Direct and Cross Forward Hedging of Transaction Exposure to Foreign Exchange Risk

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Abstract

Three hedging decisions are evaluated using historical data involving four currencies over the period 1986–1998. Using the mean-variance criterion as applied to the domestic currency value of foreign currency payables, it is found that the no-hedging, direct forward hedging and cross forward hedging decisions produce similar results. This is attributed to the validity of the unbiasedness hypothesis and the cyclical movements of exchange rates, which cause the extreme domestic currency values of the payables to cancel out over a long period of time. This finding is not interpreted to mean that hedging is a useless operation because the results are only valid in the long run and on average.

Introduction

Firms whose activities give rise to foreign exchange risk use a wide range of instruments and techniques to hedge this exposure (see, for example, Stanley and Block, 1980; Khoury and Chan, 1988). Some firms may not hedge or may partially hedge depending on their perception about exchange rate behaviour (see, for example, Dolde, 1993). Furthermore, the hedging decision may be adjusted to reflect expectations of changes in exchange rates. For example, if the forward rate is a biased predictor of the spot rate expected to prevail in the future, hedgers may choose to alter their hedging strategies to accommodate this effect (see, for example, Berg and Moore, 1991; Schooley and White, 1995). Finally, the literature shows that firms tend to place more emphasis on transaction exposure than on economic and translation exposure (see, for example, Khoury and Chan, 1988; Joseph and Hewins, 1991). Joseph (2000) and Marshall (2000) provide survey evidence on these issues. The general conclusion arising out of these studies is that foreign exchange risk management has become one of the key factors in overall financial management, and that there is a need to measure the extent of exposure and manage it to an acceptable level (see, for example, Rawls and Smithson, 1990).

This paper has the limited objective of dealing with the hedging of transaction exposure to foreign exchange risk by using forward contracts. Specifically, the paper examines the hedging versus no-hedging decisions and the choice between direct forward hedging and cross forward hedging. The latter may be the only option avail-

able if no forward contract is available on the underlying foreign currency.

The objective of hedging transaction exposure to foreign exchange risk is to lock in the domestic currency value of foreign currency payables or receivables irrespective of what happens to the spot exchange rate between the present time (when a transaction is concluded) and the time at which the payables or receivables become due. If forward contracts are used as the hedging instrument then the foreign currency is bought forward in the case of payables and sold forward in the case of receivables. By doing this the hedger knows in advance the domestic currency value of the payables and receivables, which will be independent of the spot exchange rate prevailing on the future date. Naturally, the maturity date of the forward contract should be identical to the date on which the payables or receivables become due.

If a forward contract is available on the foreign currency in which the payables or receivables are denominated then the operation described above may be called direct forward hedging. If, on the other hand, there is no forward contract on the foreign currency then cross hedging may be an alternative worth considering. In the case of payables another foreign currency is bought forward against the domestic currency, then when the payables become due the proceeds are converted spot to the currency denominating the payables. The problem here is that there is no guarantee that the amount of the foreign currency denominating the payables that is obtained from the spot transaction will turn out to be exactly equal to the payables. If so, a supplementary spot market operation is needed to fill in the gap or otherwise dispose of the excess foreign currency balances. This also means that it is not possible to lock in the domestic currency value of the payables. Hence, a question arises as to whether cross hedging has any benefit over being unhedged.

This paper is structured as follows. The starting point is the derivation of expressions for the domestic currency value of the payables under the no-hedging, direct hedging and cross hedging decisions. This is followed by a presentation of the hypotheses to be tested and a description of the tests used for testing the hypotheses. Then the empirical results are presented and discussed. The paper ends with some concluding remarks.

A Comparison of Direct and Cross Forward Hedging

In this illustration we concentrate on the hedging of payables. The hedging of receivables works in a similar manner. Let x and y respectively be the domestic currency and the foreign currency in which payables are denominated. If the amount of payables is K units of y due at $t+n$, where t is the present time, then the domestic currency value of the payables under the no-hedging decision, V_N, is

$$V_N = KS_{t+n}(x/y) \qquad (1)$$

where $S_{t+n}(x/y)$ is the spot exchange rate between x and y that will prevail at time $t+n$. Since this exchange rate is unknown at time t, foreign exchange risk arises from the fluctuations of the spot exchange rate between t and $t+n$.

Assuming the availability of a forward contract on currency y that matures at time $t+n$, the domestic currency value of the payables that can be locked in using forward hedging, V_D, is

$$V_D = KF_t\,(x/y) \qquad (2)$$

where $F_t\,(x/y)$ is the forward rate between x and y implicit in a forward contract initiated at t and matures at $t+n$. In this case what we have on our hands is direct forward hedging.

Let us now assume that a forward contract is not available on currency y but a contract on another foreign currency, z, is available. Cross forward hedging boils down to buying forward an amount of z that is equivalent to the payables at the current spot rate between y and z. At this exchange rate the z amount equivalent to K units of y is $K/S_t\,(y/z)$. The domestic currency value of this amount when it is bought forward is

$$V_C = \frac{KF_t\,(x/z)}{S_t\,(y/z)} \qquad (3)$$

where V_C is the domestic currency value of the payables under cross hedging. At time $t+n$, the amount z bought forward, $K/S_t\,(y/z)$, is converted spot to y and the proceeds are used to meet the payables in y. The amount of y obtained is

$$A = \frac{KS_{t+n}\,(y/z)}{S_t\,(y/z)} \qquad (4)$$

Notice, however, that this amount may or may not be equal to the amount of the payables, K. The two amounts are equal (i.e., $A = K$) only if the spot exchange rate between y and z is stable such that $S_{t+n}\,(y/z) = S_t\,(y/z)$. This will be the case if the two foreign currencies, y and z, are perfectly correlated against the domestic currency such that their cross rate is stable. If this is not the case then the deficit is met by buying currency y against x spot at $t+n$, while the surplus can be converted back to x at the same rate. Hence, the domestic currency value of the payables under cross hedging is

$$V_C = \frac{KF_t\,(x/z)}{S_t\,(y/z)} - (A-K)\,S_{t+n}\,(x/y) \qquad (5)$$

Notice that if $A-K = 0$, then equation (5) will be identical to equation (3).

The Hypotheses and Testing Procedures

In this section the procedures for testing four different hypotheses are illustrated. The first of these hypotheses is that the amount of foreign currency obtained in the process of cross hedging, A, is equal on average to the value of the payables, K. Hence, we want to test the null hypothesis

$$H_0 : \mu_A = K \qquad (6)$$

against the alternative hypothesis

$$H_1 : \mu_A \neq K \qquad (7)$$

where μ_A is the population mean of A. In this case the null hypothesis is rejected if

$$\frac{\bar{A}-K}{s_A/\sqrt{n}} > t\,(n-1) \tag{8}$$

where $\bar{A}$ is the sample mean of A, s_A is the sample standard deviation, n is the sample size and $t\,(n-1)$ is the critical value of the t distribution with $n-1$ degrees of freedom.

The second hypothesis is the equality of the means of the domestic currency values of the payables under the no-hedging, direct hedging and cross hedging decisions. Let μ_N, μ_D and μ_C be the population means of the domestic currency values of the payables under no-hedging, direct hedging and cross hedging respectively. For the purpose of illustrating this test we use μ_N and μ_D only, in which case the null hypothesis is written as

$$H_0 : \mu_N = \mu_D \tag{9}$$

whereas the alternative hypothesis is written as

$$H_1 : \mu_N \neq \mu_D \tag{10}$$

The null hypothesis is rejected if

$$\frac{\bar{V}_N-\bar{V}_D}{\hat{\sigma}}\sqrt{\frac{n_N n_D}{n_N+n_D}} > t\,(n_N+n_D-2) \tag{11}$$

where $\bar{V}_N$ and $\bar{V}_D$ are respectively the sample means of the domestic currency values of the payables under no-hedging and direct hedging decisions, n_N and n_D are the corresponding sample sizes, $t\,(n_N+n_D-2)$ is the critical value of the t distribution with n_N+n_D-2 degrees of freedom, and

$$\hat{\sigma} = \sqrt{\frac{n_N s_N^2+n_D s_D^2}{n_N+n_D-2}} \tag{12}$$

where s^2 is the estimated sample variance.

The third hypothesis is the equality of the estimated sample variances of the domestic currency values of the payables. If σ^2 is the population variance then the null hypothesis is written as

$$H_0 : \sigma_N^2 = \sigma_D^2 \tag{13}$$

while the alternative hypothesis is written as

$$H_0 : \sigma_N^2 \neq \sigma_D^2 \tag{14}$$

If $s_N^2 > s_D^2$ then the null is rejected if

$$\frac{s_N^2}{s_D^2} > F\,(n_N-1,\, n_D-1) \tag{15}$$

where $F\,(n_N-1,\, n_D-1)$ is the critical value of the F distribution with the degrees of freedom given in parentheses. If $s_D^2 > s_N^2$, then the ratio of the estimated sample variances and the ordering of the degrees of freedom have to be inverted.

The fourth hypothesis is whether or not the domestic currency values of the payables under two different decisions come from the same distribution or from identical distributions. For this purpose the Wald-Wolfowitz (1940) test is used.

This is a nonparametric test designed to find out if two samples are from the same population. Consider two samples, V_{Ni} and V_{Dj}, where $i = 1, 2, \cdots, n_N$ and $j = 1, 2, \cdots, n_D$. To find out if these two samples come from the same population, the two samples are merged and the observations are arranged in ascending order. Then a complementary dummy sequence to the one obtained is constructed such that 0's correspond to V_{Ni} and 1's correspond to V_{Dj}. Each set of 0's and 1's is called a run. Let R_0 and R_1 be the number of runs whose elements are 0's and 1's respectively. The test is based on the statistic

$$R = R_0 + R_1 \tag{16}$$

Wald and Wolfowitz (1940) derive the exact distribution of R under the null hypothesis that V_{Ni} and V_{Dj} come from the same distribution. They show that the mean and variance of R are given by

$$E(R) = \frac{2n_N n_D}{n_N + n_D} + 1 \tag{17}$$

$$\sigma_R^2 = \frac{2n_N n_D (2n_N n_D - n_N - n_D)}{(n_N + n_D)^2 (n_N + n_D - 1)} \tag{18}$$

They also show that

$$\frac{R - E(R)}{\sigma_R} \sim N(0, 1) \tag{19}$$

which means that the null hypothesis is rejected if $[R - E(R)]/\sigma_R$ is greater than the critical value of the standard normal distribution (1.96 at the 5 per cent significance level).

Data and Empirical Results

The empirical results presented in this paper are based on quarterly data covering the period 1986 : 1 − 1998 : 4. Four currencies are considered : U. S. dollar (USD), Japanese yen (JPY), German mark (DEM) and British pound (GBP). The data, which were obtained from Bloomberg, consist of spot and three-month forward rates observed at the end of each quarter.

We consider the matter from a U. S. perspective and a Japanese perspective by taking the domestic currency (x) to be the U. S. dollar and the Japanese yen respectively. For a given domestic currency, we use two of the other three currencies to be y and z in all possible combinations. With a total of three other currencies there are six possible combinations. In all cases it is assumed that the foreign currency value of the payables, K, is 100 units of currency y. The mean-variance criterion is used to evaluate the hedging decisions. The lower the mean and variance of the domestic currency value of the payables the better is the hedging decision.

Table 1 reports the estimated mean value of A, $\bar{A}$, its standard deviation, s_A, and the t statistics (with 53 degrees of freedom) for $H_0 : \mu_A = 100$. Since equation (4) implies that $A = K$ if $S(y/z)$ is so stable that $S_{t+n}(y/z) = S_t(y/z)$, the table also reports the coefficient of variation of $S(y/z)$. It is obvious that irrespective of the differences in the stability of $S(y/z)$, A turns out to be equal to K on average as the

Table 1 Estimated Mean and Standard Deviation of A for Various Combinations

x	y	z	$\bar{A}$	s_A	t ($H_0: \mu_A = K$)	CV of S (y/z)
USD	JPY	DEM	99.96	5.96	−0.007	0.11
USD	JPY	GBP	99.57	6.52	−0.066	0.18
USD	DEM	JPY	100.40	6.15	0.065	0.11
USD	DEM	GBP	99.67	4.53	−0.072	0.11
USD	GBP	JPY	100.86	6.76	0.127	0.18
USD	GBP	DEM	100.54	4.78	0.113	0.12
JPY	USD	DEM	100.86	6.42	0.134	0.11
JPY	USD	GBP	100.38	5.67	0.067	0.08
JPY	DEM	USD	99.54	6.34	−0.073	0.11
JPY	DEM	GBP	99.67	4.53	−0.073	0.11
JPY	GBP	USD	99.92	5.73	−0.014	0.08
JPY	GBP	DEM	100.53	4.78	0.111	0.12

The 5 per cent critical value is 2.01.

Table 2 Estimated Mean and Standard Deviation of the Domestic Currency Value of Payables

x	y	z	$\bar{V}_N$	s_N	$\bar{V}_D$	s_D	$\bar{V}_C$	s_C
USD	JPY	DEM	0.815	0.131	0.815	0.137	0.811	0.137
USD	JPY	GBP	0.815	0.131	0.815	0.137	0.808	0.138
USD	DEM	JPY	60.07	6.05	59.76	6.40	59.98	7.12
USD	DEM	GBP	60.07	6.05	59.76	6.40	59.52	6.47
USD	GBP	JPY	164.72	12.40	163.17	12.12	164.28	15.16
USD	GBP	DEM	164.72	12.40	163.17	12.12	163.76	14.55
JPY	USD	DEM	12564.1	1887.3	12595.2	2041.1	12498.6	1900.4
JPY	USD	GBP	12564.1	1887.3	12595.2	2041.1	12452.4	1936.6
JPY	DEM	USD	7466.4	808.2	7435.1	808.2	7470.3	941.8
JPY	DEM	GBP	7466.4	808.2	7435.1	808.2	7398.7	838.0
JPY	GBP	USD	20738.5	3638.7	20569.8	3619.0	20772.0	3937.2
JPY	GBP	DEM	20738.5	3638.7	20569.8	3619.0	20646.9	3697.0

null is not rejected for any currency combination. The reasoning behind this result is simple: although the value of A may turn up to be much higher or lower than K at a certain point in time, exchange rates move in cycles such that the extreme values cancel out over time. On average, therefore, the difference between A and K is zero. For the cyclical variation in exchange rates to have this effect, we need a relatively long period of time.

Table 2 reports the estimated mean and standard deviation of the domestic currency value of the payments under the no-hedging decision, V_N, the direct hedging decision, V_D, and the cross hedging decision, V_C. The results are then used to test for differences in the mean values under these decisions as represented by equations (8) – (10). Table 3 reports the t statistics for testing the equality of the means of the domestic values of payables under the three hedging decisions. Obviously, the null cannot be rejected for any currency combination. This means that, on average, hedging a foreign currency position or otherwise will yield the same results. Moreover, if

Table 3 t Statistics for Testing Equality of Means of the Domestic Currency Value of Payables

x	y	z	$H_0: \mu_N = \mu_D$	$H_0: \mu_N = \mu_C$	$H_0: \mu_D = \mu_C$
USD	JPY	DEM	−0.006	0.147	0.150
USD	JPY	GBP	−0.006	0.270	0.269
USD	DEM	JPY	0.224	0.069	−0.139
USD	DEM	GBP	0.224	0.444	0.216
USD	GBP	JPY	0.638	0.160	−0.408
USD	GBP	DEM	0.638	0.359	−0.223
JPY	USD	DEM	−0.080	0.175	0.247
JPY	USD	GBP	−0.080	0.295	0.362
JPY	DEM	USD	0.196	−0.022	−0.203
JPY	DEM	GBP	0.196	0.415	0.223
JPY	GBP	USD	0.235	−0.045	−0.270
JPY	GBP	DEM	0.235	0.126	−0.106

The 5 per cent critical value is 1.98.

Table 4 F Statistics for Testing Equality of Variances of the Domestic Currency Value of Payables

x	y	z	$H_0: \sigma_N^2 = \sigma_{V_D}^2$	$H_0: \sigma_N^2 = \sigma_C^2$	$H_0: \sigma_D^2 = \sigma_C^2$
USD	JPY	DEM	1.10	1.10	1.00
USD	JPY	GBP	1.10	1.10	1.02
USD	DEM	JPY	1.12	1.39	1.23
USD	DEM	GBP	1.12	1.15	1.02
USD	GBP	JPY	1.05	1.49	1.56
USD	GBP	DEM	1.05	1.37	1.45
JPY	USD	DEM	1.16	1.01	1.15
JPY	USD	GBP	1.16	1.05	1.11
JPY	DEM	USD	1.00	1.34	1.35
JPY	DEM	GBP	1.00	1.08	1.08
JPY	GBP	USD	1.03	1.18	1.14
JPY	GBP	DEM	1.03	1.03	1.04

The 5 per cent critical value is 1.58

the decision to hedge is taken then direct forward hedging and cross forward hedging will produce the same result.

Table 4 presents the results of testing for the equality of the variances of the domestic currency values of payables under the three hedging decisions. Again, the null of the equality of the variances cannot be rejected for any currency combination. So, the underlying variables have measures of central tendency and dispersion that are not significantly different from each other. The Wald-Wolfowitz (1940) test is now used effectively to test simultaneously for the equality of the means and variances. The results of this test are presented in Table 5. The results obviously show that the null hypothesis that the samples come from the same distribution (or from identical distributions) cannot be rejected at the 5 per cent significance level.

These results may sound strange, but one must remember that they are obtained

Table 5 Results of the Wald-Wolfowitz Test

x	y	z	(V_N, V_D)	(V_N, V_C)	(V_D, V_C)
USD	JPY	DEM	1.37	1.18	0.39
USD	JPY	GBP	1.23	1.15	0.48
USD	DEM	JPY	1.14	1.87	0.16
USD	DEM	GBP	1.38	1.31	0.74
USD	GBP	JPY	1.07	1.09	0.43
USD	GBP	DEM	1.09	1.24	0.95
JPY	USD	DEM	1.63	1.16	0.25
JPY	USD	GBP	1.64	1.30	0.71
JPY	DEM	USD	1.47	1.38	0.62
JPY	DEM	GBP	1.01	1.23	0.64
JPY	GBP	USD	1.48	1.50	0.90
JPY	GBP	DEM	1.17	0.92	0.80

The 5 per cent critical value is 1.96.

only on average and in the long run. The no-hedging decision produces, on average or in the long run, the same outcome as the direct hedging decision because, on average or in the long run, the forward rate is after all an unbiased predictor of the spot rate. The forward rate is as likely to overestimate as to underestimate the future spot rate, and on average they are equal. If this is the case then the value of the payables converted at the current forward rate will fluctuate around the value of the payables converted at the future spot rate, and on average they will be equal. This observation, as well as the rationale for why the condition $A = K$ holds on average, explain why the no-hedging decision produces the same result as the cross hedging decision and why both hedging decisions produce the same result.

Does this mean that hedging is a useless operation because staying unhedged produces the same results? The answer is "not necessarily". The conclusions reached earlier are based on the following pillars : (i) they are only valid "on average" and "in the long run", (ii) the assumption of the constancy of K, and (iii) the assumption that the payables arise and the operation has to be repeated frequently (every three months in the case under investigation). Under these conditions and assumptions, high and low domestic currency values of the payables cancel out to give the same result on average. But at certain points in time the outcomes could be completely different.

Consider the case when x is the U. S. dollar, y is the Japanese yen and z is the German mark. Table 6 reports the range of fluctuations in A, V_N, V_D and V_C. The value of A can be significantly (not in a statistical sense) above or below 100, ranging between 82.85 and 114.17. The U. S. dollar value of 100 yen ranges between 0.611 and 1.182 under the no-hedging decision, between 0.567 and 1.196 under the direct hedging decision and between 0.578 and 1.191 under the cross hedging decision. Direct hedging of 100 yen can be less expensive than the no-hedging decision by 0.193 dollars and more expensive by 0.141 dollars and so on. The bottom line is that the results obtained on a certain occasion can be completely different from what is obtained on average.

Now, it could happen at a certain point in time that the amount of payables is so great and that different hedging decisions lead to entirely different outcomes. In this

Table 6 Maximum and Minimum Values of Some Variables

Variables	Maximum	Minimum
A	114.17	82.85
V_N	1.182	0.611
V_D	1.196	0.567
V_C	1.191	0.578
$V_N - V_D$	0.141	−0.193
$V_N - V_C$	0.127	−0.936
$V_D - V_C$	0.151	−0.145

case the wrong decision (particularly not to hedge in the face of an adverse exchange rate movement) could wipe out a whole company, so that there is no long run to count on. Let us consider this possibility with reference to our data set. Again, let the dollar, yen and mark be x, y and z respectively. Imagine a U. S. dollar based company faced with a short exposure (payables) of 10 billion yen at the end of 1994 such that the payables were due at the end of the first quarter of 1995. Let us see what would have happened if this firm had decided not to hedge, to use direct hedging and to use cross hedging. Our results show that for $K = 100$ we get $V_N = 1.1554$, $V_D = 1.0145$ and $V_C = 1.0283$. If the position had not been hedged, meeting the payables would have cost 1.4 million dollars more than under direct hedging and 1.3 million dollars more under cross hedging. Obviously, these amounts are not negligible.

Concluding Remarks

This paper has considered a comparison between the hedging and no-hedging decisions, and between direct and cross forward hedging using quarterly historical data on four currencies covering the period 1986−1998. By assuming a fixed foreign currency value for the payables arising each quarter it was found that the three possible decisions with respect to hedging the exposure produce the same results in terms of the mean and variance of the domestic currency value of the payables. This finding turned out to be valid for all of the 12 currency combinations considered. This finding was attribute to the apparent validity of the unbiased efficiency hypothesis and the cyclical behaviour of exchange rates which leads to similar outcomes in the long run and on average.

This finding, however, cannot be interpreted to mean that hedging is a useless operation. It was demonstrated that on certain occasions the three decisions can lead to significantly different outcomes. This is particularly the case with respect to the hedging versus the no-hedging decisions. If the exposure is massive and the decision not to hedge is taken when there is an adverse exchange rate movement, the result could be catastrophic, and there would be no long run to count on. Recent financial history tells us that adverse exchange rate movements can wipe out whole companies. In the 1970s the failure of the Beecham's Group, a British company, to cover its short Swiss franc exposure against the pound led to its bankruptcy. Another British company, Laker Airlines, experienced the same fate when it failed to cover its U. S. dollar

exposure.

What the results presented in this study tell us is the following. If foreign currency payables are not huge compared to the company's total assets and if they arise frequently then, over a long period of time, hedging will not produce superior results over a decision to leave the exposure uncovered. If, for some reason, it is felt that forward hedging is the preferred course of action and in the absence of a forward contract on the currency, then the hedger may resort to cross forward hedging, since this course of action will produce similar results to those obtained by resorting to direct hedging.

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