such a situation, the change in the nominal exchange rate *is* a change in the real exchange rate. When other prices are moving, however, it is important to distinguish contractually between movements in nominal and real exchange rates. It will turn out that if the base price increases at the U.S. rate of inflation, only movements in the real exchange rate are a source of risk. The key thing to remember is that as long as a nominal variable like the retail price of the tank or the cost of production changes at the rate of inflation, real values are constant.

In the situation in the case, it is reasonable to assume that Safe Air will only be able to raise its retail price by the U.S. rate of inflation. It is also reasonable to assume that their other costs will be increasing at the U.S. rate of inflation. Similarly, Metallwerke's costs are likely to increase at the German rate of inflation, but its euro revenue will be affected both by the change in the dollar price of the tank and by the rate of change of the dollar–euro exchange rate. Thus, we only need to focus on what happens to the base price of the tank.

In doing the analysis, it will be useful to have some notation for the percentage rates of change of several key variables. The percentage rate of change of any variable Z from period 0 to period 1 is $\%Z = [Z(1) - Z(0)]/Z(0)$. Let's define the following variables:

Rate of change of the contractual base dollar price = $\%B(\$)$

U.S. rate of inflation = $\pi(\$) = \%P(\$)$

German rate of inflation = $\pi(€) = \%P(€)$

Rate of change of the dollar–euro exchange rate = $\%S(\$ / €)$

We place an R before a real variable.

Safe Air's Real Cost per Tank

In period 1, the base dollar price per tank that Safe Air pays will increase by $\%B(\$)$, and the U.S. price level will increase by $\pi(\$)$ because of inflation. Hence, the period 1 real imported cost for Safe Air will be

$$RB(1, \$) = \frac{B(1, \$)}{P(1, \$)} = \frac{B(0, \$) \times (1 + \%B(\$))}{P(0, \$) \times (1 + \pi(\$))} = RB(0, \$) \times \frac{(1 + \%B(\$))}{(1 + \pi(\$))}$$

Increases in the base price that are larger (smaller) than the U.S. rate of inflation increase (decrease) real imported part costs.

Metallwerke's Real Revenue per Tank

The real revenue per tank for Metallwerke is the dollar price per tank the company charges Safe Air, divided by the \$/€ exchange rate, and divided by the German price level. In period 1, Metallwerke's new real revenue will be

$$\begin{aligned} RR(1, \text{€}) &= \frac{B(1, \$)/S(1, \$/\text{€})}{P(1, \text{€})} \\ &= \frac{B(0, \$) \times (1 + \%B(\$)) / [S(0, \$/\text{€}) \times (1 + \%S(\$/\text{€}))]}{P(0, \text{€}) \times (1 + \pi(\text{€}))} \\ &= RR(0, \text{€}) \times \frac{(1 + \%B(\$))}{(1 + \pi(\text{€})) \times (1 + \%S(\$/\text{€}))} \end{aligned}$$

Only if the percentage change in the base price satisfies

$$(1 + \%B(\$)) = (1 + \pi(\text{€})) \times (1 + \%S(\$/\text{€}))$$

will Metallwerke's real revenue be constant. Notice that this analysis indicates that Metallwerke would like to increase the base price of the tank to offset both the German rate of inflation and any appreciation of the euro relative to the dollar. But this is not how the proposed contract is written.

Designing a Contract That Shares the Real Exchange Risk

It is possible to share real exchange risk almost equally between two parties. Recall that the percentage change in the real exchange rate is

$$(1 + \%RS(\$/\text{€})) = \frac{(1 + \%S(\$/\text{€})) \times (1 + \pi(\text{€}))}{(1 + \pi(\$))}$$

Here $\%RS$ represents the real rate of appreciation (if positive) or depreciation (if negative) of the euro relative to the dollar. Then, one way to share the risk is to let the base dollar price of the product increase one for one with the U.S. rate of inflation and make an additional adjustment to the base price for changes in the real exchange rate. Equal sharing of the risk would make the base price higher by one-half of any real appreciation of the euro relative to the dollar, but would make the base price lower by one-half of any real depreciation of the euro relative to the dollar:

$$(1 + \%B(\$)) = (1 + \pi(\$)) \times (1 + (\%RS(\$/\text{€})/2))$$

Now, Safe Air's real cost is

$$RB(1, \$) = RB(0, \$) \times \frac{(1 + \%B(\$))}{(1 + \pi(\$))} = RB(0, \$) \times (1 + (\%RS(\$/\text{€})/2))$$

It is constant if the real exchange rate is constant, $\%RS(\$/\text{€}) = 0$. It increases by one-half of any real appreciation if the euro strengthens relative to the dollar, when $\%RS(\$/\text{€}) > 0$, but it decreases by one-half of any real depreciation if the euro weakens relative to the dollar, when $\%RS(\$/\text{€}) < 0$.

Now, consider Metallwerke's real revenue under the revised contract. We know that

$$RR(1, \text{€}) = RR(0, \text{€}) \times \frac{(1 + \%B(\$))}{(1 + \%S(\$/\text{€})) \times (1 + \pi(\text{€}))}$$

which we can rewrite substituting the new terms of the contract as

$$RR(1, \text{€}) = RR(0, \text{€}) \times \frac{(1 + \pi(\$)) \times [1 + \%RS(\$/\text{€})/2]}{(1 + \%S(\$/\text{€})) \times (1 + \pi(\text{€}))}$$

Because $(1 + \%RS(\$/\text{€})) = (1 + \%S(\$/\text{€})) \times (1 + \pi(\text{€})) / (1 + \pi(\$))$, we have

$$RR(1, \text{€}) = RR(0, \text{€}) \times \frac{(1 + \%RS(\$/\text{€})/2)}{(1 + \%RS(\$/\text{€}))} \approx RR(0, \text{€}) \times (1 - \%RS(\$/\text{€})/2)$$

The approximation works well for small percentage changes.² Consequently, Metallwerke's real revenue goes up by one-half of any real depreciation of the euro when $\%RS < 0$, and it goes down by one-half of any real appreciation of the euro when $\%RS > 0$.

Understanding the Contract

The reason that the redesigned contract shares the real exchange risk is that if the euro appreciates relative to the dollar by more than is warranted by the differential rates of inflation, Metallwerke's real revenue falls. The redesigned contract forces the nominal base price to increase in this situation, which causes Safe Air to bear part of the loss. But if the euro weakens relative to the dollar by more than the inflation differential, Metallwerke's real revenue rises. The redesigned contract makes Metallwerke share this gain with Safe Air by lowering the rate at which the dollar base price is increasing.

Would the Redesigned Contract Be Adopted?

Whether the redesigned contract would actually be adopted by the firms as a way of sharing real exchange risk depends on several factors. For example, real exchange rate changes may be correlated with other production costs for the two firms. Suppose that Safe Air's workers demand higher wages when the dollar is weak because their purchasing power decreases. Safe Air would face additional cost pressure when the euro is strong and would not like to see the price of the tank increased very much. This might lead both firms to use a number less than one-half in the formula. Alternatively, it is possible that Safe Air has foreign competitors in the United States who price more aggressively when the dollar is strong and who fade away when the dollar is weak. In this case, Safe Air might like the risk-sharing coefficient to be larger than one-half.

Relative Bargaining Strength

The last issue that determines how the contract will be written is the relative bargaining strength of the two firms. As the contract was initially written, Metallwerke received all the benefit of a strong dollar, and when the dollar was weak, Safe Air still had to share part of the cost. This may be the best that Cromwell can do, given his precarious position with the board of directors. If Spiegel knows that his initial base price is attractive, he may be able to force Cromwell to accept a current benefit in exchange for possible problems in the future. In contrast, if Metallwerke really needs Safe Air's business, Spiegel might be more willing to accept a fixed-price contract and bear the risk while hoping that the dollar will strengthen.

²Note that $\frac{(1 + \%RS(\$/\text{€})/2)}{(1 + \%RS(\$/\text{€}))} = 1 - \frac{\%RS(\$/\text{€})/2}{(1 + \%RS(\$/\text{€}))}$. Hence, for small percentage changes, the denominator on the right-hand side is close to 1.

9.4 PRICING-TO-MARKET STRATEGIES

Another aspect of managing real exchange risk is the phenomenon of **pricing-to-market**, which simply means that producers charge different prices (measured in the same currency) for the same good in different countries. Examples of pricing-to-market abound. Apple's iPads and iPhones are often cheaper in the United States than in other countries. However, comparisons are complicated by the fact that the United States allows Apple to sell iPhones only through certain telecom service providers, AT&T and Verizon, who in turn subsidize the cost of the phone while locking the consumer into a 2-year service contract. Other countries, such as Hong Kong and Singapore, require the factory to unlock the phone so that the consumer may use it with any telecom service provider.

The Economist on July 14, 2001, noted that handbags manufactured by the French luxury goods producer Louis Vuitton cost 40% more in Japan than in Europe at that time. Enterprising Hong Kong merchants tried to arbitrage this differential by sending employees to purchase handbags in Europe for resale in Japan, much to the chagrin of the French handbag maker. The problem in Europe was how to tell an arbitrageur from a legitimate tourist. Do you draw the line at the purchase of five bags or 10?

In both examples, the producers sell a unique product in high demand. The goal of this section is to understand why producers in markets that are less than fully competitive price to market. We do this by examining how a monopolist responds to fluctuations in real exchange rates.³

Pricing-to-Market by a Monopolist

A Monopolistic Exporter

Consider the problem of a domestic **monopolist**, a sole producer who sells a non-storable good to both the domestic market and the foreign market. The monopolist faces a different demand curve in each market, and as the price of the product increases in each market, the monopolist will sell fewer units there. We can think of the monopolist as choosing the domestic and foreign prices of the goods it will supply to each market and letting the quantities it sells in each market be determined by the respective demand curves, or alternatively, we can think of the monopolist as choosing the quantities to supply to each market with the demand curves then determining the prices.

Example 9.5 A Monopolist Seller in Two Markets

Demand Curves

Suppose a monopolist faces the same linear demand curve in the domestic and foreign markets. The domestic demand curve is

$$Q = 1,000 - P$$

where Q is the quantity sold in the domestic market, and P is the domestic relative price. At a price of zero, the monopolist could sell 1,000 units. As the monopolist

³The issues in this section are explored more formally in Marston (1990), which provides a static, one-period profit maximization, and in Kasa (1992), which provides a dynamic formulation of the problem.

increases the price, the number of units sold decreases until none are sold at a price of 1,000. The demand curve in the foreign market is similarly

$$Q^* = 1,000 - P^*$$

where Q^* represents the quantity sold in the foreign market at the foreign relative price of P^* .

Domestic and Foreign Revenues

From the domestic demand curve, we find that $P = 1,000 - Q$, and revenue from domestic sales is

$$P \times Q = (1,000 \times Q) - Q^2$$

From our earlier analysis, we know that when the monopolist sells output in the foreign market, the domestic real value of revenue from foreign sales is the real exchange rate, RS , multiplied by the foreign relative price, multiplied by foreign sales. By substituting $P^* = 1,000 - Q^*$, we find

$$RS \times P^* \times Q^* = (RS \times 1,000 \times Q^*) - RS \times Q^{*2}$$

Cost of Production

Suppose that the **marginal cost** of production is constant, and let this per-unit cost of production be 500. Then the total cost of production is the per-unit cost multiplied by the total quantity produced for sale in each of the two markets:

$$500 \times (Q + Q^*)$$

Profit-Maximizing Quantities

A profit-maximizing monopolist produces an amount of a good such that the **marginal revenue** earned from each market is equal to the common marginal cost.⁴ The marginal revenue from domestic sales is $1,000 - 2Q$, and the marginal revenue from the foreign market is $RS \times 1,000 - RS \times 2Q^*$. Thus, the monopolist should sell a quantity in the domestic market that satisfies

$$1,000 - 2Q = 500$$

or, by solving for Q , we find

$$Q = (1,000 - 500)/2 = 250$$

The optimal quantity in the foreign market satisfies

$$RS \times 1,000 - RS \times 2Q^* = 500$$

or, once again solving for Q^* , we find

$$Q^* = [1,000 - (500/RS)]/2$$

The Equilibrium with $RS = 1$

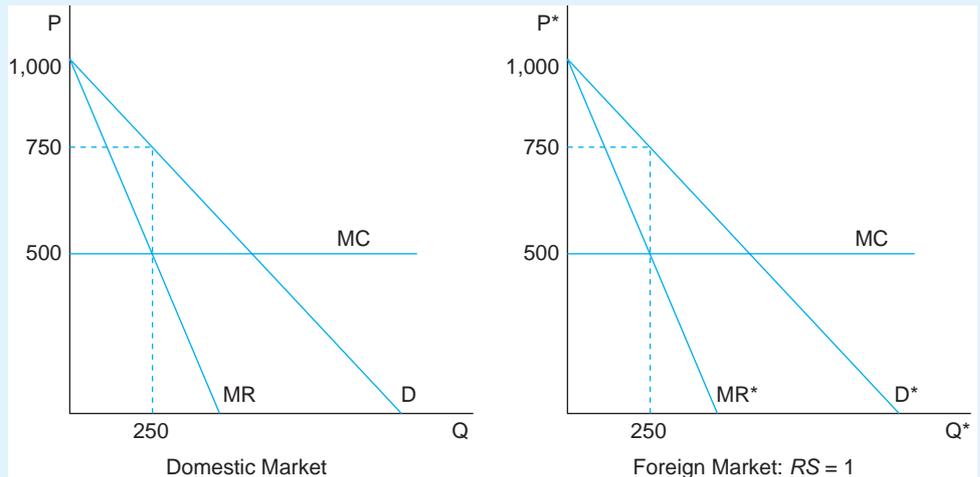
Suppose that the real exchange rate is initially equal to 1. In this case, the monopolist should sell 250 in each market by charging the relative price of 750 in each country. The total real profit would be

$$(750 \times 250) + (750 \times 250) - [500 \times (250 + 250)] = 125,000$$

⁴Marginal revenue is the derivative of total revenue with respect to the quantity sold.

Exhibit 9.4 summarizes this equilibrium in the domestic and foreign markets.

Exhibit 9.4 A Monopolistic Exporter



The Equilibrium with a Real Appreciation

Now, suppose there is a 20% real appreciation of the foreign currency such that the new real exchange rate is 1.2. The real appreciation benefits the exporting monopolist because total real revenue in the foreign country is now

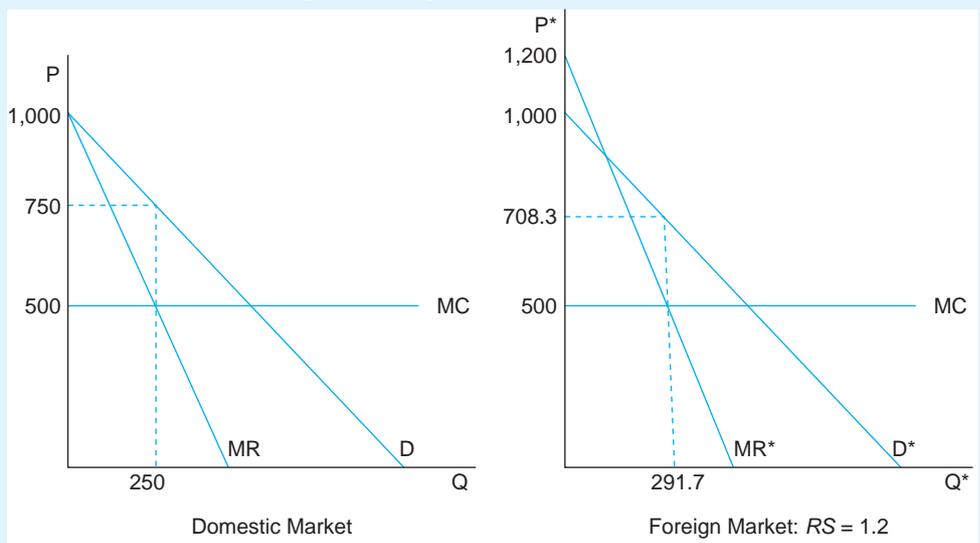
$$1.2 \times (1,000 - Q^*) \times Q^*$$

How will the monopolist respond to this new environment? By equating the foreign marginal revenue to the unchanged domestic marginal cost of 500 and solving for Q^* , we find

$$Q^* = [1,000 - (500/1.2)]/2 = 291.7$$

Exhibit 9.5 summarizes the new foreign equilibrium.

Exhibit 9.5 A Monopolistic Exporter When $RS=1.2$



In order to sell the 291.7 units in the foreign market, the monopolist must lower the foreign price per unit to

$$P^* = 1,000 - 291.7 = 708.3$$

Because the marginal cost of production is constant, the domestic price per unit remains at 750, and the domestic sales remain at 250.

Notice that although the foreign currency appreciates by 20%, the monopolist only decreases the relative price in the foreign market by 5.6% because the ratio of the new foreign price to the old foreign price is

$$708.3/750 = 0.944$$

The 5.6% pass-through reduction in the relative foreign price resulting from the 20% appreciation of the foreign currency is quite small. Put differently, the domestic currency price that is equivalent to the new foreign price multiplied by the real exchange rate has increased drastically from 750 to

$$1.2 \times 708.3 = 850$$

Because the actual domestic price stays constant at 750, the law of one price is now violated.

Violations of the Law of One Price

Exhibit 9.5 demonstrates that whenever demand curves differ across countries, a monopolist finds it in his interest to violate the law of one price. Because the demand curves depend only on the relative price of the product in the consumer's country and not on the relative prices in other countries, these deviations from the law of one price do not trigger arbitrage in the goods markets. Implicit in the formulation of the demand curves are some costs that prevent arbitrage.

The real appreciation of the foreign currency makes the monopolist more profitable. Even if the monopolist lowered the foreign relative price by the full amount of the foreign currency appreciation to $625 = 750/1.2$, in which case, the law of one price would not be violated, the monopolist's profits would still increase because foreign sales would increase to $375 = 1,000 - 625$. At these prices and quantities, total profit would increase to

$$(750 \times 250) + (1.2 \times 625 \times 375) - [500 \times (250 + 375)] = 156,250$$

or by 25%, because the ratio of new profit to old profit is $156,250/125,000 = 1.25$. But the monopolist can do even better by violating the law of one price. At the new optimal prices and quantities, total profit increases to

$$(750 \times 250) + (1.2 \times 708.3 \times 291.7) - [500 \times (250 + 291.7)] = 164,583.3$$

or by 31.7%, because the ratio of new profit to old profit is $164,583.3/125,000 = 1.317$. By acting optimally, the exporting monopolist exploits the real appreciation of the foreign currency to become even more profitable.

A Monopolistic Net Importer

Now, consider how a monopolist who is a net importer responds to changes in the real exchange rate.

Example 9.6 A Monopolist with Imported Costs

The Demand Curve

Consider a monopolist who faces a domestic demand curve given by

$$Q = 1,000 - P$$

where Q is the quantity demanded at the domestic relative price, P .

Domestic and Foreign Costs

The cost of production involves a domestic cost per unit of C and a foreign cost per unit of C^* . Total cost is the sum of domestic costs, $C \times Q$, and the domestic value of foreign costs, which is total foreign costs, $C^* \times Q$, multiplied by the real exchange rate, RS . Hence, total real domestic costs are

$$(C \times Q) + (RS \times C^* \times Q)$$

Because $P = 1,000 - Q$, total revenue is

$$P \times Q = 1,000 \times Q - Q^2$$

and marginal revenue is $1,000 - 2Q$. Marginal cost is $C + (RS \times C^*)$.

The Equilibrium

Suppose that initially $C = 250$, $C^* = 200$, and $RS = 1$. Then, the profit-maximizing decision of the monopolist is to set marginal revenue equal to marginal unit cost:

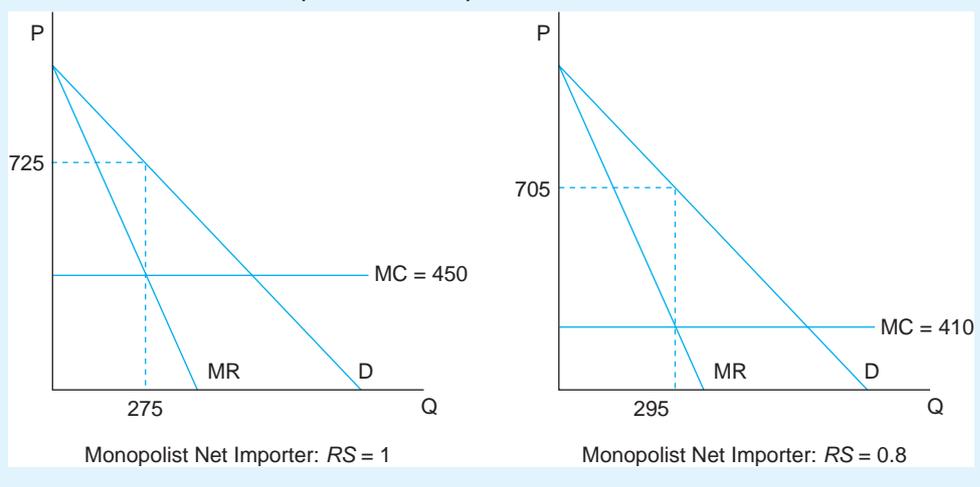
$$1,000 - 2Q = 250 + (1 \times 200) = 450$$

or, solving for Q , we find

$$Q = (1,000 - 450)/2 = 275$$

The monopolist would produce 275 units and sell them in the domestic market at the relative price of 725. The initial equilibrium is given in Exhibit 9.6.

Exhibit 9.6 A Monopolist with Imported Costs



A Real Depreciation

Now, suppose there is a 20% real depreciation of the foreign currency such that the new real exchange rate is 0.8. This causes the domestic value of the monopolist's foreign costs to fall by 20% to $0.8 \times 200 = 160$. Because marginal cost falls to $250 + 160 = 410$ (versus 450), the monopolist increases his production. The optimal quantity now sets the old marginal revenue, $1,000 - 2Q$, equal to the new marginal cost:

$$1,000 - 2Q = 250 + (0.8 \times 200) = 410$$

or

$$Q = (1,000 - 410)/2 = 295$$

In order to sell 295 units, the monopolist decreases the domestic relative price to 705.

Pass-Through Pricing

How much of the cost saving shown in the preceding section is passed through to consumers? The monopolist's marginal cost has fallen by 8.9% because the ratio of new marginal cost to the old is $(410/450) = 0.911$. But the reduction in the domestic price is only 2.8% because the ratio of the new price to the old price is $(705/725) = 0.972$. Thus, once again, the pass-through is much less than one for one. In this case, the monopolist increases his profits because the real depreciation of the foreign currency lowers the cost of his imports. With a real exchange rate of 1, profits were

$$(725 \times 275) - [(250 \times 275) + (1 \times 200 \times 275)] = 75,625$$

With a real exchange rate of 0.8, profits are

$$(705 \times 295) - [(250 \times 295) + (0.8 \times 200 \times 295)] = 87,025$$

Notice that profits have risen by 15.1% because the ratio of new profits to old profits is $(87,025/75,625) = 1.151$. If the monopolist had passed through the full cost saving of 8.9% from the exchange rate to the domestic price, the new price would have been $0.911 \times 725 = 660.5$, and the new quantity sold would have been $1,000 - 660.5 = 339.5$. Hence, profits would have been

$$(660.5 \times 339.5) - [(250 \times 339.5) + (0.8 \times 200 \times 339.5)] = 85,045$$

As you can see, the monopolist's profits would, again, increase (from 75,262 to 85,045) with the complete pass-through of the reduction in foreign costs to the domestic price. However, the monopolist can do better by passing less of the savings on to consumers. Instead, he charges domestic consumers a relatively higher price per unit than with complete pass-through and produces fewer units, thereby earning 87,025 instead of just 85,045.

Empirical Evidence on Pricing-to-Market

The examples just examined demonstrate what could happen in monopolistic environments. Although there are few monopolists in actual markets, economists do generally find strong evidence that the exports of various countries are priced to market, suggesting that firms do have some market power.

For example, in their comprehensive review of the literature, Goldberg and Knetter (1997) found that the elasticity of U.S. import prices to changes in exchange rates was typically about 0.5. In other words, a 10% depreciation of the dollar was associated with a 5% increase in the dollar prices of imports. Foreign exporters consequently received about 5% less in their currencies after the dollar depreciation. For other Organization for Economic Cooperation and Development (OECD) countries, Campa and Goldberg (2005) found pass-through elasticities of 0.46 over one quarter rising to 0.64 over the longer term. They also found that pass-through elasticities seem to be declining over time.

A more recent study by Marazzi and Sheets (2007) found that pass-through to U.S. import prices has fallen from the 0.5 reported earlier to 0.2 in the 2000s. Although understanding why pass-through has fallen is a difficult problem, the economists attribute the change to a reduced share of commodity-intensive industrial supplies in U.S. imports and the increased presence of Chinese exports in the U.S. market. Because China was pegging the yuan to the dollar during this period, any depreciation of the dollar versus third currencies that would have potentially led to an increase in dollar prices of third-country exports to the United States was held in check by competition from China.

The studies discussed earlier use relatively aggregated data. Gopinath and Itskhoki (2010) use micro data from the U.S. Bureau of Labor Statistics for the period of 1994 to 2005 to investigate pass-through in the manufacturing sector because this is where they expect to see imperfect competition and imperfect pass-through. Gopinath and Itskhoki note that it takes time for firms to adjust their prices, and they consequently investigate how often prices change and by what amount over a 24-month period. The primary findings are that firms that adjust more frequently also have greater pass-through, and high-frequency adjusters have a pass-through of 0.4, whereas low-frequency adjusters have a pass-through of 0.2.

Another study, conducted by Nakamura and Steinsson (2009), uncovered a potential bias in earlier analyses of pass-through. Nakamura and Steinsson note that, in micro data, product replacement is quite frequent, whereas price changes are infrequent. Consequently, firms adjust their prices as they introduce new products. When Nakamura and Steinsson take this product replacement bias into account, they find that the price of non-oil U.S. imports respond by 0.6% to 0.7% for a 1% change in the real exchange rate, whereas prices of U.S. exports respond by roughly 0.8%. These findings show both more pass-through and more symmetry across imports and exports than previous studies.

9.5 EVALUATING THE PERFORMANCE OF A FOREIGN SUBSIDIARY

The fact that fluctuations in real exchange rates affect the profitability of international businesses severely complicates the process of evaluating the performance of managers of foreign subsidiaries.⁵ We know that a real depreciation of the local currency, that is, the currency of the country in which the foreign subsidiary resides, hurts the performance of a net importing company because it increases the company's costs. Conversely, a real depreciation of the local currency improves the operating performance of a net exporting company because it increases the company's revenues.

Because fluctuations in real exchange rates are large and difficult to forecast, the operating performance of foreign subsidiaries is quite variable. How can we design a system to determine good management from bad management in such an environment?

⁵The approach in this chapter is based on the analysis in Lessard and Sharp (1984).

Three Types of Subsidiaries

Consider the initial situations of three different Japanese subsidiaries operating in Thailand, where the local currency is the baht. The three firms are ThaiComp, which is a net importer; WeRToys, which is a net exporter; and RiceNoodle, which neither imports nor exports.

The Net Importer

ThaiComp imports personal computer (PC) parts, assembles the PCs in Thailand, and sells most of its PCs in Thailand. ThaiComp exports some computers to Malaysia, Indonesia, and China. Because the computer maker is a net importer, its costs increase more than its revenues when there is a real depreciation of the baht. The Japanese owners of ThaiComp then experience an additional loss in real terms when they convert baht profit into yen.

The Net Exporter

WeRToys produces and exports toys. Although it also sells some toys in the local Thai market, and it, too, has some imported inputs, WeRToys's export sales produce a large fraction of its revenues. Consequently, its operating performance improves with a real depreciation of the baht, but its Japanese owners experience less of this increase in real profitability when the yen strengthens.

The Neutral Firm

RiceNoodle is a restaurant chain that serves the Thai market. It has no export revenues, no direct foreign costs, and no foreign competition. Consequently, RiceNoodle's real profit, which is its baht profit divided by the Thai price level, should not be affected by changes in the real exchange rate. However, a real depreciation of the baht relative to the yen does adversely affect the real value of RiceNoodle's profits for the company's Japanese owners.

Initial Operating Profitability

Exhibit 9.7 shows the operating profits earned by the three firms when the real exchange rate of baht per yen equals 1. The real revenues, real costs, and real operating profits are presented, along with the percentage of total revenue that each category represents. Real units are found by deflating nominal variables denominated in baht by the Thai price level. Exhibit 9.7 indicates that each firm has real revenue of 2,303. Notice that RiceNoodle gets 100% of this revenue from sales in Thailand. ThaiComp gets 70% of its real revenue in the local Thai

Exhibit 9.7 Operating Profit with a One-to-One Real Exchange Rate Between the Baht and the Yen

	RiceNoodle		ThaiComp		WeRToys	
	Real Baht	% of Sales	Real Baht	% of Sales	Real Baht	% of Sales
Sales						
Exported	0	0	696	30	1,607	70
Local	2,303	100	1,607	70	696	30
Costs of Goods Sold						
Imported	0	0	(900)	(39)	(825)	(36)
Local	(1,725)	(75)	(825)	(36)	(900)	(39)
Local Fixed Costs	(350)	(15)	(350)	(15)	(350)	(15)
Operating Profit in Real Baht	228	10	228	10	228	10
Operating Profit in Real Yen	228	10	228	10	228	10

market and 30% from exports out of Thailand. In contrast, WeRToys gets 30% of its real revenue from the Thai market and 70% from exports. Each firm initially has real costs of goods sold equal to 1,725. Of this, ThaiComp's local costs are only 825, whereas its imported costs are 900. These figures are reversed for WeRToys, whose local costs are 900 and whose imported costs are 825. All three firms have real local fixed costs of 350. By subtracting costs of goods sold and fixed costs from total revenue, we find that each firm has an initial real operating profit of 228, which is 10% of real revenue.

The last line of Exhibit 9.7 evaluates the real operating profit of the three subsidiaries in real yen by dividing by the real exchange rate. Although this conversion has no effect when the real exchange rate is 1, a real depreciation of the baht involves an increase in the real exchange rate of baht per yen and a consequent lowering of real profitability when the baht are converted into yen. So, even though RiceNoodle is not exposed directly to foreign exchange risk, the Japanese owners of RiceNoodle still suffer a decline in yen revenue when there is a real depreciation of the baht (as we will see in Exhibit 9.8).

Actual Versus Forecasted Operating Results

If we want to evaluate the performance of a foreign subsidiary's managers, we first need to look at the subsidiary's expected operating results. This represents the managers' best forecasts of what will happen in the upcoming year and how the subsidiaries will respond to changing economic circumstances. For simplicity, assume that Exhibit 9.7 also represents what is expected to happen during the coming year—that managers expect the same real earnings in the year to come, and they do not expect the real exchange rate to change. (Of course, in actual practice, managers generally expect these variables to change.)

Exhibit 9.8 presents the actual operating results for the three firms in the following year during which there is a 10% real appreciation of foreign currencies relative to the Thai baht. Thus, the real exchange rate is now 1.1. Let's examine how each firm is doing.

RiceNoodle's Results

RiceNoodle's real sales are down somewhat relative to what was expected, but its costs are also lower. Real operating profit is 199, down 12.7% from 228. Because the change in the real exchange rate is not supposed to affect RiceNoodle, the local Thai managers must accept

Exhibit 9.8 Actual Operating Profit After a 10% Real Appreciation of the Yen

	RiceNoodle		ThaiComp		WeRToys	
	Real Baht	% of Sales	Real Baht	% of Sales	Real Baht	% of Sales
Sales						
Exported	0	0	830	35	1,900	75
Local	2,188	100	1,526	65	648	25
Costs of Goods Sold						
Imported	0	0	(980)	(42)	(945)	(37)
Local	(1,656)	(76)	(810)	(34)	(969)	(38)
Local Fixed Costs	(333)	(15)	(349)	(15)	(355)	(14)
Operating Profit in Real Baht	199	9	217	9	279	11
% Change in Real Baht Profit	(12.7)		(4.8)		22.4	
Operating Profit in Real Yen	181	9	197	9	254	11
% Change in Real Yen Profit	(20.6)		(13.5)		11.4	

responsibility for the shortfall in baht profit relative to what was forecast. Presumably, this would affect the current compensation these managers receive, and continued substandard performance of this kind would probably result in a change in local management. Notice also that real operating profit in yen is even lower because of the real depreciation of the baht. Real operating profit in yen is now 181, down 20.6% from 228. Now, let's consider the other two firms.

Results at ThaiComp and WeRToys

Exhibit 9.8 indicates that the 10% real appreciation of the yen has hurt the profitability of ThaiComp. Real baht operating profit has fallen by 4.8%, to 217 from 228. The increase in imported costs has caused operating profit to fall to 9% of sales from 10%. In contrast, the real baht operating profit of WeRToys has risen by 22.4%, from 228 to 279, and its operating profit is now 11% of total revenue.

The last two lines of Exhibit 9.8 show how converting the baht operating profits of the foreign subsidiaries into real yen by dividing by the real exchange rate lowers the profitability of these firms as well. ThaiComp's real operating profit in yen has fallen by 13.5%, and the good performance of WeRToys, when evaluated in Thai baht, is reduced to an 11.4% increase when converted to real yen.

A naïve interpretation of these annual performances (either in real baht or real yen) would award a substantial bonus to the managers of WeRToys, who produced a profit that impressively exceeded what was forecast. Of course, headquarters would recognize that WeRToys had a favorable operating environment, in light of the unanticipated 10% real depreciation of the baht. Nevertheless, the local managers of WeRToys would argue that some of the increase in operating performance was due to superior management. They would try to take as much credit for this good performance as possible, arguing that a 22.4% increase in real baht profitability cannot be due strictly to chance.

Evaluating the performance of ThaiComp would be a problem. The managers of ThaiComp would claim that the firm's poor performance was due strictly to the real depreciation of the baht. A debate might ensue regarding whether a 4.8% fall in profitability should be expected for this type of firm operating in this adverse environment.

Comparing the Optimal Response with No Response by Managers

The previous section highlights the problem of evaluating the performance of the foreign subsidiaries only with *ex post* information. Because we know ThaiComp will do relatively poorly and WeRToys will do relatively well when the baht suffers a real depreciation, merely observing the direction of the change in operating profit gives no indication of how well the firms' managers are performing. What we need to know is how poorly ThaiComp would be expected to do and how well WeRToys would be expected to do, contingent on a 10% real depreciation of the baht.

Comparisons with No Operating Responses

One starting point would be to evaluate the operating performance of the firms if there were no operating responses by their managers. This perspective is presented in Exhibit 9.9.

With no operating responses, the firms would charge the same relative prices in their local and export markets. They would presumably sell the same quantities, and they would have the same costs of production as in their respective expected budgets in Exhibit 9.7. Differences in sales, costs of goods sold, and profitability would arise merely because each of the figures associated with international transactions—export sales and imported costs—would be multiplied by the new real exchange rate of 1.1.

Exhibit 9.9 Operating Profit After a 10% Real Appreciation of the Yen:
No Response by Managers

	RiceNoodle		ThaiComp		WeRToys	
	Real Baht	% of Sales	Real Baht	% of Sales	Real Baht	% of Sales
Sales						
Exported	0	0	766	32	1,768	70
Local	2,303	100	1,607	68	696	30
Costs of Goods Sold						
Imported	0	0	(990)	(42)	(908)	(37)
Local	(1,725)	(75)	(825)	(35)	(900)	(37)
Local Fixed Costs	(350)	(15)	(350)	(15)	(350)	(14)
Operating Profit in Real Baht	228	10	208	8	306	12
% Change in Real Baht Profit	0		(8.8)		34.2	
Operating Profit in Real Yen	207	10	189	8	278	12
% Change in Real Yen Profit	(9.2)		(17.1)		21.9	

Now, look at Exhibits 9.7 and 9.9. Comparing the two exhibits shows that a 10% real depreciation of the baht, with no operating response by managers, would cause ThaiComp's operating profit in real baht to fall from 228 to 208. The fall of 20 arises because imported costs rise from 900 to 990, or 20 more than the increase in exports from 696 to 766. WeRToys's real baht operating profit would rise from 228 to 306. The increase of 78 arises because at the original one-to-one exchange rate, export revenue (1,607) exceeds imported costs (825) by 782, and the exchange rate has increased by 10%.

It's critical for the Thai managers of the three firms to understand how their imports and exports are affected by real exchange rates changes. In other words, they need to think through what their reactions will be. By responding appropriately to these changes, the firms should be able to achieve higher profits than those shown in Exhibit 9.9.⁶

Comparisons with Optimal Responses

Earlier in this chapter, we indicated that the firms' responses to a real depreciation of the baht would involve an appropriate pricing-to-market strategy. That is, in response to a real depreciation of the baht, the firms should try to shift some sales from the Thai market to the export market. This could be accomplished by increasing the relative price charged in the Thai market and decreasing the relative price charged in the export market. The increase in the import costs of production also dictates reducing the overall quantity of production for ThaiComp because its costs have increased more than the benefit of additional international sales. WeRToys, on the other hand, should expand production.

Exhibit 9.10 provides this contingent forecasting information associated with the managers' anticipated responses to a 10% real depreciation of the baht.

Notice that revenues from export sales are higher for ThaiComp and WeRToys than in Exhibit 9.9 and that their revenues from local sales are lower than in Exhibit 9.9. Also, ThaiComp's local costs of production and imported costs of production are lower in Exhibit 9.10 than in Exhibit 9.9. These lower costs reflect the decreased output of the firm. Overall, with an optimal response by ThaiComp to the real depreciation of the baht, the operating profit in

⁶Marston's (2001) research indicates that the first-order effect of a real depreciation with an optimal operating response is still given by the effect of the real exchange rate on the net exposure of the firm because the firm has already optimized quantities it is selling in each market. Hence, changes in the quantities produced and sold in the different markets will not produce large improvements in operating profit.

Exhibit 9.10 Operating Profit After a 10% Real Appreciation of the Yen:
Managers Respond Optimally

	RiceNoodle		ThaiComp		WeRToys	
	Real Baht	% of Sales	Real Baht	% of Sales	Real Baht	% of Sales
Sales						
Exported	0	0	815	35	1,848	74
Local	2,303	100	1,522	65	644	26
Costs of Goods Sold						
Imported	0	0	(969)	(41)	(920)	(37)
Local	(1,725)	(75)	(807)	(35)	(913)	(37)
Local Fixed Costs	(350)	(15)	(350)	(15)	(350)	(14)
Operating Profit in Real Baht	228	10	211	9	309	12
% Change in Real Baht Profit	0		(7.5)		35.5	
Operating Profit in Real Yen	207	10	192	9	281	12
% Change in Real Yen Profit	(9.2)		(15.8)		23.2	

real baht is 211, which is 1% higher than the corresponding value in Exhibit 9.9. WeRToys, the net exporter, can also do better. Exhibit 9.10 indicates that WeRToys can produce an operating profit in real baht of 309, which is slightly better than the corresponding value of 306 in Exhibit 9.9.

Who Deserves a Bonus?

The question of which of the three Thai companies deserves a bonus is now easily assessed. Exhibit 9.11 compares the actual operating results (shown in Exhibit 9.8) after a 10% real appreciation of the yen to the anticipated operating responses (shown in Exhibit 9.10) that are contingent upon the same 10% real appreciation of the yen. Notice that only ThaiComp's

Exhibit 9.11 Actual Versus Optimal Operating Profit After a 10% Real Appreciation of the Yen

	RiceNoodle Real Baht		ThaiComp Real Baht		WeRToys Real Baht	
	Optimal	Actual	Optimal	Actual	Optimal	Actual
Sales						
Exported	0	0	815	830	1,848	1,900
Local	2,303	2,188	1,522	1,526	644	648
Costs of Goods Sold						
Imported	0	0	(969)	(980)	(920)	(945)
Local	(1,725)	(1,656)	(807)	(810)	(913)	(969)
Local Fixed Costs	(350)	(333)	(350)	(349)	(350)	(355)
Operating Profit in Real Baht	228	199	211	217	309	279
% Change in Real Baht Profit	0	(12.7)	(7.5)	(4.8)	35.5	22.4
Operating Profit in Real Yen	207	181	192	197	281	254
% Change in Real Yen Profit	(9.2)	(20.6)	(15.8)	(13.5)	23.2	11.4

actual results are better than the optimal result. Managers can do better than they anticipate because they have additional information and can respond to it.

RiceNoodle's local sales were less than anticipated, but so were its costs. Unfortunately, its operating profit falls short of what was expected, conditional on operating in the new environment.

WeRToys actually sold more goods than was anticipated, both in Thailand and as exports from Thailand. Unfortunately, all of its costs, imported, local, and fixed, were higher than they should have been. Its overall profit of 279 falls substantially short of the 309 that should have been produced.

ThaiComp, on the other hand, was operating in an adverse environment. Its actual local revenues were higher, as were its exports. Its imported costs and its local fixed costs were also higher than expected. Overall, though, ThaiComp's real operating profit of 217 exceeds the 211 that was forecast for this situation. After converting to real yen, its operating profit of 197 exceeds the contingent value of 192. Clearly, the management of ThaiComp deserves a bonus for their superior performance.

Assessing the Long-Run Viability of a Subsidiary

The contingent forecasting approach can be used to assess the long-run viability of a subsidiary as it is currently being managed. Suppose that, at the real exchange rate of 1, the Thai baht is currently 10% undervalued relative to the Japanese yen. We know that in the long run, such an undervaluation is likely to be corrected. This will provide a favorable shock to the profitability of ThaiComp, the net importer, as the baht strengthens in real terms; but it will hurt the long-run profitability of WeRToys, the net exporter.

Exhibit 9.12 provides the anticipated operating responses for the three firms, contingent on a 10% real depreciation of the yen to a new real exchange rate of 0.9 in baht per yen. The figures incorporate the optimal operating responses of each firm.

RiceNoodle has no exposure to real exchange rates, so its real operating profit in Thailand is anticipated to remain at 228 baht. However, when the profits are converted into real yen, the appreciation of the baht raises the value to 253 yen.

Compared to the base case in Exhibit 9.7 with a real exchange rate of 1, the real appreciation of the baht increases ThaiComp's real operating profit in Thailand from 228 to 251.

Exhibit 9.12 Operating Profit After a 10% Real Depreciation of the Yen: Managers Respond Optimally

	RiceNoodle		ThaiComp		WeRToys	
	Real Baht	% of Sales	Real Baht	% of Sales	Real Baht	% of Sales
Sales						
Exported	0	0	574	25	1,361	65
Local	2,303	100	1,687	75	745	35
Costs of Goods Sold						
Imported	0	0	(822)	(36)	(725)	(34)
Local	(1,725)	(75)	(838)	(37)	(878)	(42)
Local Fixed Costs	(350)	(15)	(350)	(15)	(350)	(17)
Operating Profit in Real Baht	228	10	251	11	153	7
% Change in Operating Profit	0		10.1		(32.9)	
Operating Profit in Real Yen	253	10	279	11	170	7
% Change in Real Yen Profit	11		22.4		(25.4)	

When this is converted to real yen, the real profits increase to 279, which is 22.4% higher than the base case.

In contrast, a real appreciation of the baht hurts WeRToys. Even with optimal operating responses, the firm's real operating profit in Thailand would be expected to fall from 228 in the base case to 153. The conversion to real yen increases this to 170 yen, but this still represents a 25.4% fall in real operating profit. Because the operating margin is now only 7%, WeRToys looks like a marginal business unless an alternative operating strategy can be found to increase its profitability.

9.6 STRATEGIES FOR MANAGING REAL EXCHANGE RISK

Given that real exchange rates fluctuate, how should the management team of a large multinational firm respond to various real exchange risks? The most important point is that managers must recognize that the influences of real exchange rates are pervasive. They directly affect foreign pricing and domestic costs of foreign imports, but they also affect the nature of competition between firms in different countries.

Obviously, financial managers must understand these risks, but hedging against adverse real exchange risks is complicated. Consequently, we devote Chapter 17 to a more formal analysis of that issue. Here, we merely note that financial hedging can help by assuring the firm of cash flow when changes in exchange rates would otherwise make the firm unprofitable.

It is also important for marketing and operations managers to understand the nature of real exchange risks that the firm faces. The managers of the firm must be aware that fluctuations in real exchange rates will create problem situations and profit opportunities that call for appropriate managerial responses.

Transitory Versus Permanent Changes in Real Exchange Rates

One key element that influences a firm's optimal response to a given change in the real exchange rate is the length of time that the change in the real exchange rate is expected to persist. How long a real depreciation is expected to last can affect both the amount of the exposure and managers' possible responses to that exposure. The time frame of the change in the exchange rate affects the firm's response because it is costly to change the operations of the firm. The next sections explore how managers can respond to real exchange rates in a dynamic way.

Production Management

How can a firm's production processes be designed to reflect real foreign exchange risk? Certainly, the production schedule, the sourcing of inputs, and even the location of production facilities ought to be sensitive to prospective fluctuations in real exchange rates.

Production Scheduling

Production scheduling must be sensitive to the real exchange rate because its fluctuations affect the demand for the firm's products. Many firms use changes in inventory to meet their transitory fluctuations in demand because it is usually less costly to run a smooth production process than a fluctuating one. Inventories accumulate during periods of slack demand, and inventories fall during periods of high demand, but production remains steady. In Example 9.5, we saw how a real appreciation of the foreign currency motivates a monopolist to increase its exports to foreign markets. In that example, per-unit costs were

constant. However, if per-unit costs increase with the amount of production because of overtime pay and increased maintenance costs related to machines, the monopolist can earn more revenue in the foreign market simply by selling more of the product out of inventory than by increasing production. The major factor that determines by how much the firm will increase the sale of its goods from inventory versus increasing production depends on the persistence of the change in the real exchange rate. The more persistent the change, the longer the firm expects to have high demand, and the more the firm will want to increase its production rather than sell out of inventory. If the change in the exchange rate were perceived as permanent, the firm would want to permanently adjust its prices and production.

Input Sourcing

Sources of materials and intermediate parts in the production process should be sensitive to the real exchange rate. When the domestic currency is strong, domestic companies should use foreign inputs because they are relatively inexpensive. But these foreign sources should be lined up in advance to take full advantage of the fluctuations in exchange rates.

One mitigating influence that prevents manufacturers from changing between domestic and foreign suppliers is the value the firm puts on its long-term relationships with its suppliers. Having a stable and reliable source of parts or materials is a valuable asset. If the firm shifts to a foreign supplier today, there is no guarantee that its current domestic supplier will still be interested in servicing the firm's business in the future. Thus, managers must assess how long the domestic currency is expected to remain strong. If the firm switches too quickly to a foreign supplier in response to a transitory real appreciation of the domestic currency, it may ultimately end up with no domestic suppliers or with unreliable suppliers when the domestic currency depreciates and foreign supplies are no longer competitively priced.

Using foreign suppliers can also either mitigate or exacerbate a firm's exposure to real exchange risk. For example, if a firm is exporting a lot to a country that has a foreign supplier for its intermediate inputs, using the foreign supplier would mitigate the real exchange risk. But if using the foreign supplier adds a new source of real exchange risk because the firm has no exposure to that currency, the domestic firm's managers must think about this dimension as well as the respective domestic and foreign costs.

Plant Location

If a multinational firm has production operations in several countries, it is natural for the managers to shift production among the plants to minimize costs. As real exchange rates fluctuate, the firm should increase production in countries whose currencies have depreciated in real terms, and it should decrease production in countries whose currencies have strengthened in real terms. However, because opening a plant abroad represents a long-term investment, management should be reasonably sure that the current cost advantage that the country enjoys is not likely to be undone by a real appreciation of the foreign currency. It may be that the currency has experienced a temporary real depreciation that is likely to be reversed within a few years.

In the 1990s, Japanese and European car manufacturers such as Toyota and BMW invested in U.S. production facilities to hedge against the adverse effects of a real depreciation of the dollar. With their production facilities located in the market of their sales, only their profits were exposed to the risk of dollar depreciation. In contrast, when these firms merely export products to the United States, their revenues are entirely exposed to possible losses if the dollar depreciates.

A firm's ability to shift production around the world is also limited by the cost structure of its plants. If a firm operates a plant that is too small, it loses the economies of scale it could have obtained by operating a larger plant, and this increases its costs per unit. Thus, instead

of limiting its real exchange risk by operating smaller plants in different countries, a firm might choose to achieve economies of scale by operating a single large plant.

A good example of this situation occurred after Jaguar was privatized in 1984. At the time, Jaguar had only one plant, which was located in the United Kingdom. Because over 50% of its sales were made in the United States, when the dollar weakened in the late 1980s, Jaguar's revenues plummeted. One way to limit the exposure of Jaguar's U.S. dollar revenue stream would have been to build a production facility in the United States. But the economies of scale Jaguar needed to remain profitable didn't allow for this.

In 1989, Jaguar became the takeover target of General Motors and Ford. These companies realized that Jaguar was more valuable as part of a larger company than as an independent entity. Ford subsequently purchased Jaguar and began sourcing additional parts from the United States. Unfortunately, even after massive capital investments, Jaguar never achieved the profitability that Ford predicted, and in 2009, Ford sold Jaguar to Tata Motors of India.

Marketing Management

How can marketing strategy and pricing policy be designed to offset real foreign exchange risk? Pricing policies, promotional strategies, market entry decisions, and even product development should be designed with exchange rate changes in mind.

Pricing Policies

We have already discussed some specific examples of pricing-to-market. In general, however, when a currency depreciates, exporters to that country face a trade-off: They can maintain either their profits or their market shares, but not both. If the firm increases its foreign currency price to maintain its profit, it will lose sales to foreign rivals. If the firm maintains a given foreign currency price, it will maintain its market share but lose profit. Research indicates that the optimal thing for firms to do lies somewhere between the two extremes. Faced with a real depreciation of the foreign currency, an exporter typically increases its relative price in the foreign country but not by the full percentage of the depreciation. The firm loses market share and earns a smaller profit on all sales.

A couple of factors affect this strategy, however. One is the elasticity of demand for the exporter's product. If demand is highly elastic, the firm's loss of market share will be large when the product's price is increased. In this case, the exporter needs to lean toward not increasing its prices. By contrast, if demand is highly inelastic, the exporter can afford to increase its prices by a greater amount. Another factor has to do with the nature of the firm's cost structure. For example, if there are important economies of scale in production, the firm's costs will increase significantly if it reduces production. Hence, the firm will hold down foreign price increases in response to a foreign currency depreciation to keep the demand for its products high. In contrast, if the firm's costs are less affected when the company loses market share, the firm may be able to reduce the quantities it produces and increase its prices.

The Frequency of Price Adjustments

Another marketing consideration that should be addressed is the frequency of price adjustments. Demand for a product often depends on the stability of its price. Consumers want to be able to compare items in different stores, and this takes time. Potential customers want to know nominal prices in advance, and this requires advertising. Customers hate surprise price increases. Given that consumers like price stability, foreign exporters are faced with the decision of how frequently to adjust prices in response to exchange rate changes. Firms consequently develop boundaries for exchange rate fluctuations that will not trigger a change in the firm's foreign currency prices. Then, only sufficiently large changes in exchange rates cause the firm to change its product price.

Market Entry Decisions

Firms often introduce new products in foreign markets when the foreign currencies are strong in real terms. Doing so allows a firm to set a comparatively low foreign currency price for a product so that it can better compete and become an established player in the market. For example, the large real appreciation of the dollar from 1980 to 1985 gave Honda and Toyota a golden opportunity to penetrate the U.S. market with low dollar prices that translated into high yen revenues. The Japanese companies were able to establish a reputation in the United States for providing high-quality, low-priced cars. This reputation persisted in the United States, even after a substantial real appreciation of the yen.

Brand Loyalty

Brand loyalty describes a situation in which consumers continue to purchase a brand they have purchased in the past even though it costs more now.⁷ Developing brand loyalty clearly helps in situations of real exchange risk because consumers will not switch to competitors' products that enjoy a temporary pricing benefit from a favorable fluctuation in the exchange rate. Thus, it is important for a domestic company to develop loyal customers—especially when it's facing competition from abroad. But the firm must also recognize that in entering a foreign market, it will have to win over the customers who are loyal to brands in their home countries. That said, entering a foreign market when the foreign currency is strong in real terms makes a lot of sense because the firm can use advertising campaigns and low foreign prices to get consumers to try its product without sacrificing too much profit. Establishing a large foreign market share when the foreign currency is strong in real terms means that a large number of foreign customers will have tried the firm's product. These foreign customers will not all be lost when the foreign currency depreciates in real terms and the firm is forced to raise foreign currency prices.

The discussion in this section is summarized in Exhibit 9.13.

Exhibit 9.13 A Checklist for Managers of Real Exchange Risk

<p>Production Inputs—Source inputs from suppliers in countries suffering real depreciations of their currencies.</p> <p>Production Location—Shift production to plants located in countries suffering real depreciations of their currencies or countries with low-cost production.</p> <p>Pricing-to-Market—Allow a real appreciation of the foreign currency to increase the profitability of foreign sales but lower foreign prices to expand market share.</p> <p>Market Entry—Begin selling in foreign markets after a real appreciation of the foreign currency.</p> <p>Brand Loyalty—Create loyal customers who will not “buy foreign” when the domestic currency strengthens in real terms.</p> <p>Price Consistently—Recognize that exchange rates will be more volatile than prices of goods. Be prepared for short-run swings in profitability due to exchange rates.</p> <p>Hedging—Use derivatives securities such as forward contracts or options to hedge foreign exchange risk to assure cash flow when changes in exchange rates would make the firm unprofitable.</p> <p>Currency of Denomination of Debt—Denominate long-term debt in foreign currencies in which the firm has substantial assets or sales to reduce exposure to foreign exchange risk.</p>
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⁷Is brand loyalty a rational phenomenon? Whenever consumers cannot easily find out information about how a new product will perform without experiencing the product, it is costly for consumers to switch brands. In such a situation, brand loyalty is a rational economic phenomenon. Economists use the term *experience goods* for this situation, and in such markets, future demand depends on current market share. See Froot and Klemperer (1989) for a formal analysis of these effects.

9.7 SUMMARY

This chapter introduces the idea of real exchange risk. The main points in the chapter are as follows:

1. Real exchange risk, which is also called real operating exposure and real economic exposure, is the variability in the present value of a firm's profits that is caused by unpredictable fluctuations in real exchange rates.
2. A real depreciation of the domestic currency makes domestic exporters and import competitors more profitable because it shifts demand to the domestic market.
3. Real exchange risk is present in any long-term contract between parties from two countries that do not share a common currency. Making product prices in the contract contingent upon the real exchange rate helps firms share the real operating risk.
4. The pass-through to product prices from changes in real exchange rates is not one-to-one if goods markets are not perfectly competitive because producers optimally adjust their profits in response to fluctuations in the real exchange rate.
5. Evaluating the performance of a foreign subsidiary is complicated by fluctuations in real exchange rates. Establishing contingent forecasts based on optimal responses by managers can help determine how they have performed under a variety of exchange rate scenarios.
6. Managers can utilize pricing, promotional, and product development strategies to help reduce real exchange risks. The extent to which they are able to utilize these strategies depends on a firm's economies of scale and the elasticity of its demand curve.
7. Fluctuations in real exchange rates affect the cost of operating in different countries. A firm's input sources and plant location decisions need to take this into account.

QUESTIONS

1. As the vice president of finance for a U.S. firm, what do you say to your production manager when he states, "We shouldn't let foreign exchange risk interfere with our profitability. Let's simply invoice all our foreign customers in dollars and be done with it."
2. What do economists mean by *pricing-to-market*?
3. Why does a monopolist not charge the same price for the same good in two different countries?
4. What determines how much a foreign producer allows the dollar price of a product sold in the United States to be affected by a change in the real exchange rate?
5. Why is the pass-through from changes in exchange rates to changes in the prices of products not one-for-one?
6. Given that real exchange rates fluctuate, when would be the best time to enter the market of a foreign country as an exporter to that market?
7. You have been asked to evaluate possible sites for an Asian production facility that will manufacture your firm's products and sell them to the Asian market. What real exchange rate considerations should you entertain in your evaluation?
8. Why is it important for an exporter to understand the distinction between a temporary change in the exchange rate and a permanent change in determining whether to respond to a real depreciation of the home currency with increased production or sales out of inventories?

PROBLEMS

1. If there is 10% inflation in Brazil, 15% inflation in Argentina, and the Argentine peso weakens by 21% relative to the Brazilian real, by how much has the peso strengthened or weakened in real terms? What effect do you expect that this change in the real exchange rate would have on trade between the two countries?
2. Suppose that you have one domestic production facility that supplies both the domestic and foreign markets. Assume that the demand for your product in the domestic market is $Q = 2,000 - 3P$, and in the foreign market, demand is given by $Q^* = 2,000 - 2P^*$. Assume that your domestic marginal cost of production is 600. If the initial real

- exchange rate is 1, what are your optimal prices and quantities sold in the two markets? By how much will you change the relative prices of your product if the foreign currency appreciates in real terms by 10%? What will you do to production?
3. How would you respond in Problem 2 if the marginal cost of production were increasing? Why?
 4. Suppose you are a monopolist who faces a domestic demand curve given by $Q = 1,000 - 2P$. Your domestic cost of production involves domestic costs per unit of 300 and a foreign cost per unit produced of 150. If the real exchange rate is 1.1, what would be the price you would charge and the quantity you would sell? How do these variables change when the real exchange rate increases by 10%?
 5. Use a program like Crystal Ball to generate Monte Carlo simulations of the profits of Safe Air and Metallwerke under various contracting clauses.
 6. In 2008, Endo Pharmaceuticals, a U.S. firm, signed a 5-year contract with Novartis, a Swiss firm, to obtain the exclusive U.S. marketing rights for Voltaren Gel, an anti-inflammatory useful in treating osteoarthritis. Search the Internet for information about the contract. Who bore the real exchange risk?

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