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# Survey of Hedging Techniques to Manage Foreign-Exchange Risk

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**Abstract**

This literature review surveys some of the main topics regarding foreign-exchange risk exposure managment. The basic goal is to conduct literature surveys on some of the major studies in the field that focus on foreign-exchange risk managment. The primary focus is to undersand when the firm must hedge and to differentiate between financial and operational hedging techniques. This is done by summarising some of the existing literature in these areas in order to synthesize this topic and understand the impact of hedging techniques on corporate foreign-exchange risk.

**Keywords:** Heging, Foreign-Exchange Risk
**JEL Classification:**

## 1. Introduction

Firms that trade in internatioanal scale are concerned of foreign-exchange risk that is caused by the fllactuation of exchange-rates. Parties trade in internatioanal scale such as trades, brokers, investors,

and firms have to manage foreign-exchange risk. As the numbers of participants have increased, varied hedging products and techineues have been introduced to hedge exposure and to foreign-exchange risk.

Hedging allows firms to minimise the uncertainty associated with unexpected changes in the exchange rate. The decision on whether or not to hedge an open position is a speculative decision, as it depends on the expected spot rate when the payment or transaction settlement becomes due (Moosa, 2010). Many theoretical papers explore the incentive to hedge. For example, some papers study the agency problem and the conflict between shareholders' interest and senior claim-holders' interest related to the underinvestment problem. This underinvestment occurs when a firm abandons an attractive investment opportunity because of expensive external financing and the lack of sufficient internal funds that can be used as a substitute (Bessembinder, 1991; Froot *et al.,* 1993; Geczy *et al.,* 1997; Gay and Nam, 1998). Others examine the information effect of hedging, when hedging sends a positive signal showing that the firm is capable of reducing extraneous noise (DeMarzo and Duffie, 1995). Another strand of research deals with risk-averse managers who determine the optimal hedging policy at the corporate level in order to smooth the earnings of the firm, and at the same time maximise the managers' lifetime expected utility without affecting their own income or wealth (Stulz, 1984). Some researchers believe that using derivatives provides the following benefits for firms by allowing them to (i) ensure the stability of cash flows and the availability of internal funds; (ii) reduce the expected cost of bankruptcy; and (iii) generate lower income during high-tax-rate periods and higher income during low-tax-rate periods when the tax schedule is convex (Smith and Stulz, 1985; Stulz, 2003).

This paper demonstrates the different techniques that are used to manage exposure to foreign-exchange risk. These techniques range from financial-hedging techniques to operational-hedging techniques. Specifically, we explore how firms manage foreign-exchange risk and discuss the need for hedging, followed by the tools that are employed to manage the risk. These tools vary from short-term to long-term tools and can be classified as financial and operational hedging tools.

The following section answers the question of when firms should not worry about hedging; financial and operational hedging techniques are discussed in Section 3; in Section 4 we provide examples of operational hedging techniques that can be used to manage translation exposure; whereas, Section 5 provides examples of financial-hedging techniques for transaction exposure. Management of economic exposure and translation exposure are discussed in sections 6 and 7. Finally, in Section 8, we show how a hedge ratio is measured mathematically; we provide a conclusion in Section 9.

## 2. When Should Firms Not Worry about Hedging?

Firms do not have to hedge their position if international parity conditions (such as the unbiasedness efficiency hypothesis, uncovered interest parity, and purchasing power parity) hold, in which case there will be no foreign-exchange risk to worry about. These conditions might hold only in the long run but short-run deviations do exist.

The unbiasedness efficiency hypothesis postulates that the spot rate in the future (when the contract is due) is equal to the forward rate with the same maturity. In other words, the forward rate is an unbiased estimator of the expected spot rate. Therefore, there is no need to hedge the position by using a forward contract, since the bid–ask spread in the forward market is wider than the bid–ask spread in the spot market. This means that the same result, or an even better one, could be obtained by leaving the exposure uncovered. However, leaving the position uncovered yields a high risk in the short run, because mixed results are obtained and little evidence supports this hypothesis (Moosa, 2010). For example, the results from studies on individual countries reject the unbiasedness hypothesis, while the results from panel cointegration for 17 OECD countries suggest that the hypothesis is not rejected at the 5% level of significance (Ho, 2002). Copeland *et al.* (2005) show that deviations in the short run are mainly driven by risk premia and expectational errors.

Jung *et al.* (1998) argue that the result depends on the model and whether it employs a level specification or a percentage-change specification, as the two give different results. Wolff (2000) tests

whether adding a risk premium can be useful for forecasting the future spot rate, but his model fails to outperform random-walk forecasting. In his study that covers six exchange rates, Moosa (2002) finds that the forward rate is not an unbiased estimator of the spot rate, and is attributing this result to the presence of a risk premium.

Contrary to covered interest parity (CIP), whereby the investor locks his future pay-off by a forward contract, uncovered interest parity (UIP) arises when a domestic investor borrows $K$ amount of money in the domestic currency at cost $i\%$ and converts this amount into a foreign currency to be invested at the foreign yield of $i^*\%$. At the end of the investment horizon, this investor should convert the foreign currency back into the domestic currency at the expected spot rate. The uncovered position means that the investor has not entered the forward market, and has left the position open and exposed to spot-rate fluctuations. As a result, this investor is exposed to foreign-exchange risk, because at the beginning of their investment, they do not know the expected spot rate that will prevail in the future.

When UIP holds, the domestic-currency return (with no foreign-exchange risk) equals the foreign-currency return (with foreign-exchange risk), which implies that the interest-rate differential between the two countries will change to offset the change in the exchange rate, in such a way as to keep the domestic-currency return equal to the foreign-currency return. However, in practice, UIP does not hold and the foreign-currency return does not equal the domestic-currency return (Moosa, 2010). UIP depends on both CIP and the unbiasedness efficiency hypothesis.

Purchasing power parity (PPP) is based on the relationship between the exchange rate and the inflation rate for a country relative to another country. It shows that the currency of the country with the higher rate of inflation depreciates against the other, and vice versa. As a result, there will be no real-exchange-rate exposure. However, PPP might hold as a long-run relationship, but in the short run, there are significant deviations (Moosa, 2010). The loss of GBP 58 million by Rolls Royce in 1979 was caused by reliance on PPP, which provides an example of violation of this theory (Dufey and Srinivasulu, 1983).

Another condition under which firms do not have to worry about foreign-exchange risk is when a firm can forecast the exchange rate precisely, in which case it can control foreign-exchange risk and avoid losing some of the gain as in the previous case, when the hedging decision is undertaken as the exchange rates move in a favourable direction. However, in practice, forecasting the exchange rate is not an easy task, as it relies on unanticipated events (Moosa, 2000a). Yet another condition is when shareholders can diversify their portfolios. In this case, there is no reason for the firm to engage in an expensive hedging transaction, because shareholders are naturally hedged.

The capital assets pricing model (CAPM) and the Modigliani and Miller (1958) theorem imply that corporate risk management does not add value to the firm, because shareholders can protect themselves through a diversified portfolio (Dufey and Srinivasulu, 1983). In practice, it might be too expensive for a shareholder to hedge their position and they might not find the appropriate hedging tool to cover their exposure—such as operational hedging. In the real world, managers engage in financial-risk management practices because of imperfections in capital markets (Dufey and Srinivasulu, 1983). Recent studies also contradict Modigliani and Miller. For example Joseph (2000) finds a significant relationship between some financial measures and hedging techniques. This contradicts the view that hedging does not affect the firm's value. According to Stulz (2013), different views on hedging are due to the fact that the costs of risk management are explicit and obvious, whereas the benefits are unobvious and not easily identified. The opponents argue that there is no need for firms to hedge, since stockholders can hedge by diversifying portfolios or by selling the stock of the firm that is exposed to risk. In addition, they argue that a firm can only minimise the total risk that is unrelated to the value of the firm, and what is related to the value of the firm is systematic risk, not the total risk. Therefore, they suggest hedging at the corporate level is worthless and does not add any value. These views are valid only in the presence of perfect capital markets, but capital markets around the globe are imperfect, and this is why the proponents have put forward their own views that support hedging.

The proponents of hedging argue that markets are imperfect because of (i) the existence of information asymmetry; (ii) differential transaction costs; (iii) default costs; and (iv) progressive corporate taxes (Eun and Resnick, 2009). Information asymmetry implies that the managers of a firm know more about its financial position than outsiders do, and that they are capable of taking and managing foreign-exchange exposure. In other words, managers' goals are not aligned with principals' goals. To clarify this situation, suppose that there is a project that needs to be undertaken by the management. The management has to convince the stockholders to increase the equity and invest in this project. However, stockholders will ask about all of the information related to this project before taking a decision, and they may not believe in the management and may oppose such an investment. The case worsens and creates an agency cost of managerial discretion when the project has a negative present value and the managers would benefit from this project at the cost of stockholders (Stulz, 2003).

Differential transaction cost implies that firms have a better advantage in hedging against financial risk at a lower cost than stockholders have. Firms are at an advantage, because they have more hedging tools than stockholders, whereas stockholders might face regulatory obstacles and difficulties imposed on their transactions by financial markets (the size of transactions being an example).

When default costs materialise, the firm is in a better position than the stockholders are in bearing costs and it can reduce the probability of default, which will consequently improve the credit rating and lower the cost of debt (Eun and Resnick, 2009). Stulz (1996) argues that firms with debt are always associated with bankruptcy costs, which can be eliminated as long as the firm employs a risk-management programme to reduce the probability of bankruptcy by minimising the volatility of cash flows to zero. This will in effect boost the value of the firm and also have an effect on its capital structure and ownership structure, due to the lower cost of finance. To illustrate this point, the value of the firm is equal to the present value of its future cash flows. Given that the firm has debt, the present value of the bankruptcy cost should be deducted from the value of the firm. As stated earlier, because risk management eliminates the bankruptcy cost, the value of the firm will be equal to the present value of the cash flows.

A firm also encounters an increased cost of financial distress when it uses debt in its capital structure. The financial-distress cost could arise even if the firm has not filed for bankruptcy, as this is an indirect cost that is related to poor financial performance. When a firm employs debt in its capital structure, interest payments have a tax-deductible feature for the firm; it can increase its debt and interest payments to benefit from this tax-deductibility feature and increase its value. Therefore, the value of a leveraged firm becomes greater than the value of an unleveraged firm. However, this increase in debt is only valid up to a certain level at which time more debt becomes costly, producing a higher cost of financial distress. With a good risk-management programme, firms can reduce the cost of financial distress and enhance the capacity for debt by taking advantage of the tax shield. The optimal capital structure will balance the tax benefit against financial distress (Stulz, 2003). In other words, by minimising earnings volatility through a risk-management programme, firms can boost their debt capacity, which will result in greater benefit from the tax shield and, at the same time, reduce the present value of the expected disruption cost (Stulz, 1984; Smith and Stulz, 1985).

In addition, proper risk management will ensure that the probability of omitting promising investment opportunities due to a lack of external finance is minimised. This means that the underinvestment problem, where the firm forgoes projects with positive NPV due to the principal–agent problem, is solved by ensuring the availability of internal funds.[1] Hagelin (2003) surveys Swedish firms and finds that hedging transaction exposure can add to the value of the firm by reducing

[1] The underinvestment problem occurs when there is a conflict in views between the managers and shareholders of the firm on the method of financing attractive projects when the firm lacks sufficient internal funds. Shareholders do not agree with the management view of investing in such a project through debt finance, as the profit generated by the project in the future will be directed towards bondholders' interest.

the indirect cost of financial distress and circumventing the underinvestment problem, whereas hedging translation exposure shows no evidence related to its effect on the value of the firm.

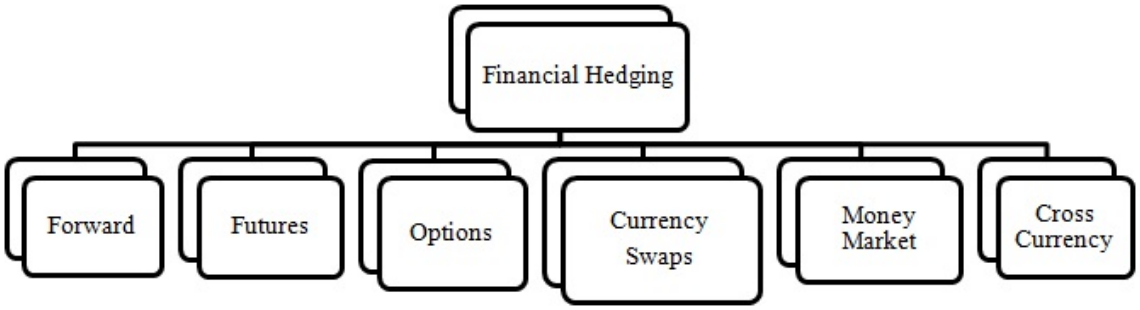
A progressive corporate tax implies that firms pay more taxes during high-income periods than they save during low-income periods. Therefore, stable before-tax earnings reduce the corporate tax payments as compared with volatile before-tax earnings. In addition, since firms pay higher taxes during higher-income periods, and lower taxes during lower-income periods, a good risk-management programme will ensure lower income during high-tax-rate periods and greater income during low-tax-rate periods. As a result, the present value of tax payments is minimised when the firm is taxed differently at different levels (Stulz, 2003).

## 3. Financial and Operational Hedging Techniques: An Overview

Due to the exchange-rate volatility to which firms are exposed, coupled with the objective of minimising unexpected exchange-rate fluctuations, firms have two techniques to hedge their position. These techniques are financial hedging or operational hedging.

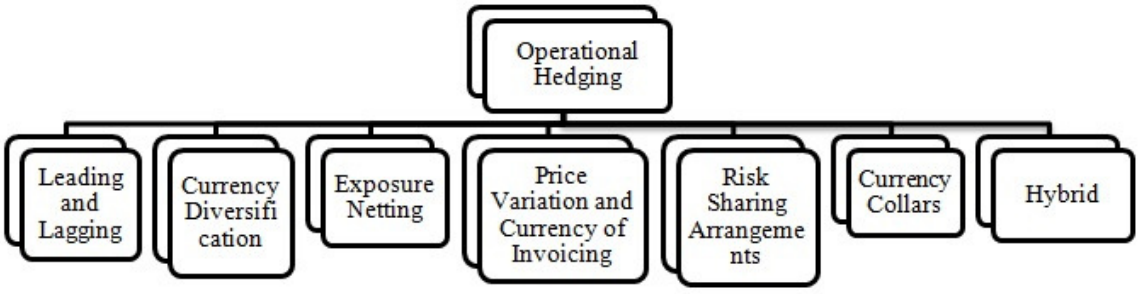
Financial-hedging techniques include use of: (1) financial derivatives (such as forward, futures, options, and swaps); (2) money-market hedging; (3) Cross-currency hedging (such as buying a third currency in the spot market).

**Figure 1** Financial-Hedging Techniques




On the other hand, operational-hedging techniques include: (1) Leading and lagging; (2) Currency diversification; (3) Exposure netting, price variation; and currency of invoicing; (4) risk-sharing arrangements; (5) currency collars (Moosa, 2010).

**Figure 2** Operational-Hedging Techniques




Operational-hedging techniques, which are also known as internal-hedging techniques, are employed when financial-hedging techniques (such as derivatives) are unavailable or are not easy to acquire.

Pramborg (2005) also finds that internal-hedging techniques are widely used among Swedish and Korean firms. For example he finds that matching inflows and outflows is the most popular method in the two countries, followed by the inter-company netting method in Sweden and the leading and lagging method in Korea. Pramborg defines internal hedging as 'leading and lagging of revenues and costs, netting of trade receivables and payables among associated companies, and domestic currency invoicing'. On the other hand, Bodnar *et al.* (1998) find that a large number of firms use foreign-currency derivatives to manage short-term maturity exposure, while few firms do so when they have long-term maturity exposure. Logue (1995) and Chowdhry and Howe (1999) share the point of view that operational hedging should be used to manage long-term exposure, whereas financial hedging should be used to manage short-term exposure. It is notable that Bodnar *et al.* (1998) find that nearly 44 per cent of firms that use derivatives in hedging currency exposure do not have a benchmark against which to evaluate their performance and to decide whether their risk-management process is useful or not.

Naylor and Greenwood (2006) find that 55 per cent of firms in New Zealand use internal-hedging techniques; however, although this percentage is very high for a small open economy, it is still lower than the international norm. Moreover, they find that matching, and leading and lagging are the most commonly used techniques by those firms. El-Masry (2003) conducts a survey covering UK non-financial firms and finds that 67 per cent of firms use derivatives to hedge four types of financial risk—interest-rate risk, foreign-exchange risk, commodity-price risk, and equity-price risk. Of those firms that manage risk by derivatives, 64 per cent of them use currency derivatives to manage foreign-exchange risk.

## 4. Operational Hedging Techniques for Transaction Exposure

Operational-hedging techniques are used when a firm faces difficulties associated with financial hedging, such as high cost or the absence of specific financial instruments. In this case, the firm needs to implement other techniques. In this section we discuss each of these operational techniques.

### 4.1 Leading and Lagging

This method deals with the timing of the realisation of foreign-currency receivables and payables. An example of leading is that if a firm has foreign-currency payables and expects the foreign currency to appreciate, it would be better to meet the payables as soon as possible before the settlement date by amending the agreement with the counterparty. On the other hand, lagging is used when the firm has foreign-currency payables and expects the foreign currency to depreciate, in which case it would be better for the firm to enter negotiations with the counterparty to amend the agreement and delay payment. With respect to receivables, the opposite is true. Contrary to external hedging, this method circumvents maturity problems (Joseph, 2000).

### 4.2 Currency Diversification

When a firm diversifies its foreign-currency portfolio with currencies whose exchange rates are not highly positively correlated (for example $y$ and $z$), and given that the firm has payables in foreign currency $y$, an appreciation of $y$ will be offset by the depreciation of another currency $z$. Moosa (2003b) shows that diversification could be implemented by using a basket of currencies or a composite currency, such as special drawing rights (SDRs).

### 4.3 Exposure Netting

When the firm has both payables and receivables in the same foreign currency, the firm should only hedge the difference between the two exposures (net exposure). This is called natural hedging. However, in real-life situations, firms usually have exposures to many foreign currencies. For example if a firm has payables in foreign currency $y$ and receivables in another foreign currency $z$ (if the exchange rates are highly correlated), the loss in one currency will be offset by the profit in the other

currency. After combining the two positions, we will only have residual risk that should be hedged by a derivative instrument.

### 4.4 Price Variation and the Currency of Invoicing

This technique is based on changing the price of exports when the exchange rate changes. For example for a Japanese firm based in Japan that exports goods to the United States, if the USD depreciates the firm will be affected and therefore it should increase the price of its exports to avoid losses from the dollar depreciation. However, this method is not easily implemented because (i) if the competition among other foreign goods is very high, any change in the price will lead to lower demand; and (ii) the prices agreed in the contract are usually fixed and the firm might not be able to change them. To overcome this problem, the exporting firm may invoice the products in the domestic currency and adjust the price of the product in the foreign currency, based on the change in the exchange rate. For example when the foreign currency appreciates, the firm will lower the price of the goods in the foreign currency, or vice versa. The currency of invoicing refers to the choice of the firm to use one currency for both payables and receivables.

### 4.5 Risk-Sharing Arrangements

With this technique, the importer and exporter face the burden of foreign-exchange risk when they both use domestic-currency terms in the invoice for part of the shipment (Moosa, 2010). The parties may agree to add a clause that allows them to set and change the base price due to a change in the exchange rate. This clause is named a price-adjustment clause (Shapiro, 2010). The parties agree on a base rate $\bar{S}$ and a range of exchange rates called the neutral zone with minimum and maximum values of $\bar{S}(1-\theta)$ and $\bar{S}(1+\theta)$, respectively, where $\theta$ is between 0 and 1. Suppose that an importing firm adopts $x$ as its base currency and has $k$ payables in foreign-currency $y$. If the spot rate on the settlement date $S_{t+1}$ is within the neutral zone $\bar{S}(1-\theta) < S_{t+1} < \bar{S}(1+\theta)$, then the cash flow (payables) in the domestic-currency will be calculated by using the base rate $\bar{S}$, which gives $V_x = K\bar{S}$. This suggests that in the neutral zone, the sensitivity of the domestic-currency value to the spot rate on the settlement date is zero, $dV_x/dS_{t+1} = 0$. However, when the spot rate moves outside the neutral zone, payables are calculated as follows. If the spot rate on the settlement date depreciates and falls below the minimum value $S_{t+1} < \bar{S}(1-\theta)$, the domestic currency value of the cash flow will be calculated as

$$V_x = K\left[\bar{S} - \frac{\bar{S}(1-\theta)-S_{t+1}}{2}\right] > KS_{t+1} \quad (1)$$

In this case, the payee will benefit because the amount that they will receive is not fully affected by depreciation compared with the no-hedge decision, whereas the payer will suffer because they will not enjoy full depreciation of the currency.

On the other hand, if the spot rate on the settlement date rises beyond the maximum value $S_{t+1} > \bar{S}(1+\theta)$, the domestic currency cash flow will be calculated as

$$V_x = K\left[\bar{S} + \frac{S_{t+1}-\bar{S}(1+\theta)}{2}\right] < KS_{t+1} \quad (2)$$

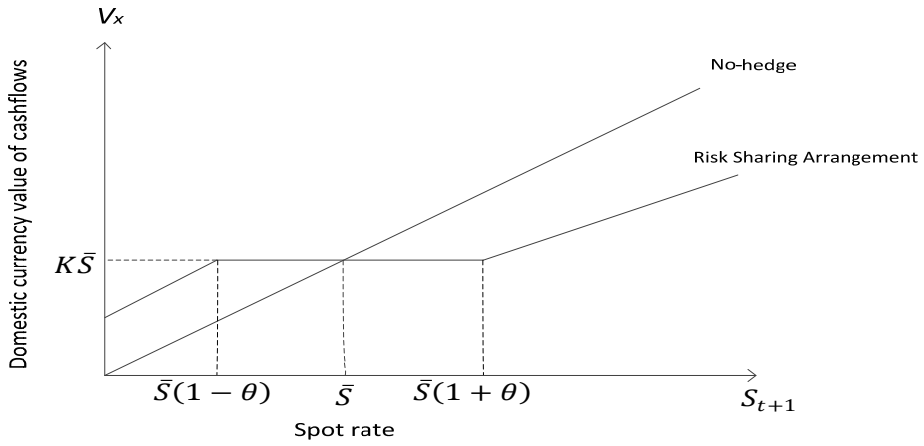
In this case, the payer will benefit because the amount that they will pay is not fully affected by appreciation compared with the no-hedge decision, whereas the payee will suffer because they will not enjoy full appreciation of the currency. As a result, under the no-hedge decision $dV_x = KdS_{t+1}$, as $dV_x/dS_{t+1} = K$, whereas under a risk-sharing arrangement, the risk is shared between the two parties, $dV_x = KdS_{t+1}/2$, which gives $dV_x/dS_{t+1} = K/2$.

In sum, if the spot rate, on the settlement date $S_{t+1}$ is within the neutral zone $\bar{S}(1-\theta) < S_{t+1} < \bar{S}(1+\theta)$, the base rate itself will be used to calculate the domestic-currency value of payables $V_x = K\bar{S}$. If the spot rate exceeds the maximum value $S_{t+1} > \bar{S}(1+\theta)$, the domestic-currency value of payables will be calculated by dividing the difference between the current rate and the maximum

value by 2 and then adding the outcome to the base rate and multiplying by $k$ amount using this formula, which gives $V_x = K\left[\bar{S} + \frac{S_{t+1} - \bar{S}(1+\theta)}{2}\right]$.

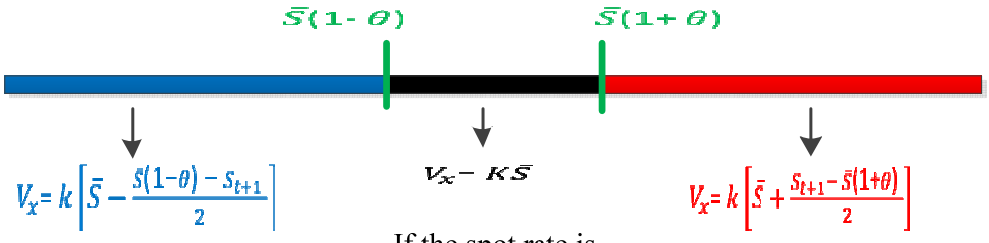
On the other hand, if the spot rate on the settlement date rate falls below the minimum value $S_{t+1} < \bar{S}(1-\theta)$, the domestic-currency value of payables will be calculated by dividing the difference between the spot rate and the minimum value by 2 and then subtracting the outcome from the base rate and multiplying by $K$ amount, which gives $V_x = K\left[\bar{S} - \frac{\bar{S}(1-\theta) - S_{t+1}}{2}\right]$. It should be noted that as $\theta$ increases, the possibility that cash flows will be converted at a fixed exchange rate $\bar{S}$ increases, because the neutral zone becomes wider. Therefore, an importer with a highly risk-averse profile will ask for the highest $\theta$ to ensure that the cash flows (payables) are converted at a fixed exchange rate, whereas an exporter does not need to engage in hedging at all, as they are not exposed to currency risk and they sell goods (receivables) in the currency $y$. If the exporter decides to participate in a risk-sharing arrangement due to influence from the importer, they will ask for the lowest $\theta$ to avoid converting cash flows (receivables) at a fixed exchange rate. Figure 3.3 clarifies the above example easily by illustrating how a risk-sharing arrangement works in general. Figure 3.4 shows an example of a risk-sharing arrangement for an importer with payables in a foreign currency.

**Figure 3** Risk-Sharing Arrangement




Source: McDonald and Moosa (2003)

**Figure 4** Conversion Rates under Risk-Sharing Arrangement




This formula is used to calculate the domestic currency value of payables

If the spot rate is in this range, the base rate is used to calculate the domestic currency value of payables

This formula is used to calculate the domestic currency value of payables

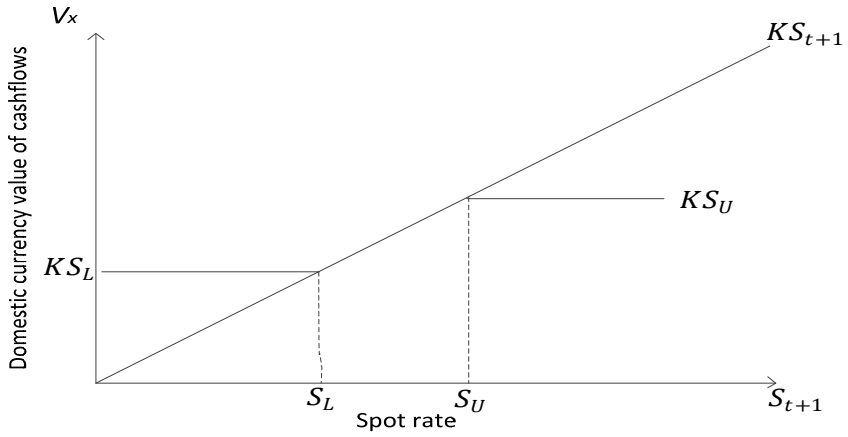
## 4.6 Currency Collars

The currency-collars technique, which is also known as range forward (Moosa, 2003b), involves the determination of a minimum value $S_L$ and a maximum value $S_U$. If the spot rate on the settlement date

$S_{t+1}$ exceeds the maximum value, the two parties use the maximum value, whereas if the spot rate $S_{t+1}$ falls below the minimum value, the two parties use the minimum value. If the spot rate $S_{t+1}$ is in the range between the minimum and the maximum values, the spot rate $S_{t+1}$ itself is used by the two parties. Moosa (2003b) argues that the currency collar works as a trade-off between prospective gain and prospective loss. It can be created by taking a strategy of short-call and long-put with an exercise exchange rate of $S_U$ and $S_L$, respectively. The pay-off from such a strategy is called the cylinder (Moosa, 2003b; Shapiro, 2010). This means that we set a maximum value (cap) for the payables of an importing company at the expense of setting a minimum value (floor)—that is, scarifying the prospective profit from foreign-currency depreciation (Moosa, 2003b). The opposite applies to an exporting company, in which we set a minimum value (floor) at the expense of setting a maximum value (cap)—that is, scarifying the prospective loss from foreign currency appreciation.

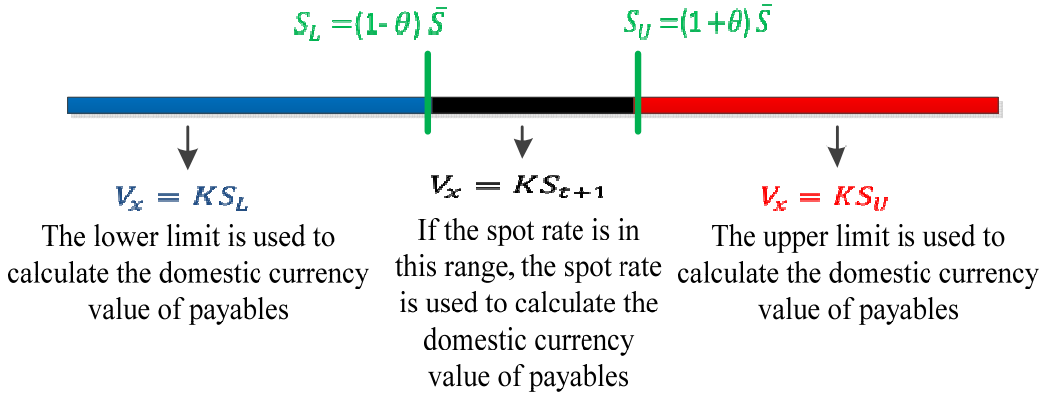
An importing firm that wants to hedge its payables in a foreign currency engages in a currency-collars agreement with the exporter in which they agree on risk parameter $\theta$, a base rate $\bar{S}$, a lower rate $S_L$ and an upper rate $S_U$. Figure 3.5 illustrates how the currency collars work in general, and Figure 3.6 shows how the currency collars work in the case of payables in a foreign currency.

**Figure 5** Currency Collars




Source: McDonald and Moosa (2003)

**Figure 6** Conversion Rates under Currency Collars




On the settlement date, if the spot rate $S_{t+1}$ is within the maximum-minimum range $S_L < S_{t+1} < S_U$, the spot rate itself will be used to calculate the domestic-currency value of payables, $V_x = KS_{t+1}$, which means that the sensitivity of the domestic-currency value of cash flows to the spot rate

on the settlement date $dV_x = KdS_{t+1}$, which gives $dV_x/dS_{t+1} = K$. If the spot rate on the settlement date exceeds the maximum rate $S_{t+1} > S_U$, the domestic-currency value of payables will be calculated using the maximum rate itself as $V_x = KS_U$. On the other hand, if the spot rate on the settlement date falls below the minimum value $S_{t+1} < S_L$, the domestic-currency value of payables will be calculated using the minimum rate itself, $V_x = KS_L$. Therefore, at both $S_{t+1} > S_U$ and $S_{t+1} < S_L$, the sensitivity of the domestic-currency value of payables to the spot rate on the settlement date equal to zero, that is, $dV_x/dS_{t+1} = 0$.

It should be noted that, as $\theta$ increases, the neutral range widens. Therefore, in contrast to the risk-sharing arrangement (RS), an importer with a highly risk-averse profile under a currency collar will ask for the lowest value of $\theta$ so that the possibility of converting their cash flows (payables) at the spot rate on the settlement date is minimised. In addition, when $S_{t+1} < \bar{S}(1-\theta)$ and $S_{t+1} > \bar{S}(1+\theta)$, the exporter is subject to foreign-exchange risk and they will ask for the highest value of $\theta$ to ensure converting their cash flow (receivables) at the spot rate prevailing on the settlement date, given that the currency of invoicing is $y$. To sum up, as long as the currency of invoicing is $y$, and there is no agreement that obliges the exporter to participate in operational hedging, the importer is the only party that is exposed to foreign-exchange risk with $dV_x/dS_{t+1} = K$, whereas the exporter is not exposed to such risk, given that $dV_y/dS_{t+1} = 0$ and, as a result, they will remain unhedged.

Sometimes, some pressure maybe put by the importer on the exporter to enter into operational hedging. If such pressure exists and the exporter enters into operational hedging (such as a risk-sharing arrangement or currency collars) their main concern will be associated with the amount of risk that will be shifted from the importer to the exporter, which will urge them, the exporter, to ask for the lowest value of risk parameter $\theta$.

### 4.7 Hybrid Arrangement

A hybrid arrangement is a hedging technique based on the weighted average of the two exchange rates under a risk-sharing arrangement and currency collars that is used to convert cash flows. According to Moosa (2011b), an exporter would prefer a hybrid arrangement to both a risk-sharing arrangement and currency collars due to the sensitivity of $V_x$ to changes in $\theta$. The following equations are used to calculate the domestic-currency value of payables under the hybrid arrangement, where $\beta$ represents the weight assigned to each technique:

$$V_x = \frac{\beta K}{2}[\bar{S}(1+\theta) + S_{t+1}] + (1-\beta)K\bar{S}(1-\theta) \text{ If } S_{t+1} < \bar{S}(1-\theta) \quad (3)$$

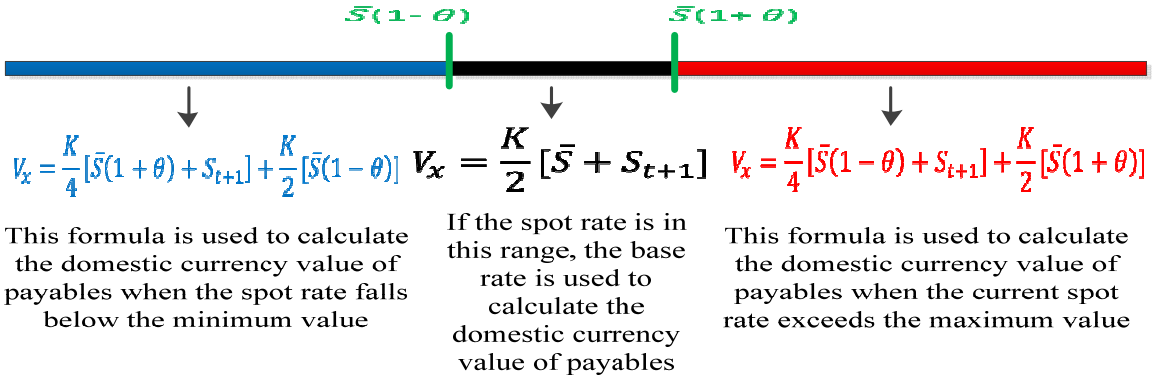
$$V_x = \beta K\bar{S} + (1-\beta)KS_{t+1} \text{ If } \bar{S}(1-\theta) < S_{t+1} < \bar{S}(1+\theta) \quad (4)$$

$$V_x = \frac{\beta K}{2}[\bar{S}(1-\theta) + S_{t+1}] + (1-\beta)K\bar{S}(1+\theta) \text{ If } S_{t+1} > \bar{S}(1+\theta) \quad (5)$$

Figure 3.7 shows how the hybrid arrangement is structured where the cash flows are calculated from the perspective of an importer with payables in a foreign currency, and equal weights of the risk-sharing arrangement and the currency collars ($\beta = 0.5$).

In a real-life scenario, in which we have different risk preferences for both the importer and exporter, they will negotiate the value of $\theta$. Hence, they may not reach an agreement regarding the exact value of $\theta$. In this case, they either do not engage in operational hedging or they modify the weights of the risk-sharing arrangement and currency collars to produce a value of the cash flow that is insensitive to changes in the risk parameter that is, $dV_x/d\theta = 0$. This means that the hybrid arrangement solves the problem associated with different preferences for risk tolerance between the two parties to the trade.

**Figure 7** Hybrid Arrangement for Equal Weights ($\beta = 0.5$)




Moosa (2009) argues that when both the importer and exporter decide to enter into operational hedging, the importer would prefer to use either of the two hedging techniques, which are the risk-sharing arrangement and the currency collars, as they are better than being unhedged; the exporter would prefer to enter into a hybrid arrangement, as it is better for them than the risk-sharing arrangement and the currency collars. The reason for such preferences lies behind the sensitivity of $V_x$ to changes in $\theta$. For example, for an importer with payables in foreign currency $y$, when $S_{t+1} < \bar{S}(1-\theta)$, $dV_x/d\theta = K\bar{S}/2$ for the risk-sharing arrangement and $dV_x/d\theta = -K\bar{S}$ for the currency collars. This means that a change in $\theta$ has a positive effect on $V_x$ for the risk-sharing arrangement, $dV_x/d\theta > 0$, and a negative effect for the currency collars, $dV_x/d\theta < 0$. When $S_{t+1} > \bar{S}(1+\theta)$, the opposite is true. For example for the risk-sharing arrangement $dV_x/d\theta = -K\bar{S}/2$, which means that $dV_x/d\theta < 0$, and for the currency collars $dV_x/d\theta = K\bar{S}$, which means that $dV_x/d\theta > 0$. These relationships suggest that a change in $\theta$ has different effects in the opposite direction on $V_x$ for each of the risk-sharing arrangement and the currency collars. As a result, a hybrid arrangement that combines the risk-sharing arrangement and the currency collars with optimum weights will absolutely eliminate the effect of $\theta$ on $V_x$. Table 3.1 summarises the relationship between $\theta$ and $V_x$ for each type of operational hedging from the perspective of an importer with payables in foreign currency $y$. It shows that the negative relationship between $V_x$ and $\theta$ under hybrid hedging is the same as the relationship under the currency collars when $S_{t+1} < \bar{S}(1-\theta)$. On the other hand, the positive relationship between $V_x$ and $\theta$ under hybrid hedging is the same as the relationship under the risk-sharing arrangement when $S_{t+1} > \bar{S}(1+\theta)$. In addition, the table shows that the hybrid arrangement of equal weights can minimise the sensitivity of $dV_x/d\theta$ from $\frac{1}{2}K\bar{S}$ under the risk-sharing arrangement to $\frac{1}{4}K\bar{S}$ under hybrid arrangement, as well as minimising $dV_x/d\theta$ from $K\bar{S}$ under the currency collars to $\frac{1}{4}K\bar{S}$ under hybrid arrangement.

**Table 1** Relationship between the Domestic-Currency Value of Payables $V_x$ and $\theta$

| Price condition | RS | CC | HY ($\beta$ =0.5) |
|---|---|---|---|
| $S_{t+1} < \bar{S}(1-\theta)$ | $\frac{dV_x}{d\theta} = \frac{K\bar{S}}{2} > 0$ | $\frac{dV_x}{d\theta} = -K\bar{S} < 0$ | $\frac{dV_x}{d\theta} = -\frac{K\bar{S}}{4} < 0$ |
| $\bar{S}(1-\theta) < S_{t+1} < \bar{S}(1+\theta)$ | $\frac{dV_x}{d\theta} = 0$ | $\frac{dV_x}{d\theta} = 0$ | $\frac{dV_x}{d\theta} = 0$ |
| $S_{t+1} > \bar{S}(1+\theta)$ | $\frac{dV_x}{d\theta} = -\frac{K\bar{S}}{2} < 0$ | $\frac{dV_x}{d\theta} = K\bar{S} > 0$ | $\frac{dV_x}{d\theta} = \frac{K\bar{S}}{4} > 0$ |

Source: Moosa (2011b)

Given that Equation (3) is used to calculate the cash flow under the hybrid arrangement when $S_{t+1} < \bar{S}(1-\theta)$, we demonstrate how to construct a hybrid arrangement of different weight combinations that provides us with a domestic cash flow $V_x$ that is insensitive to a change in $\theta$. If $S_{t+1} < \bar{S}(1-\theta)$, then

$$V_x = \frac{\beta K}{2}[\bar{S}(1+\theta) + S_{t+1}] + (1-\beta)K\bar{S}(1-\theta) \quad (6)$$

which can be manipulated to obtain

$$V_x = \frac{\beta K\bar{S}}{2} + \frac{\beta K\bar{S}\theta}{2} + S_{t+1} + (1-\beta)(K\bar{S} - K\bar{S}\theta) \quad (7)$$

by differentiating Equation (7) with respect to $\theta$, we obtain

$$\frac{dV_x}{d\theta} = \frac{\beta K\bar{S}}{2} + \frac{\beta K\bar{S}\theta}{2} + S_{t+1} + (1-\beta)K\bar{S} - (1-\beta)K\bar{S}\theta \quad (8)$$

by equating the first derivative to zero and simplifying the equation, we obtain

$$K\bar{S}\left(\frac{1}{2}\beta - 1 + \beta\right) = 0 \quad (9)$$

which gives

$$\left(\frac{1}{2}\beta - 1 + \beta\right) = 0 \quad (10)$$

Equation (10) can be solved for $\beta$, which gives $\beta = 2/3$ . By substituting this value into Equation (6) and simplifying, we end up with the expression

$$V_x = \frac{K}{3}(2\bar{S} + S_{t+1}) \quad (11)$$

The result means that the weight of the risk-sharing arrangement in the hybrid arrangement is equal to $\beta = 0.667$, whereas the weight of the currency collars equals $1 - \beta = 0.333$.

## 5. Financial Hedging of Transaction Exposure

Assume that the (base) domestic-currency and the foreign-currency values are *x* and *y*, respectively. An asset denominated in *y* indicates that the firm has a long exposure, whereas a liability denominated in *y* indicates that the firm has a short exposure. Table 3.2 illustrates the effect of currency appreciation and depreciation on the base-currency value of the assets and liabilities that are denominated in *y* when the firm chooses to hedge or not to hedge its exposure.

**Table 2 Profit and Loss from the Hedge and No-Hedge Decision**

| | **No hedge** | | **Hedge** | |
|---|---|---|---|---|
| | **If *y* appreciates** | **If *y* depreciates** | **If *y* appreciates** | **If *y* depreciates** |
| Long exposure | Profit | Loss | Loss | Profit |
| Short exposure | Loss | Profit | Profit | Loss |

With respect to the no-hedge decision, when the exchange rate moves in a favourable direction ($y$ appreciates when the firm has a long exposure, and depreciates when the firm has a short exposure), the firm makes a profit. On the other hand, the firm incurs a loss when the exchange rate moves in an unfavourable direction ($y$ appreciates when the firm has short exposure, and depreciates when the firm has long exposure). The converse is true when the hedge decision, the opposite, occurs. The firm incurs a loss when the exchange rate moves in a favourable direction ($y$ appreciates when the firm has long exposure, and depreciates when the firm has short exposure). On the other hand, the firm makes profit when the exchange rate moves in an unfavourable direction ($y$ appreciates when the firm has short exposure, and depreciates when the firm has long exposure). The techniques of hedging transaction exposure are described in turn.

### 5.1 Money-Market Hedging of Short-Term Transaction Exposure

Money-market hedging is based on the CIP condition, which suggests that the difference between spot and forward rate is cause by the difference in interest-rates between countries. CIP implies that a high-interest currency sells at a forward discount, and a low-interest currency sells at a forward premium. If the market is efficient with no transaction costs, interest-rate differential equals to the forward spread in equilibrium (Shapiro, 2010). CIP confirms that the return on unhedged local interest-rate investment and hedged foreign-currency investment will be equal. Therefore, the return differential becomes zero. When such a condition does not hold, an arbitrage opportunity arises by borrowing one currency and investing in the other.

Money-market hedging consists of borrowing in the domestic currency and lending in the foreign currency, or vice versa, to cover expected receivables and payables. This process creates an implicit forward rate $\bar{F}$ (the price of a synthetic forward contract). Therefore, the forward contract can be replaced by money-market hedging, as long as CIP holds (Khoury and Chan, 1988). Given that the base currency is $x$ and the foreign currency is $y$, we can use money-market hedging for payables and receivables as follows. Suppose that a firm has payables of $K$ in foreign currency $y$ due at time $t+1$:

1- At time $t$, the company borrows the present value of amount $K$ discounted at foreign interest rate $i^*$ from a local bank in the domestic currency. This is $KS_t/(1+i^*)$.
2- The domestic-currency amount is then converted into the foreign currency $y$ at $S_t$ (to obtain the present value of the foreign currency payable) that will be invested at $i^*$. The amount from this investment is used to cover the payables due at $t+1$.
3- At $t+1$, the domestic-currency loan becomes due, so the firm should repay the principal and interest $KS_t\ (1+i)/(1+i^*)$.
4- Given that we pay $KS_t\ (1+i)/(1+i^*)$ units of $x$ to obtain $K$ units of $y$, hence, the implicit forward rate is $\bar{F}_t = \frac{KS_t(1+i)/(1+i^*)}{K} = S_t\ (1+i)/(1+i^*)$.

From the above operations, no matter what value $S_{t+1}$ is, the firm realises in advance the domestic-currency value of payables because they will act on $\bar{F}_t$. Therefore, the firm knows in advance how much they will pay in the case of payables, and if $\bar{F}_t < S_{t+1}$, this means that the uncovered interest-rate parity ($\bar{F}_t = S_{t+1}$) has been violated and the hedge decision will be the best decision. However, if $\bar{F}_t > S_{t+1}$, no hedge will be the best decision. Finally, if $\bar{F}_t = S_{t+1}$, the decision on whether to hedge or not to hedge will yield the same result. When we compare the implicit forward rate with the forward rate, if $\bar{F} < F$, this means that a money-market hedge is better than a forward hedge and CIP does not hold. However, if $F = \bar{F}$, then CIP holds and there is no difference between hedging by forward contract and hedging by the money market. One should note that money-market hedging consists of many transactions and could be costly. Therefore, it should only be used if there is no forward contract.

In terms of receivables, we would have the same operations except that the decision would be the opposite. The firm knows in advance how much they will receive, and if $\bar{F}_t < S_{t+1}$, this means that the uncovered interest-rate parity ($\bar{F}_t = S_{t+1}$) has been violated and the no-hedge decision will be the best decision. However, if $\bar{F}_t > S_{t+1}$, hedging will be the best decision. Finally, if $\bar{F}_t = S_{t+1}$, the decision on whether to hedge or not to hedge will yield the same result. Table 3.3 summarises the money-market hedging decision for both payables and receivables.

**Table 3** Money-Market Hedging Decision for both Payables and Receivables

| Price condition | In the case of payables | In the case of receivables |
|---|---|---|
| $\bar{F}_t < S_{t+1}$ | Hedge | Not to hedge |
| $\bar{F}_t > S_{t+1}$ | Not to hedge | Hedge |
| $\bar{F}_t = S_{t+1}$ | Same result | Same result |

Source: Moosa (2003b)

### 5.2 Forward and Futures Hedging of Short-term Transaction Exposures

After measuring foreign-currency exposure, the firm can either buy foreign-currency forward or futures contracts to hedge payables, or sell foreign-currency forward or futures contracts to hedge receivables. A forward contract is an agreement between two parties to buy and sell an asset based on the future price at a specific time in the future. One of the parties goes long on the contract (buying the asset), while the other party goes short (selling the asset). The pay-off for the party with a long position is $S_{t+1} - F_t$, whereas the pay-off for the party with a short position is $F_t - S_{t+1}$. $F_t$ stands for the forward price on which both parties have agreed, whereas $S_{t+1}$ stands for the future spot price at the maturity of the contract. The contract is traded over the counter where there is no clearing house or physical exchange to regulate the procedure. Forward contracts are not standardised and are initiated between a bank and a customer, based on their needs.

A futures contract can be used in a similar manner to a forward contract, except that a futures contract is a standardised contract with respect to the settlement date and size. It also requires an initial margin and needs to be marked to market on a daily basis. If the market value of the contract falls below the maintenance margin (which is usually below the initial margin), a margin call is needed to satisfy the requirement. In addition, a clearing house exists for futures contracts that operates as an intermediary that guarantees the performance of the two parties to the trade. These differences make forward contracts more attractive than futures contracts. Clark and Ghosh (2004) recognise four disadvantages of futures contracts: (i) short maturity; (ii) the fixed maturity of the contract size; (iii) infrequent maturity date of the contract; and (iv) margin requirements. Therefore, if the holder of a futures contract expects the interest rate to be constant during the life of the contract, the value of the futures contract will decline relative to a forward contract (Khoury and Chan, 1988). In addition, Khoury and Chan show that futures contracts are ranked as the third preferred method after forward contracts and the matching method because of cost, liquidity, and expected profit. Lien and Tse (2001) find that hedging effectiveness improves when the hedger uses futures instead of options to hedge currency risk. Moreover, Albuquerque (2007) finds that using futures instead of options improves hedging results when the downside risk becomes the firm's main consideration. This situation is opposed only when the hedger becomes optimistic and less worried about large losses. Hull (2011) summarises the differences between forward and futures contracts as shown in Table 3.4.

**Table 4** Differences between Forward and Futures Contracts

| Forward contract | Futures contract |
|---|---|
| Over the counter | Traded on centralized exchanges |
| Not standardised | Standardised |
| With a specific delivery date | Several delivery dates |
| Settled at the end of the contract | Daily settelment – marked to market |
| Delivery or cash settlement | Usually prior to maturity contract are closed |
| Credit risk involved | Credit risk is minimized by the central counter party |

Source: Hull (2011)

#### a) Forward Hedging of Payables

Suppose that an importing firm has a short exposure (payables) of $K$ in foreign currency $y$ to be paid at time $t + 1$ in the future (settlement date). If the firm does not buy foreign currency forward $F$ and the spot rate $S$ rises, the firm will incur a loss on the due date. However, if the spot rate falls, the firm will make profit. On the other hand, if the firm is hedged by buying foreign currency forward at $F_t$ ($KF_t$ amount of $x$) and the spot rate $S_{t+1}$ rises ($KF_t < KS_{t+1}$), a profit will be made because the exchange rate is locked $\pi = K(S_{t+1} - F_t)$. However, if the spot rate $S_{t+1}$ falls, the firm will make a loss.

In terms of the comparison between forward hedging and money-market hedging, if CIP holds, then $\bar{F}_t = F_t$, which means that both forward hedging and money-market hedging are effective and produce the same result. However, if $KF_t < K\bar{F}_t$, then forward hedging is better than money-market

hedging. Finally, if $KF_t < K\bar{F}_t < KS_{t+1}$, this means that forward hedging is better than both money-market hedging and the no-hedging decision.

**b) Forward Hedging of Receivables**

Suppose that an exporting firm has long exposure (receivables) of $K$ in foreign currency $y$ to be received at time $t+1$. If the firm does not sell foreign currency forward $F_t$ and the spot rate $S_{t+1}$ rises, the firm will make a profit on the due date. However, if the spot rate $S_{t+1}$falls, the firm will incur a loss. On the other hand, if the firm is hedged by selling foreign currency forward at $F_t$ ($KF_t$ amount of $x$) and the spot rate $S_{t+1}$rises, a loss will be made because the exchange rate is locked $\pi = K(F_t - S_{t+1})$. However, if the spot rate $S_{t+1}$falls, the firm will make a profit. The profit or loss can be calculated by the difference between $F_t$ and $S_{t+1}$. Table 3.5 from Moosa (2003b) summarises the decision that should be taken under different prices.

**Table 5** Hedging Decisions under Different Scenarios

| Price condition | In the case of payables | In the case of receivables |
|---|---|---|
| $F_t < \bar{F}_t < S_{t+1}$ | Forward hedging | No hedge |
| $\bar{F}_t < F_t < S_{t+1}$ | Money market hedging | No hedge |
| $F_t > \bar{F}_t > S_{t+1}$ | No hedge | Forward hedging |
| $\bar{F}_t > F_t > S_{t+1}$ | No hedge | Money market hedging |
| $F_t = \bar{F}_t = S_{t+1}$ | It does not matter | It does not matter |

Source: Moosa (2003b)

**c) Forward Hedging in the Presence of Bid–Ask Spreads**

Bid–ask rates are rates at which the dealer buys–sells security to or from investors. Spreads are applied to both spot and forward exchange rates and the bid rate is lower than the ask rate. When firms want to hedge their exposure, they cover long exposure (receivables) by buying forward at the ask rate, whereas they cover short exposure (payables) by selling forward at the bid rate. Table 3.6 shows the domestic-currency value of payables and receivables in the presence of bid–ask spread.

**Table 6** Domestic-Currency Value of Payables and Receivables in the Presence of Bid–Ask Spreads

| | In case of payables | In case of receivables |
|---|---|---|
| Hedge | $KF_{at}$ | $KF_{bt}$ |
| No hedge | $KS_{a,t+1}$ | $KS_{b,t+1}$ |

Source: Moosa (2003b)

**d) Option Hedging of Short-Term Transaction Exposure**

Options contracts can be call and put options. A call-option contract provides the right to the holder to buy an asset at a certain price (exercise price), whereas a put option provides the right to the holder to sell an asset at a certain price (exercise price). The option holder could take the following decisions (i) buy a call option; (ii) sell a call option; (iii) buy a put option; and (iv) sell a put option. The date when the option is exercised is called the expiry date. A European option gives the holder the right to exercise only on the expiry date, whereas a US option gives the holder the right to exercise on any date during the option's lifetime. Options can be traded either on an exchange or over the counter.

Options differ from forward and futures contracts, in that options have an up-front cost called the premium and that the domestic-currency value of payables or receivables depends on whether the option is exercised or not. Hull (2011) states that

> *"Forward contract neutralizes risk by fixing the price that the hedger will pay or receive, whereas option contract provides insurance for the hedger. They offer a way for investors to protect themselves against adverse price movements in the future while still allowing*

*them to benefit from favourable price movements. Unlike forwards, options involve the payment of an up-front cost."*

The option is used to ensure that payables does not exceed a certain amount and that receivables does not drop below a certain amount (Moosa, 2010). Options could also have a similar effect to the forward contract when both a long call and a short put are exercised (Khoury and Chan, 1988). Option hedging makes firms match and coordinate their investment and financing plans more accurately than forward or futures contracts, since the pay-off of the former (option) is non-linear and the latter (forward and future) is a linear contract (Froot *et al.,* 1993).

In their survey of non-financial firms in the United States, Bodnar *et al.* (1998) find that options are used extensively for managing foreign-exchange risk, relative to their use for managing interest-rate risk and commodity-price risk. In addition, they find that 67 per cent of firms use European-style options, while 41 per cent of firms use US-style options for managing foreign-exchange risk. Firms do not use options for managing foreign-exchange exposure because of the lack of expertise, the high cost associated with options, and because options are not appropriate for the underlying exposure, in which case they use other suitable instruments (Bodnar *et al.,* 1998). El-Masry (2003) finds that the most commonly used instrument in managing contractual commitment by non-financial firms in the United Kingdom is options (25.4 per cent of firms use them).

**e) Hedging of Payables and Receivables with Options Contracts**

When a firm has $K$ amount payables in a foreign currency $y$, it may long call option to cover the position against any appreciation of foreign currency, the call option provides right to the firm to buy the foreign currency $y$ at exercise rate $E$. For example, suppose that the firm has a European call option on foreign currency:

1 If at expiry $S_{t+1} > E$, the firm will exercise the contract and buy the foreign currency at exercise rate $E$. Therefore, the total cost will equal $KE$ plus the cost of premium $R$, which is $KR$. This is represented as $(KE + KR)$.

2 If at expiry $S_{t+1} < E$, the firm will not exercise the contract and will buy foreign currency at $S_{t+1}$. Therefore, the total cost will equal $KS_{t+1}$ plus the cost of premium $R$ for the unexercised option, which is $KR$. This is represented as $(KS_{t+1} + KR)$.

Therefore, if the firm has payables in a foreign currency and expects the spot rate on the settlement date to rise, it will exercise the call option. In other words, if the firm takes the no-hedge decision, the payables will be $KS_{t+1}$, and if this amount is greater than the expected value of the hedge decision, the firm should buy the call-option hedge.

In terms of receivables, the firm would use a put option instead of a call option to cover the position against any depreciation in the foreign currency. The decision of the firm will be (i) if at expiry $S_{t+1} < E$, the firm will exercise the contract and sell the foreign currency at exercise rate $E$. Therefore, the total amount that will be received will equal $(KE - KR)$; and (ii) if at expiry $S_{t+1} > E$, the firm will not exercise the contract and will sell the foreign currency at $S_{t+1}$. Therefore, the total amount that will be received is $(KS_{t+1} - KR)$.

**f) Cross-Currency Hedging**

Cross-currency hedging can be implemented by either taking a position on another foreign-currency derivative or another foreign-currency spot rate. When a derivative instrument such as a forward or an option is unavailable for a certain foreign currency $y$, the firm can take the position of buying or selling a derivative for another foreign currency $z$, which has an exchange rate against the domestic currency $F(x/z)$, that is correlated with the original exchange rate $S(x/y)$. For example if company A has foreign exposure of currency $y$ but there is no derivative instrument for currency $y$, then this firm can take a position of buying or selling derivatives for the $z$ currency, based on the strong correlation between $S(x/y)$ and $F(x/z)$.

Another technique for cross-currency hedging instead of using currency derivative, is when the firm takes a spot position on another foreign currency $z$. For example, suppose that a firm has a short position on currency $y$, it can hedge the position by taking a long position on a third currency $z$ (given that the foreign-currency exchange rate $S(x/y)$ and the third-currency exchange rate $S(x/z)$ are highly correlated), and vice versa. For example if a firm has payables (short position) in currency $y$, it can buy (long position) currency $z$. Therefore, if currency $y$ appreciates, the third-currency exchange rate $S(x/z)$ will also rise, which means that the loss that would occur from currency $y$ is offset by the profit from currency $z$. This technique relies on the spot market, not the forward market. Schwab and Lusztig (1978) argue that if the transacting partners aim to minimise the risk and their concern is a nominal return and cost, a mix of the two currencies for the two parties should be used; if the concern is the real return and cost based on the reference basket, a third currency should be used.

### 5.3 Hedging Long-Term Transaction Exposure

According to Moosa (2010), three techniques can be used to hedge long-term exposure (a length of five years or more) of receivables and payables when the exposure is estimated. These are (i) long-term forward contracts; (ii) currency swaps; and (iii) parallel loans.

#### a) Long-Term Forward Contracts

Long-term forward contracts are offered by commercial banks only to top-rated companies, because of the risk associated with this type of contract. The normal forward contracts come with maturities of 30 days, 60 days, 90 days, 180 days, and 360 days. For maturities greater than these, banks can customise contracts depending on their customer's needs.

#### b) Currency Swaps

A currency swap is the exchange of a certain amount for two different currencies between two counterparties at the inception of the contract, and they will be re-exchanged at the end of the period, based on a predetermined agreement. It is used to manage foreign-exchange risk (Shapiro, 2010). To illustrate the swap, consider company A working in Kuwait, which borrows Kuwaiti dinar at a fixed interest rate, and company B, working in the United States, which borrows USD at a fixed interest rate. Both institutions agree to swap the cash flows so that each company will have its desired currency of cash flows.

#### c) Parallel Loans

According to Moosa (2010), parallel loans are similar to currency swaps but they do not involve foreign-exchange risk or transaction risk. However, a firm that wants to hedge using a parallel loan should find a counterparty that needs the exact amount of the loan.

## 6. Managing Economic (Operating) Exposure

As stated earlier, this type of exposure depends on the change in the real exchange rate. When the real exchange rate changes, the revenues and costs of the firm will also change and this will affect net operating income. For example if the firm has elastic demand for its products, a real appreciation of foreign currency will increase both domestic and foreign sales and, at the same time, will increase the cost of raw material and the foreign-borrowing costs. The outcome of this situation depends on the elasticity of revenues and costs with respect to the exchange rate. If the revenues are highly sensitive, and costs are less sensitive to appreciation of the foreign currency, then the net result will be positive due to the increase in net operating income. On the other hand, if costs are highly sensitive, and revenues are less sensitive to appreciation of the foreign currency, then the net outcome will be negative due to the decrease in net operating income. It works the other way around if the firm encounters real depreciation of foreign currency.

To hedge this type of exposure, a firm might focus on changing the sensitivity of the revenues and costs to changes in the exchange rate by restructuring its operations. For example if the firm is suffering from negative net operating income, it should increase the sensitivity of revenues and, at the same time, reduce the sensitivity of costs to an exchange-rate change. This might be achieved by increasing the expenditure on advertising and relocating its production sites. Moosa (2010) shows that this exposure could be managed by (i) diversifying the markets in which the firm sells products or from which it imports raw material; (ii) building or shifting production sites abroad; and (iv) changing the foreign-currency debt level. Aggarwal and Soenen (1989) state that marketing, production, and financial strategies should be used by firms with long-term foreign-exchange exposure, instead of other traditional techniques.

Marshall (2000) shows that forward contracts, swaps, and options are the most commonly used instruments as external hedging tools, whereas pricing strategy, planning, and raising productivity are widely used as internal-hedging tools. He argues that it is not unexpected that many firms do not manage their economic exposure. The reasons behind that are the possibilities that the cost of managing the exposure exceeds the benefit (which is not easily quantifiable), and the absence of an effective tool to manage the exposure.

## 7. Managing Translation Exposure

Although translation exposure does not affect the economic value of firms, it does affect the earnings per share data and other financial variables appearing on the financial statements. Firms manage this exposure by using three different techniques: fund adjustment, forward contracts, and exposure netting or balance-sheet hedging (Moosa, 2010). Fund adjustment is a procedure that is undertaken to affect the foreign cash flows generated by subsidiaries or projects of the firm in a way that minimises exposure to foreign-currency risk. For example consider a parent firm with foreign-currency cash inflows generated by a subsidiary: if the parent firm expects the foreign currency to depreciate, it could try to speed up the payments of dividends or use the leading method to avoid currency depreciation. Another solution is to use a stable currency in pricing exports, while using domestic currency in pricing imports, or investing in stable currency instruments (Moosa, 2010). A forward contract, which we have already discussed, basically entails selling an amount of the foreign currency forward (the amount of cash inflows of a currency that is expected to depreciate) in the future. For example suppose that the parent firm is based in Kuwait and has a subsidiary working in the United Kingdom with cash flows in GBP (as the base currency for the subsidiary), which should be transferred from the United Kingdom to Kuwait. If the parent firm expects the foreign currency, GBP, to depreciate, it should sell a forward contract on the foreign-currency cash flows.

Exposure netting involves hedge of net exposure that is calculated as the difference between foreign-currency payables and receivables. Balance-sheet hedging pertains to the difference between assets and liabilities on the balance sheet in the same currency. Firms should not worry about foreign-exchange risk if the value of assets is equal to the value of liabilities, because no effect will emerge from changes in the exchange rate on value. Marshall (2000) shows that balance-sheet hedging is the most widely used method, followed by netting and matching. On the other hand, although few firms use external methods to manage translation exposure, forward contracts, options, and swaps are the most commonly preferred methods.

## 8. Measuring the Hedge Ratio

Hedging is usually aimed at protecting the hedger from unfavourable movements in the exchange rate. It consists of taking an opposite position on a financial derivative instrument, or another asset, so that the loss from one position can be offset by the profit from the other position. For example a firm with a long position can hedge its position by taking a short position to avoid unfavourable movements in the exchange rate. However, the question that arises is by how much they should hedge. In other words,

should they hedge the full exposure so that the hedge ratio is 1, or should they hedge a fraction of the exposure? Moosa (2003b) argues that using a hedge ratio of 1 is not always the best hedging decision, as it might not eliminate the total risk, or it might reduce the risk slightly, but not completely. To determine the hedge ratio, the firm should determine the size of the financial derivative that will be used as a hedging instrument against the unhedged position. If they are equal, then a hedge ratio of 1 is obtained (perfect hedge). Consider the following formula

$$R_H = R_U - hR_A \tag{12}$$

where $R_H$ is the rate of return on the hedged position, $R_U$ is the rate of return on the unhedged position (spot), $R_A$ is the rate of return on the hedging instrument, and $h$ is the hedge ratio. For a perfect hedge in which $R_H = 0$ , the hedge ratio becomes

$$h = \frac{R_U}{R_A} \tag{13}$$

Otherwise, it is not the optimal hedge ratio as the hedge ratio will be greater or less than 1.[2]

**Mathematics of the Hedge Ratio**

The rate of return on the hedged position equals the value of the cash position at the end of the investment period plus the rate of return on the hedging instrument. Given that we have a forward or future, and given that we have a long position in the spot currency, the size of the hedging instrument should be equal to the spot currency position but in the opposite direction—as in Equation (12). For example with a long currency spot, we should short currency forward and vice versa. The $h$ in Equation (12) is simply a slope coefficient calculated as

$$h = \frac{Cov(R_U,R_A)}{Var(R_A)} \tag{14}$$

to calculate the variance of the hedged portfolio

$$\sigma^2(R_H) = \sigma^2(R_U - hR_A) \tag{15}$$

Therefore,

$$\sigma^2(R_H) = \sigma^2(R_U) + h^2\sigma^2(R_A) - 2\,h\,cov(R_U, R_A) \tag{16}$$

To minimise the variance, we take the first-order derivative of Equation (17) and equate it to zero as

$$\frac{dVar(R_H)}{dh} = 2h\,\sigma^2(R_A) - 2\,cov(R_U, R_A) = 0 \tag{17}$$

$$2h\,\sigma^2(R_A) - 2\,cov(R_U, R_A) = 0$$

which gives us a minimum-risk hedge ratio as

$$h = \frac{cov(R_U,R_A)}{\sigma^2(R_A)} \tag{18}$$

The hedge ratio is estimated using ordinary least squares (OLS) regression as in

$$\Delta p_{u,t} = \alpha + h\Delta p_{a,t} + \varepsilon_t \tag{19}$$

where $p_{U,t}$ and $p_{A,t}$ are historical prices in logarithmic form under unhedged position $p_{u,t} = s(x/y)$ and hedged positions $p_{a,t} = [f(x/y), \bar{f}(x/y), s(x/z)]$ for forward hedge, money-market hedge, and cross-

[2] Moosa (2003b) states that for a perfect hedge, exchange rates of the unhedged position (spot) and hedged instrument (forward as an example) should be perfectly correlated. If they are not perfectly correlated, and they want to obtain a perfect hedge in which $R_H = 0$, they should have a hedge ratio greater than 1 when $R_U > R_A$ or a hedge ratio less than 1 when $R_U < R_A$.

currency hedge, respectively. Given that the coefficient of determination $R^2$ is used to measure the goodness of fit, we can use this $R^2$ to measure the effectiveness of the hedge. Obtaining $R^2 = 1$ means that we have a perfect hedge and the hedged position has no variance, whereas obtaining $R^2 = 0$ indicates that the hedged position has the variance of the unhedged position (Moosa, 2003b). According to Stulz (2003), the $R^2$ shows the extent to which the independent variable explains the variance of the dependent variable. Moosa (2003b) argues that we can evaluate the effectiveness of the hedge by calculating the variance ratio (VR) and variance reduction (VD) as:

$$VR = \frac{\sigma^2(R_U)}{\sigma^2(R_H)} = \frac{\sigma^2(R_U)}{\sigma^2(R_U)+h^2\sigma^2(R_A)-2\,h\,cov(R_U,R_A)} \tag{20}$$

and given that

$$\rho = \frac{cov(R_U,R_A)}{\sigma(R_U).\sigma(R_A)} \tag{21}$$

where $\rho$ is correlation coefficient

$$cov(R_U,R_A) = \rho\,.\sigma(R_U).\sigma(R_A) \tag{22}$$

By substituting Equation (22) into Equation (18), we get

$$h = \frac{\rho\,.\sigma(R_U).\sigma(R_A)}{\sigma^2(R_A)} = \rho.\frac{\sigma(R_U)}{\sigma(R_A)} \tag{23}$$

This equation illustrates the relationship between the hedge ratio and the correlation coefficient. If $\sigma(R_U) = \sigma(R_A)$, the hedge ratio will simply be the correlation coefficient. From Equations (3.20) and (3.23), we obtain

$$VR = \frac{\sigma^2(R_U)}{\sigma^2(R_U)+[\rho^2.(\frac{\sigma^2(R_U)}{\sigma^2(R_A)})\sigma^2(R_A)]-2\,\rho.(\frac{\sigma(R_U)}{\sigma(R_A)})\,\rho\,.\sigma(R_U).\sigma(R_A)} \tag{24}$$

which can be simplified as following to obtain Equation (3.25)

$$VR = \frac{\sigma^2(R_U)}{\sigma^2(R_U)+\rho^2\sigma^2(R_U) - 2\rho^2\sigma^2(R_U)}$$

$$VR = \frac{\sigma^2(R_U)}{\sigma^2(R_U)-\rho^2\sigma^2(R_U)}$$

$$VR = \frac{1}{(1-\rho^2)} \tag{25}$$

and given that

$$VD = 1 - \frac{1}{VR} \tag{26}$$

To prove it, we carry out cross multiplication for Equation (26) to obtain Equation (27)

$$VR - VR\rho^2 = 1$$

$$VR\rho^2 = VR - 1$$

$$\rho^2 = \frac{VR}{VR} - \frac{1}{VR}$$

$$\rho^2 = 1 - \frac{1}{VR}$$

Therefore,

$$\rho^2 = VD = 1 - \frac{1}{VR} \tag{27}$$

where $\rho^2$ is simply the coefficient of determination obtained from the regression equation.

From the above equations, if we assume that the correlation coefficient $\rho$ is equal to zero, the VR will equal 1 and therefore the VD will equal zero. On the other hand, if we assume that the correlation coefficient is equal to 1, the variance correlation will equal infinity, and therefore the variance reduction will equal 1, that is, a perfect hedge.

## 9. Conclusion

In this paper, we showed how the decision on hedging is a speculative decision and we explored different points of view regarding the hedging decision. We showed how whenever international-parity conditions hold, firms do not need to worry about foreign-exchange risk. We showed that there are different types of hedging techniques that firms could use to manage their transaction exposure. These techniques are divided into financial (internal) and operational (external) hedging techniques. In addition, we surveyed the literature, and we showed how different types of foreign-exchange exposure (such as transaction exposure, economic exposure, and translation exposure) are managed using the previously mentioned techniques. At the end of this paper, we discussed the mathematics behind hedge ratio and how it is linked to VR and VD.

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