MANAGING EXCHANGE RISKS IN A FLOATING WORLD

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Managing the risks associated with exchange rate changes is one of the most pervasive problems faced by financial executives in the multinational corporation (MNC) today. Now that most major currencies are floating, the problem is visible as never before.

Daily currency fluctuations almost guarantee that the foreign-currency-denominated assets and liabilities of MNCs will continually change value. Compounding this problem is the new ruling by the Financial Accounting Standards Board (FASB) that companies must handle foreign exchange gains and losses (accounting exposure) in a uniform way. This ruling eliminates the reserves many companies previously used to smooth fluctuations in reported earnings due to exchange rate changes. Now all gains and losses must flow through to the profit and loss statement. Furthermore, selling and pricing, as well as buying, decisions are made more complex due to the continually changing currency values. No matter which currency is used, at least one party to any international transaction is bearing exchange risk. In addition, the value of a given foreign investment may be highly dependent on future changes in exchange rates.

In this paper we present a comprehensive view of exchange risk management and offer alternative decision criteria to those normally advocated for use in hedging. A workable approach is provided for managers trying to cope with the problem of when and how much to hedge in the face of highly uncertain exchange rate fluctuations. This approach only requires estimates of the maximum and minimum values of future exchange rates; it does not require the specification of currency change probabilities. Companies willing to specify these probabilities, though, are shown how they can be used to reduce their overall hedging costs (provided these estimates generally outperform the market's forecasts).

Additional topics covered in this paper include traditional hedging strategy and techniques, currency forecasting, the value of hedging, accounting and economic concepts of exchange risk, and tax effects of exchange rate changes.

Our major thesis is that firms engaged in traditional financial hedging actions can expect, at best, to break even in the long run. Instead, the new emphasis by financial management should be on smoothing earnings

fluctuations by setting maximum loss limits, analyzing impact of exchange rate changes on cash flows from existing and proposed investments, taking advantage of tax differentials in sourcing exchange gains and losses, and planning operations in countries with blocked currencies and other market imperfections.

Financial Hedging—The Traditional Approach

The traditional concept of exchange risk management is based on reducing accounting or balance sheet exposure. This approach assumes that only financial items on the current balance sheet, whose dollar (or some other base currency) value will be adversely affected by a devaluation or revaluation, are exposed to exchange risk.

Exhibit 1. Basic Hedging Strategy

	Assets	Liabilities
Hard currencies (Unlikely to devalue)	Increase	Decrease
Soft currencies (Likely to devalue)	Decrease	Increase

Exhibit 2. Basic Hedging Techniques

Devaluation	Revaluation
Sell local currency forward	Buy local currency forward
Reduce levels of local currency cash and marketable securities	Increase levels of local currency cash and marketable securities
Tighten credit (reduce local receivables)	Relax local currency credit terms
Delay collection of hard currency receivables	Speed up collection of soft currency receivables
Increase imports of hard currency goods	Reduce imports of soft currency goods
Borrow locally	Reduce local borrowing
Delay payment of accounts payable	Speed up payment of accounts payable
Speed up dividend and fee remittances to parent and other subsidiaries	Delay dividend and fee remittances to parent and other subsidiaries
Speed up payment of intersubsidiary accounts payable	Delay payment of intersubsidiary accounts payable
Delay collection of intersubsidiary accounts receivable	Speed up collection of intersubsidiary accounts receivable
Invoice exports in foreign currency and imports in local currency	Invoice exports in local currency and imports in foreign currency

The basic hedging strategy for reducing accounting exposure is shown in Exhibit 1. Essentially, it involves increasing hard-currency assets and decreasing soft (liable to devalue) currency assets, while simultaneously decreasing hard-currency liabilities and increasing soft-currency liabilities. If a devaluation appears likely, for example, the basic hedging strategy would be executed as follows: reduce the level of cash, tighten credit terms to decrease accounts receivable, increase local borrowing, delay accounts payable, and sell the weak currency forward. Any excess cash should be shifted out of the country, either directly or indirectly.

The indirect methods include adjusting transfer prices between affiliates, speeding up the payment of dividends, fees and royalties, and adjusting the leads and lags on intersubsidiary accounts [17]. The latter method, which is the one most frequently used by multinationals, involves speeding up the payment of intersubsidiary accounts payable and delaying the collection of intersubsidiary accounts receivable. These hedging procedures for devaluations would be reversed for revaluations since they present exactly the opposite problems (see Exhibit 2).

Currency Forecasting

To apply these traditional financial hedging techniques, currency forecasts are required. Most researchers in the area of currency forecasting have attempted to find some key economic indicators of when a currency is in trouble. Some of these indicators are balance of payments deficit, reserves of gold and hard currencies, borrowings (S.D.R.'s, official swap agreements) and rate of inflation relative to that of the U.S.

The use of these statistics usually relies on a non-systematic application of the purchasing-power parity (PPP) doctrine. This doctrine states that under a freely-floating exchange rate regime, a relative change in purchasing-power parity for any pair of currencies, calculated as a price ratio of traded goods, would tend to be approximated by a change in the equilibrium rate of exchange between these two currencies. Thus, according to PPP, if the U.S. had a yearly rate of inflation equal to 7%, while Germany's yearly rate of inflation equalled 4%, the dollar should be devaluing by approximately 3% per annum relative to the mark. There is still debate over the appropriate price index to use in measuring PPP, although economists tend to work with wholesale price indices [9], [23].

Under a fixed-rate system, the difference between the forecasted and actual rates of exchange provide a measure of a currency's basic disequilibrium. Political and other economic factors must then be considered in determining

how long the political leaders can and will persist with this particular level of currency disequilibrium.

A number of authors including Gailliot [9], Treuherz [24], Thomas [23], and Hodgeson and Phelps [10] have shown that this theory explains changes in exchange rates quite well both in fixed as well as floating rate regimes. In analyzing the present floating rate system, though, significant departures from purchasing-power parity are apparent for most developed countries' currencies. One possible explanation is continued central bank intervention in the currency markets *i.e., dirty floating*.

Other economic variables relevant to exchange rate forecasting include relative interest rates and national incomes [23]. Interest rate differentials are important because they stimulate short-term capital flows by affecting the profitability of interest arbitrage. Changes in national incomes also exert a powerful influence on a nation's balance of payments. The more rapidly a nation's economy grows relative to other national economies, the more rapidly its imports will increase relative to its exports and vice versa.

A number of currency forecasting models are now available either in academic journals or commercially. Proponents of these models claim various degrees of forecasting success. Ultimately, however, a forecasting model is only good to the extent that its predictions will lead to *better decisions. Unfortunately, none of the currency forecasting models currently available have been tested in a decision-making context*. This does not mean, though, that profitable predictions are impossible.

Successful forecasting is possible where a lagged relationship exists between changes in the underlying economic determinants of currency values and the actual exchange rate change, e.g., a fixed rate system or where there are market imperfections that do not allow interest rates and/or forward rates to fully adjust to new information. However, where market imperfections are not significant, forecasting models will probably not be useful. This, of course, has not stopped currency forecasts from being made.

Why Hedge?

According to U.S. accounting rules, exchange rate losses must be footnoted in a U.S. corporation's annual report. The costs of hedging are buried in the aggregates of the profit and loss statement. Therefore, hedging is justified by ethnocentric treasurers on the grounds that the erratic appearance of exchange rate losses will depress the corporation's stock price. However, the Sharpe-Lintner-Mossin capital asset pricing model suggests that the cost of equity to a firm is dependent on the firm's systematic risk. If foreign currency diversification can be accomplished by the investor, then corporate hedging becomes superfluous.

Some indirect evidence of the value of hedging to individual investors is available from a study by Agmon and Lessard [1] on the price behavior of U.S.-based multinational corporations on the New York Stock Exchange. They note that neither individuals nor mutual funds are geographically diversified; multinational corporations are the major suppliers of international diversification to NYSE investors. Their regression analysis supports the hypothesis that individuals *recognize and reward* the international composition of the activites of U.S.-based corporations. (In technical terms, β was found to be a decreasing function of the percentage of foreign to overall sales).

If NYSE investors pay to diversify out of the U.S., it is ironic that corporate treasurers are paying substantial hedging fees to avoid diversifying out of U.S. dollar assets. Hedging to reduce overall foreign exchange costs is sensible only if markets are not perfect. Otherwise, prices will adjust to reflect expectations of future exchange rate changes.

One source of market imperfection often cited is that individual investors may not have equal access to capital markets. For example, since forward exchange markets only exist for the major currencies, hedging often requires local borrowing in heavily regulated capital markets. As a legal citizen of many nations, the MNC normally has greater access to these markets. Even where forward markets exist, it is usually cheaper for a corporation to hedge than for the individual investor to do so because of the margin requirements on individuals' forward contracts compared to their absence for corporate customers. However, while hedging may be cheaper for the corporation, its cost can still be high. For example, bid-ask spreads on spot and forward transactions of approximately 1/8 to 1/4 of 1% can increase hedging costs significantly, especially when decisions are continually being revised.

Does Hedging Work?

The value of hedging in the absence of market imperfections, in fact, is questionable since evidence now exists that firms engaged in these hedging strategies can expect at best to *break even in the long run*. On average, the costs of protection appear to be slightly greater than the benefits derived. The cost of hedging by borrowing locally, for example, is the higher interest rate invariably associated with a soft currency loan. Even shifting funds from one country to another is not a costless means of

hedging. The net effect of speeding up remittances while delaying receipt of intracompany receivables is to force a subsidiary in a devaluation-prone country to increase its local currency borrowings to finance these additional working capital requirements. As mentioned above, this involves paying higher interest rates.

A study by Robbins and Stobaugh [16] indicates that the cost of hedging using forward contracts over a 3 year period in 7 countries averaged about .7% more than a do-nothing policy. More recent estimates by Kohlhagen [11] of forward contract costs in six major currencies during the floating-rate period April 1973–December 1974 put this average excess cost at about .65%. In addition, even though the British government supported sterling futures in the past, an internal Ford Motor Company study shows that through the years 1946 to 1969 a policy of always hedging was appreciably more expensive than one of never hedging but taking losses when devaluation occurred.

Mandelbrot's [14] theoretical view that prices in speculative markets behave as a martingale (that patterns in price movements are so weak as not to justify transaction costs) has been confirmed by Giddy and Dufey [5]. They used 1973–74 data to predict the U.S. prices of the Canadian dollar, British pound, and French franc for 1, 7, 30 and 90 days ahead. They concluded that it is a random walk—an even tighter property than martingale that says it is profitless to predict even if transaction costs were zero. As a result, the best estimate of a currency's future appreciation or depreciation is its forward premium or discount. According to Solnik, though, "[T]he forward rate is a biased estimate of the future spot rate. The bias is due to risk diversification arguments" [21, p. 369]. Therefore, unless capital market imperfections exist and persist, a treasurer or anyone else engaged in selective hedging (or speculative) activities will not be able to earn consistent foreign exchange profits (or reduce total costs) in excess of those due to risk-taking.

Where market imperfections exist and are significant, exchange risk management policies may be useful. Suppose, for example, that a subsidiary is located in a country that restricts profit repatriation. A forecasted local currency (LC) devaluation can provide this firm with an opportunity to shift excess funds elsewhere where they will earn a higher rate of return. This can be accomplished by invoicing exports from that subsidiary to the rest of the corporation in the local currency at a contracted price. As the local currency deteriorates, profit margins are squeezed in the subsidiary, compared to what they would have been with hard currency billing, but improved elsewhere in the system. In effect, cost savings from the devaluation will be shifted elsewhere in the system. If that subsidiary were exporting $1 million worth of goods monthly to its parent, for example, then a 10% LC devaluation would involve a monthly shift of $100,000 to the parent. Thus, where market imperfections such as currency controls, restricted access to capital markets, etc. do exist, there is the possibility of successful forecasting. However, the very nature of these imperfections severely restricts a company's ability to engage in profitable financial operations.

In deciding on an appropriate exchange risk management strategy, it is necessary to determine what is at risk. The following section contrasts the difference between the accounting and economic approach to measuring exposure (the degree to which a company is exposed to exchange risk).

Exposure

Under the new FASB ruling, companies are required to measure their foreign exchange exposure as the difference between current assets (except inventories and marketable securities) and virtually all short and long term liabilities [7]. This is one variant of the balance sheet approach which assumes that only financial items on the current balance sheet whose dollar value will be affected by exchange rate changes are exposed. Fixed assets are considered to maintain their dollar value after a devaluation because their local currency value is expected to rise in proportion to the extent of any devaluation (another example of the purchasing-power parity doctrine). However, this approach only considers a devaluation's effect on current year *accounting income*. In that the value of a firm is equal to the discounted sum of future after-tax *cash flows*, it is obvious that the balance sheet approach allows the first year's flow to dominate adjustments to the value of a firm. Furthermore, unless the firm can revalue its fixed assets, the dollar value of local currency cash inflows from depreciation will decline.

The myopia of acting on the basis of balance sheet exposure rather than economic impact has been scathingly portrayed by Dufey [4] in the Summer 1972 issue of *Financial Management*. In that article the French subsidiary of an American multinational corporation was instructed to reduce its working capital balances in light of a forecasted French franc devaluation, which would have forced the subsidiary to curtail its operations. However, the French subsidiary was selling all of its output to two other subsidiaries located in Germany and Belgium. Since the dollar value of its output would remain constant while franc costs expressed in dollars would decline, a 10% franc devaluation was expected to increase the dollar profitability associated with the French subsidiary by over 25%. Thus, the French manager argued, correctly, that the plant should begin expanding its operations, rather than contracting them, to take advantage of the anticipated devaluation.

The assumption that local currency sales and costs remain constant after an exchange rate change does not permit an evaluation of the typical adjustments consumers and firms undertake. In fact, Dufey [4] and Shapiro [18] have shown systematic and predictable changes to local currency cost and revenue streams, predictable both as to direction and magnitude. Discussion of some of the typical demand and cost effects of a devaluation follow.

Local Demand. If strong import competition exists, local currency prices increase, although not to the full extent of the devaluation. If import competition is weak or non-existent, local prices increase little, if at all (with weak competition, prices would have already been increased as much as possible). Demand could actually decrease if the government undertakes austerity measures in conjunction with the devaluation.

Foreign Demand. Foreign prices, expressed in dollars, remain the same or decrease, depending on the degree of competition from other exporters.

Cost of Local Inputs. Local currency costs rise although not to the full extent of the devaluation. This increase is positively associated with the import content of local inputs as well as the availability of these inputs. Inputs used in the export or import-competing sectors increase in price more than other domestic inputs. Labor costs, expressed in LC, may increase but this increase is usually less than the devaluation percentage. Hence, the greater the value added by local labor, the more dollar production costs should decline.

Cost of Imported Inputs. Dollar costs of imported inputs remain the same or decrease somewhat. The decrease depends upon the elasticity of demand for these imported goods as well as on the size of the local market relative to the world market.

Firms with world-wide production systems can be expected to increase production in a nation whose currency has devalued and decrease production in a country whose currency has revalued, all other things being equal. The greater the local labor content of a product and the percentage of local purchase, the greater the adjustment that can be expected.

All too frequently, firms neglect these effects when *analyzing proposed foreign investments*. A common mistake made is to multiply the projected local currency cash flows by the forecasted (expected) exchange rates. For example, Stonehill and Nathanson [22, p. 46] advise firms that the appropriate way to "allow for uncertainty in the multinational case would be to charge each period's incremental cash flows the cost of a program of uncertainty absorption for the period, whether or not the program was actually undertaken." For example, suppose a cash inflow of LC 1000 is expected during the current year. If the present exchange rate is LC1 = $1, while the one year forward rate is LC1 = $.80, then the Stonehill-Nathanson approach would charge the $1000 cash inflow (at current rates) the $200 cost of hedging, which would leave an adjusted cash flow of $800. As we have seen, though, such a policy disregards the effects an exchange rate change has on the actual local currency cash flows. The appropriate technique, then, is to make these cash flows contingent on future exchange rates. The expected dollar cash flows are then found by weighting each of these contingent dollar cash flows by the probability that the exchange rate upon which each is based will actually prevail.

Let L(f) be the present value of local currency cash flows with a given exchange rate f ($ value of one unit of local currency). Suppose there are 3 possible exchange rates, f_1, f_2, f_3, with probabilities of p_1, p_2, p_3, respectively. In diagram form this would appear as:

The expected present value of dollar cash flows then equals $p_1L(f_1)f_1 + p_2L(f_2)f_2 + p_3L(f_3)f_3$. For example, suppose that the proposed investment involves a plant whose entire output is to be exported. The plant's capacity is rated at one million units per annum. With a selling price of $10 per unit, the yearly revenue from this investment equals $10 million. This revenue is not expected to vary with the LC exchange rate. At the present rate of exchange, dollar costs of local production equal $6 per unit. A devaluation of 10% is expected to lower unit costs by $.30, while a 15% devaluation will reduce these costs by an additional $.15. If a devaluation of either 10% or 15% is likely with respective probabilities of .4 and .2 (the probability of no currency change is .4), then the expected value of yearly dollar cash inflows equals .4 ($10,000,000 − $6,000,000) + .4 ($10,000,000 − $5,700,000) + .2 ($10,000,000 − $5,550,000) = $4,210,000. Assuming that the forward discount equals 7% (.4 × 10% + .2 × 15%), the Stonehill-Nathanson method would instead have recognized a yearly cash inflow of $3,720,000 ($4,000,000 − .07 × $4,000,000).

The diagram becomes more complex as additional periods in which exchange rates could change are added, but the basic notion is the same—local currency cash flows branch in each period in which exchange rates are expected to change. In addition, one must not neglect the higher rate of inflation that precedes a given devaluation. In general, the effects of inflation on the dollar value of a given firm or investment are the reverse of the effects of a devaluation.

It is clear that firms cannot cover their economic exposure by traditional financial hedging. Hence, instead

of attempting to minimize the short-run balance sheet impact of an exchange rate change, managers should concentrate their efforts on the production and marketing adjustments and investment decisions necessary to ensure and increase profitability in the long run [22].

We realize, however, that managers are evaluated on the balance sheet impact of a devaluation. As Business International [3, p. 7] wryly observes:

"By U.S. accounting rules [d] evaluation losses are singled out in a U.S. firm's annual report. The costs of hedging are buried in aggregates in the P & L . . . If after a devaluation, a finance officer could say that the company was covered—he is a hero. If the devaluation loss was not hedged, his position may be in jeopardy. On the other hand, top executives and shareholders rarely complain about the cost of hedging—even if continued over a long period—the expense is a cost of doing business."

The authors do not agree with the assymmetrical reward structure implied by this quote. For those firms that insist upon hedging their balance sheet exposure, though, the next section presents a reasonable strategy designed to avoid yearly fluctuations in income caused by exchange rate changes.

Decision Criteria

The choice of how much a treasurer should hedge and the hedging costs he should be willing to pay are heavily dependent upon his decision criteria. For example, the more risk averse a treasurer is, the more that treasurer should be willing to pay to cover his exposure.

Several authors have developed models to determine the optimal amount and type of hedging that should be done using different utility-theoretic approaches. Lietaer [13], for example, assumed a one-period portfolio theory view of the problem, and presented a classical quadratic programming formulation to calculate an efficient risk-return frontier. Other writers such as Folks [8] and Wheelwright [25] take the more general approach of maximizing expected utility (or minimizing expected disutility). However, developing exchange risk management policies by applying utility theory to a subset of a firm's assets results in suboptimization, since that approach ignores both the covariances between asset returns and the effects of exchange rate changes on the firm's systematic risk.

In addition, these approaches all require the specification of probabilities for future currency values. A new approach presented by Kohlhagen [12] requires only an estimate of reasonable ranges of future exchange rates. It involves selecting the optimal hedging actions for each possible currency value within the range presented. The value of a given set of hedging actions is then studied for each different exchange rate. For example, suppose a firm has a 90 day net exposure of £1,000,000 in accounts receivable as of January 20, 1976. On that date the spot price of sterling was $2.03 while a 90 day forward pound sold for $2.01. A reasonable range for sterling 90 days hence was assumed to be $1.99–$2.04. To maximize the dollar value of these receivables, the firm should sell sterling forward only if the future spot price of sterling were to be less than $2.01. The payoff matrix for such a strategy is shown at the bottom of this page.

Without hedging, the maximum exchange loss equals $40,000 (1,000,000 × $.04) There is also the potential of a $10,000 exchange profit (1,000,000 × $.01). On the other hand, a cash flow of $2,010,000 is assured with hedging. (If the foward rate were an unbiased predictor of the future spot rate, expected revenue with no action would remain $2,010,000.)

In actuality, the firm's decision problem would be more complex since these receivables could probably be factored (sold at a discount) now and the proceeds used to purchase dollars. The optimal strategy would then depend on the relative cost of selling the expected proceeds forward versus selling the receivables immediately (see [19] for a detailed analysis of the receivables problem).

A worried treasurer working for a worried finance officer had better decide on a maximum exposure they dare take, and constantly hedge the rest. If a company has a net exposure of E dollars in a currency liable to devalue with a maximum potential devaluation of extent d, the firm's maximum possible exchange loss is dE. By varying E, then, the firm can limit its maximum loss to any set amount L. In the above example, if $25,000 is the maximum loss that would be tolerated, the treasurer should hedge at least £375,000 in the forward market (maximum exposure equals 25,000/.04 = £625,000).

At present, though, there is no way for the assistant treasurer to be absolutely certain of never losing more than the target (unless he hedges totally). That is to say, so long as the corporation has some exposure, there is always a chance that the exchange rate will drop so much that the losses will drop below the assumed set floor. The

Optimal strategy if future exchange rate is between:	Revenue if actual future exchange rate equals:					
	$1.99	$2.00	$2.01	$2.02	$2.03	$2.04
$1.99–2.01 Hedge	$2,010,000	$2,010,000	$2,010,000	$2,010,000	$2,010,000	$2,010,000
$2.01–2.04 Don't Hedge	$1,990,000	$2,000.000	$2,010,000	$2,020,000	$2,030,000	$2,040,000
Difference	$20,000	$10,000	$00	−$10,000	−$20,000	−$30,000

assistant treasurer can hedge enough to reduce the chance of that happening to, say, one year in ten.

What the assistant treasurer really wants is a foreign exchange options market. Suppose his sterling exposure is such that he would exceed his loss floor if sterling sank to parity with the dollar (£1 = $1). There is very little chance of that happening in 1976, so it would be inexpensive to buy an option to convert pounds to dollars at parity on Dec. 31, 1976. Probably the pound will not sink so low, so he won't exercise his option. But if it does devalue that much, the option protects him from exceeding the floor on losses. Although no such options are regularly available at present, they are needed, and we predict they will be available soon.

In the above example, even though a loss of $25,000 is possible, it may not be very probable. There are two possible approaches to take account of the probabilities associated with the various possible losses. One would be to limit the expected loss. If $\bar{d}$ is the expected devaluation, then the expected devaluation loss is $\bar{d}E$. By varying E, a firm's expected loss can be constrained to any desired level. Suppose a firm operating in a country whose currency is expected to devalue by an average of 10% over the coming year wishes to limit its expected exchange loss during the year to $1,000,000. This can be achieved by setting a maximum LC exposure limit of $1,000,000/.10 = $10,000,000.

The other method directly considers the various probabilities via chance-constraints, which limit the probability of losing more than L dollars in any one time period to a level of α or less. Restricting the probability of having exchange losses totalling more than $1,000,000 in a year to less than 5% would be an example of a chance-constraint. This approach is useful if a company feels that it is highly desirable to limit losses to a certain level, but is also mindful of the costs involved. The following procedure can be used to construct these constraints. Let p_i be the probability of a devaluation of extent d_i where the d_i's are ranked such that $d_1 > d_2 > d_3$, etc. For a given level of α, select that k such that

$$\sum_{i=1}^{k} p_i \leq \alpha < \sum_{i=1}^{k+1} p_i.$$

Then, by setting an exposure limit of L/d_k the probability of a firm losing more than L dollars is no greater than α. For example, suppose that a firm estimated the following probability distribution function for a devaluation: no change with probability .20, 2% change with probability .25, 3% change with probability .20, 4% devaluation with probability .15, 5% devaluation with probability .10, 7% devaluation with probability .05, 10% devaluation with probability .05. If this firm wishes to limit to 25% the probability of having exchange losses that exceed $100,000, then its total exposure must not be greater than $100,000/.05 = $2,000,000.

These constraints can still cost a firm a sizeable amount. The manager should be presented with various α and L, so as to ponder his expected savings from relaxing these exposure constraints. These savings equal the difference between the expected savings in hedging costs and the expected devaluation losses associated with an increase in exposure.

Multiple Currencies

The procedures presented above deal with the case where exposure is in only one currency. Determining possible exchange losses when several currencies are involved depends on the correlations between these currencies.

A study of currency correlations during the present floating rate system suggests that these correlations may be sufficiently unstable that extrapolation of past currency relationships may not be possible. Exhibit 3 presents the correlation coefficients among the English pound, French franc, Swiss franc, German mark, and Japanese yen versus the dollar. The first row for each currency refers to estimates based on exchange rate data taken daily from August 1, 1973 through August 21, 1973. The second row is computed from daily exchange rate movements between December 2, 1974 and December 20, 1974, while the bottom row provides the correlation coefficients for monthly exchange rates from March 1, 1973 through August 1, 1975 (taken on the first trading day of each month).

In general, the correlations based on longer-term data appear to be less positive or more negative than the shorter-run correlations. This suggests that the more diversified the currency portfolio of a multinational corporation, the fewer long-term fluctuations there should be in the dollar value of its foreign cash balances.

To provide some indication of the value of currency diversification, $100 was placed in each of the above 5 currencies on April 2. 1973. The dollar values of each of these holdings were then tracked for the next 9 quarters and compared with a naive portfolio consisting of $20 placed in each of the 5 currencies. Exhibit 4 presents these quarterly values.

The means and variances of these figures were then computed and are shown in Exhibit 5.

As can be seen, the variance of the portfolio is significantly below the variances of the French franc, Swiss franc, and German mark holdings. In addition, while the portfolio has a somewhat smaller variance than the pound and yen holdings, its mean value is significantly higher than either of these currencies' dollar values. This naive portfolio ignores the strong correlations existing between the French, Swiss, and German currencies. To minimize variance, these currencies would have to be assigned a lower proportion in any currency portfolio. To the extent,

Exhibit 3. Currency Correlation Coefficients

	£	fr(F)	fr(S)	Dm	¥	
	1.0000	0.9563	0.9344	0.9681	0.8945	Daily movements (8/1/73–8/21/73)
£	1.0000	0.1902	0.2499	0.3963	0.0000	Daily movements (12/2/74–12/20/74)
	1.0000	0.1977	−0.2571	0.0209	0.7231	Monthly movements (3/1/73–8/1/75)
		1.0000	0.9302	0.9870	0.8129	Daily movements (8/1/73–8/21/73)
fr(F)		1.0000	0.9206	0.8642	−0.2300	Daily movements (12/2/74–12/20/74)
		1.0000	0.5935	0.6500	0.1340	Monthly movements (3/1/73–8/1/75)
			1.0000	0.9786	0.7677	Daily movements (8/1/73–8/21/73)
fr(S)			1.0000	0.9439	−0.2242	Daily movements (12/2/74–12/20/74)
			1.0000	0.8047	−0.5140	Monthly movements (3/1/73–8/1/75)
				1.0000	0.8271	Daily movements (8/1/73–8/21/73)
Dm				1.0000	−0.2991	Daily movements (12/2/74–12/20/74)
				1.0000	−0.1874	Monthly movements (3/1/73–8/1/75)
					1.0000	Daily movements (8/1/73–8/21/73)
¥					1.0000	Daily movement (12/2/74–12/20/74)
					1.0000	Monthly movements (3/1/73–8/1/75)

Exhibit 4. Quarterly Dollar Values of Foreign Currency Holdings: April 2, 1973–July 1, 1975

Date	£	fr(F)	fr(S)	Dm	¥	Portfolio
4/2/73	$100.00	100.00	100.00	100.00	100.00	100.00
7/2/73	104.36	109.70	111.54	117.30	99.47	108.47
10/1/73	99.29	104.71	107.13	117.72	99.21	105.61
1/2/74	93.76	96.55	99.74	105.74	94.21	97.88
4/1/74	96.65	95.01	107.75	112.50	95.39	101.46
7/1/74	96.53	93.74	108.14	111.53	92.66	100.52
10/1/74	94.37	95.83	110.51	107.27	88.29	99.25
1/2/75	94.75	102.13	127.43	117.86	87.50	105.93
4/1/75	97.16	107.75	127.92	121.96	89.63	108.72
7/1/75	88.41	112.06	129.57	120.48	89.05	107.90

Exhibit 5. Means and Variances of Foreign Currency Holdings

	£	fr(F)	fr(S)	Dm	¥	Portfolio
Mean	96.14	101.94	114.41	114.64	92.82	103.97
Variance	16.60	48.86	105.96	30.34	18.54	15.54

then, that longer-run currency correlations are stable, a multinational corporation should hold its excess cash in a diversified portfolio of currencies, with the portfolio weight for each currency determined by its degree of correlation with the overall portfolio. The more positively correlated a given currency is with other currencies in the portfolio, the smaller the proportion of that currency that should be in the total portfolio. Conversely, a currency whose dollar value is negatively correlated with the dollar value of the portfolio should comprise a greater percentage of the final portfolio.

Even in the absence of knowledge about future values of these currency correlations, it is possible to obtain very crude bounds on possible exchange losses by studying extreme situations. Suppose that a currency A is presently valued at $.25 but that its exchange rate can vary from $.23 to $.26. At the same time, currency B's exchange rate is $.40 with a possible range of $.38 to $.42. A firm that has $1,000,000 worth of exposure in currency A (LC 4,000,000) and $500,000 (LC 1,250,000) in currency B will have the following range of possible exchange effects in each currency

A—— −$80,000 to + $40,000

B—— −$25,000 to + $25,000

Thus, the impact of this firm's exposure in A and B can range from a maximum loss of $105,000 to a maximum gain of $65,000. If $.24 and $.39 are the forward rates for A and B, respectively, then all potential profit fluctuations due to exchange rate changes can be eliminated for $52,500 (4,000,000 × $.01 + 1,250,000 × $.01).

As before, fractional hedging can eliminate as much earnings variability due to exchange rate changes as is desired. The choice of the appropriate hedging quantity is dependent on the corporation's degree of risk aversion, the cost of hedging in different currencies and currency expectations.

This approach can easily be extended to n currencies. The maximum possible exchange loss for a firm with exposure in n currencies can be found by calculating the maximum possible exchange loss in each currency and summing. Setting probabilistic limits on total losses can be achieved by varying exposure in selected currencies. In general, the quantity hedged in each currency to satisfy a

given chance-constraint will not be unique. Thus, by selectively hedging its accounting exposure, a firm can limit fluctuations in its current reported earnings due to exchange rate changes. As was pointed out previously, such a policy may be beneficial to the treasurer and other corporate officers; its value to stockholders is less clear. In fact, we will show in the next section that it is not obvious that continual hedging will reduce long-run earnings fluctuations due to exchange rate changes as compared with a policy of never hedging.

Long-Run vs Short-Run Earnings Fluctuations

Assume that a firm has anticipated yearly local currency earnings equal to C which are not expected to vary with the exchange rate. Let e_i be the unknown dollar value of one unit of local currency in year i. Then, the variance in the dollar value of LC earnings in year i, in the absence of hedging, equals C^2 Var (e_i). Suppose now that this firm decides to hedge all of its LC earnings.

Since a forward contract of maturity greater than one year is very expensive in any currency, we assume that the firm's hedging strategy involves selling C units of LC forward for dollars at the beginning of each year. If S_i is the forward exchange rate at the beginning of year i for local currency delivered at the end of year i, then the dollar value of year i's LC earnings equals S_i C. Then the variance in the dollar value of these hedged earnings equals C^2 Var (S_i). Dufey and Giddy [5] have shown that at any given moment spot and forward rates are very highly correlated. Thus, var (S_i) is likely to be approximately equal to var (e_i). Hence, unless S_i is any easier to predict than is e_i, a policy of always hedging is not likely to reduce fluctuations in reported earnings beyond the first year where these fluctuations are due to exchange rate changes.

Recommendations

Since it is unlikely that firms can consistently earn abnormally large profits from currency speculation, the goal of any hedging strategy should be at most to avoid fluctuations in the current year's reported income caused by exchange rate changes. Spending time on currency forecasting and selective hedging techniques is likely to be a misdirection of a firm's efforts. Instead, the financial officers should decide on a maximum exposure they dare take and constantly hedge the rest. Tax factors must be taken into account in deciding where and for how much to hedge (see the appendix).

REFERENCES

1. Tamir Agmon and Donald Lessard, "International Diversification and the Multinational Corporation: An Investigation of Price Behavior of the Shares of U.S. Based Multinational Corporations on the N.Y.S.E.," Working Paper #804-75, Sloan School of Management, Massachusetts Institute of Technology, 1975.

2. Gerald M. Blank, "Currency Devaluation: A Guide to Income Tax Consequences in 14 Countries," *The Journal of Taxation* (July 1971), pp. 15–19.

3. Business International Corporation. "Hedging Foreign Exchange Risks," Management Monograph No. 49, New York, 1971.

4. Gunter Dufey, "Corporate Finance and Exchange Rate Variations," *Financial Management* (Summer 1972), pp. 51–57.

5. Gunter Dufey and Ian Giddy, "The Random Behavior of Flexible Exchange Rates: Implications for Forecasting," *Journal of International Business Studies* (Spring 1975), pp. 1–31.

6. Edward L. Farrell Jr., "Tax Planning and the Multinational Corporation," *Pennsylvania CPA Spokesman* (February 1974), pp. 11–15.

7. Financial Accounting Standards Board, "Accounting for the Translation of Foreign Currency Transactions and Foreign Currency Financial Statements," Statement of Financial Accounting Standards No. 8, Stamford, Connecticut, October, 1975.

8. William R. Folks Jr., "The Optimal Level of Forward Exchange Transactions," *Journal of Financial and Quantitative Analysis* (January 1973), pp. 105–110.

9. Henry J. Gaillot, "Purchasing Power Parity as an Explanation of Long-Term Changes in Exchange Rates," *Journal of Money, Credit and Banking* (August 1970), pp. 348–357.

10. John S. Hodgson and Patricia Phelps, "The Distributed Impact of Price-Level Variations on Floating Exchange Rates," unpublished working paper, University of Oklahoma, 1973.

11. Steven W. Kohlhagen, "Evidence on the Cost of Forward Cover in a Floating System," *Euromoney* (September 1975), pp. 138–141.

12. Steven W. Kohlhagen, "Optimal Hedging Strategies for the Multinational Corporation Without Exchange Rate Projections," paper presented at Academy of International Business Annual Meeting, Dallas, Texas, December 29, 1975.

13. Bernard A. Lietaer, "Managing Risks in Foreign Exchange," *Harvard Business Review* (March–April 1970), pp. 127–128.

14. Benoit Mandelbrot, "Unbiased Markets and Martingale Models," *The Journal of Business*, Vol. 39 (1966), pp. 242–244.

15. Gordon J. Nicholson, "Tax Problems Resulting from Devaluation," *The Tax Executive* (January 1969), pp. 31–39.

16. Sidney M. Robbins, and Robert Stobaugh, *Money in the Multinational Enterprise: A Study of Financial Policy*, New York, Basic Books, 1972.

17. David Rutenberg, "Maneuvering Liquid Assets in a Multinational Corporation," *Management Science* (June 1970), pp. 671–684.

18. Alan C. Shapiro, "Exchange Rate Changes, Inflation and the Value of the Multinational Corporation," *Journal of Finance* (May 1975), pp. 485–502.

19. Alan C. Shapiro, "Optimal Inventory and Credit-Granting Strategies Under Inflation and Devaluation," *Journal of Financial and Quantitative Analysis* (January 1973), pp. 37–46.

20. Alan C. Shapiro and Thomas S. Robertson, "Managing Foreign Exchange Risks: The Role of Marketing Strategy," University of Pennsylvania Working Paper, 1975.

21. Bruno H. Solnik, "The International Pricing of Risk: An Empirical Investigation of the World Capital Market Structure," *Journal of Finance* (May 1974), pp. 365–378.

22. Arthur Stonehill and Leonard Nathanson, "Capital Budgeting and the Multinational Firm," *California Management Review* (Summer 1968), pp. 39–54.

23. Lloyd B. Thomas, "Behavior of Flexible Exchange Rates: Additional Tests from the Post-World War I Episode," *Southern Economic Journal* (October 1973), pp. 167–182.

24. Rolf M. Treuherz, "Forecasting Foreign Exchange Rates in Inflationary Economies," *Financial Executive* (February 1969), pp. 57–60.

25. Steven C. Wheelwright, "Applying Decision Theory to Improve Corporate Management of Currency-Exchange Risks," *California Management Review*, (Summer 1975), pp. 41–49.

Appendix

Only after-tax costs are relevant to a hedging decision. So before deciding *when* to hedge against exchange risk, the treasurer of a multinational corporation must decide which of its many subsidiaries to use as an intermediary. The most suitable subsidiary depends upon: the national tax treatment of foreign exchange losses and hedging costs and gains; the individual tax status of the national subsidiary in that year; and how the government of the headquarters nation will tax the gain or loss in this particular nation.

There are differences in national tax treatments of foreign exchange gains, but unfortunately the law is not clearcut in any nation. In practice the question revolves around whether exchange gains may be categorized as capital gains and what their tax rate is. Blank [2] sketches the income tax consequences in 14 countries emphasizing when gains and losses are recognized for tax purposes. In the U.S.A. there are conflicting interpretations as to whether selling for 6 months and buying for 9 (so as to cover those months that are 6 months hence) would result in a long or short term gain.

On an after tax basis we can see how erroneous is the conventional wisdom that a dollar loan provides no protection if a local currency (LC) devalues. Suppose LC 1 = $.25 when a subsidiary borrows $1 million in the Eurodollar market for one year at 10% (hence must repay $1,100,000). If the exchange rate drifts down to LC 1 = $.20 by year end, the subsidiary must repay LC 5,500,000 instead of LC 4,400,000. The interest plus exchange loss totals LC 1,500,000. (This example would not apply for a U.K. subsidiary. Andreas Prindl of Morgan Guarantee has noted that the U.K. Inland Revenue does not allow exchange losses on foreign currency borrowings to be offset against income.) If the subsidiary's marginal tax rate is 50%, its taxes are reduced by LC 750,000 (now $150,000). To the U.S. corporation the effective after-tax dollar cost of the loan is the interest cost of $100,000 less the tax saving of $150,000, which equals −$50,000 or −5%.

The tax status of each particular subsidiary affects after tax income; hence, two corporations with the same risk aversion and exposure may differ on whether to hedge. Hedging can be done through a loss subsidiary. The gains from devaluation would be taxable income if there were any, but due to the losses they are not taxed. We have interviewed many treasurers who hedge part of their exposure from one subsidiary and the remainder from another, because the first had only limited foreign tax credits. In general a corporation can rank subsidiaries by

after tax hedging cost and start at the top of the list consuming excess foreign tax credits. As Nicholson [15, p. 37] explains:

"Many companies today have credits available in excess of the foreign tax credit limitations. This arises because a creditable tax cannot exceed the "effective" tax rate times the net foreign source income. . . . To the extent that the loss on devaluation is a foreign source loss, the deductability of the loss may in effect be forfeited completely due to this limitation. If the gain is foreign source gain, the effect may be to receive the gain tax free under shelter of excess foreign tax credits."

For example, suppose the treasurer expects a $2,000,000 gain from a futures contract against the devaluation of the U.K. pound. Had he taken out the contract in New York, the gain would be domestic source income taxed at 48% of $2 million, or $960,000. If he had taken out the contract in Lichtenstein, zero tax rate, the $2,000,000 would be foreign source income in the eyes of the U.S. Internal Revenue Service. If the corporation operates profitably in any nation with a higher rate of tax than the USA, it produces excess tax credits. Such tax credits can only be applied to foreign source income, which includes this $2 million from Lichtenstein, which therefore becomes tax free.

The U.S. government may tax speculative gains abroad through the minimum distribution requirements of the Internal Revenue Code's Sub-Part F. Sub-Part F income consists of nonmanufacturing income (rents, royalties, licensing fees, dividends), income from services performed for related persons outside the nation, and income from the sale of property to related persons outside the nation. Rutenberg [17] discusses some of the tax implications of subpart F of the U.S. Internal Revenue Code.

If monetary fluctuations cause translation losses, sourcing these losses in a subsidiary having subpart F income or in a subsidiary which is included in a group or chain minimum distribution election will accelerate a corporation's foreign tax credits [6]. If gains result, these rules should be avoided.