Abstract

This study examines the effectiveness of cross-currency hedging compared to that of forward hedging and money market hedging, using the Kuwaiti dinar as a base currency. It demonstrates that cross-currency hedging is not effective because the exchange rate arrangement produces low exchange rate correlations. A policy recommendation based on the findings is that the hedging function can benefit enormously from the existence of sophisticated financial markets.

Keywords: Cross Hedging, Correlation, Foreign Exchange Exposure

JEL Classification Numbers: G15, F30
Introduction

It has been suggested that cross-currency hedging can be used to cover exposure to foreign exchange risk when it is not possible or it is too costly to engage in forward and money market hedging. Forward contracts may not be available on the currency in which the exposure is denominated (the exposure currency), either because it is an exotic, thinly-traded currency or because the exposure is of a long-term nature for which there is no matching forward contract. In addition, it may not be possible to borrow or lend funds in the currency of the exposure, which means that it is not feasible to engage in money market hedging. Finally, money market hedging may be too expensive because it involves lending and borrowing in two currencies. These problems are more likely to be encountered in an emerging economy without sophisticated financial markets.

Cross-currency hedging involves taking an offsetting position on a third currency, such that the exchange rates of the third currency and the currency of exposure against the base currency are highly correlated. If there is a long exposure, then the hedger takes a short position on the third currency and vice versa. Thus, if the exposure currency appreciates against the base currency, the third currency also appreciates (by the same percentage if the exchange rates are perfectly correlated). And since the positions on the exposure currency and the third currency are opposite, any profit (loss) made on the exposure will be offset by the loss (profit) made on the third currency position. Although the position on the third currency may involve forward, futures or options contracts, we will assume here that the offsetting positions are spot positions. If the exchange rates are negatively correlated, then a short (long) position
is taken on the third currency to hedge a short (long) position on the currency of exposure.

Some work has been done to examine the effectiveness of cross-currency hedging, using major currencies. Brooks and Chong (2001) suggest that cross-currency hedging can reduce volatility by around 15 per cent compared with 60 per cent-80 per cent when futures contracts are used. Moosa (2004) examined the effectiveness of cross-currency hedging compared to that of forward and money market hedging using several currency combinations. The results indicate that for effective cross-currency hedging, a correlation coefficient of 0.5 is required to reduce the variance of the rate of return on the unhedged position by 25 per cent. In another study, Moosa (2003) showed, by using a large number of currencies and two different base currencies, that certain currency combinations can produce effective cross-currency hedging. Furthermore, Siegel (1997) evaluated the effectiveness of cross-currency hedging by employing the cross-currency options listed on the Philadelphia Stock Exchange to extract the relationship between hedging effectiveness and the implied exchange rate correlations.

Existing work on cross-currency hedging has been done on the currencies of advanced countries, which typically have sophisticated financial markets and a wide range of derivatives that can be used to hedge open currency positions. It is perhaps the case that this exercise will be more useful if it is conducted on the thinly-traded currencies of emerging countries that have no sophisticated financial markets. If cross-currency hedging turns out to be effective, this solves a serious problem when forward contracts are unavailable and when money market hedging is difficult or costly. It is
for this reason that this paper deals with the foreign exchange exposure hedging problem, and for this reason that this paper is likely to add something to the literature on cross-currency hedging.

The objective of this paper is to test the effectiveness of cross-currency hedging compared to that of forward and money market hedging using various currency combinations, with the Kuwaiti dinar being the base currency. The significance of this exercise is two-fold: (i) if cross-currency hedging turns out to be ineffective, there would be a strong argument for developing the money and derivatives markets to facilitate the hedging function; and (ii) we will find out if the exchange rate arrangement makes any difference with respect to the effectiveness of cross-currency hedging.

This empirical exercise starts with some estimates of the optimal hedge ratios, which are subsequently used to construct hedged positions consisting of the unhedged positions and opposite positions on the hedging instrument. The effectiveness of hedging is measured by the variance of the rate of return on the hedged position relative to the variance of the rate of return on the unhedged position.

**Methodology**

In this paper, the optimal hedge ratio is measured as the slope coefficient in a regression of the rate of return on the unhedged position on the rate of return on the
hedging instrument.\(^1\) If \( p_U \) and \( p_A \) are the logarithms of the prices of the unhedged position and the hedging instruments respectively, then the underlying regression is

\[
\Delta p_{U,t} = \alpha + h\Delta p_{A,t} + \varepsilon_t
\]  

(1)

where \( h \) is the hedge ratio. In the case of foreign currency exposure, \( p_U \) is the spot exchange rate between the base currency (\( x \)) and the exposure currency (\( y \)) measured in logarithmic form as \( s(x/y) \).\(^2\) \( p_A \), on the other hand, depends on the kind of hedging instrument used. If forward hedging is used, such that the offsetting position involves a forward contract, then

\[
p_A = f(x/y)
\]  

(2)

where \( f \) is the logarithm of the forward rate. If money market hedging is used, then the price of the hedging instrument is represented by the interest parity forward rate, \( \bar{f} \), which is the forward rate consistent with covered interest parity. Thus

\[
p_A = \bar{f}(x/y)
\]  

(3)

where

\[
\bar{f}(x/y) = s + \log(1+i_x) - \log(1+i_y)
\]  

(4)

where \( i_x \) and \( i_y \) are the interest rates on currencies \( x \) and \( y \) respectively, such that the maturity of the underlying assets is identical to the maturity of the forward contract.

Finally, if a cross hedge involving a third currency (\( z \)) is used, the price of the hedging instrument is the spot exchange rate between \( x \) and \( z \), in which case

\[
p_A = s(x/z)
\]  

(5)

\(^1\) Although this is the simplest method for measuring the hedge ratio, it will be argued later that more sophisticated models and methods do not lead to a significant change in the value of the hedge ratio or hedging effectiveness.
Once the hedge ratios have been calculated, three positions are constructed, depending on the type of hedge used. The rates of return on the unhedged position and the three hedged positions are calculated as

\[ R_U = \Delta s(x/y) \] (6)

\[ R_F = \Delta s(x/y) - h_F \Delta f(x/y) \] (7)

\[ R_M = \Delta s(x/y) - h_M \Delta f(x/y) \] (8)

\[ R_C = \Delta s(x/y) - h_C \Delta s(x/z) \] (9)

where \( R_U \) is the rate of return on the unhedged position, \( R_F \) is the rate of return on a hedged position involving a forward hedge, \( R_M \) is the rate of return on a hedged position involving a money market hedge, and \( R_C \) is the rate of return on a hedged position involving a cross-currency hedge. \( h_F \), \( h_M \) and \( h_C \) are the corresponding hedge ratios.

Consider the effectiveness of a hedge against the alternative of leaving the underlying position unhedged. In this case, testing hedging effectiveness amounts to testing the equality of the variance of the hedged position and that of the unhedged position. The null hypothesis is

\[ H_0 : \sigma^2(R_U) = \sigma^2(\sigma^2(R_H)) \] (10)

against the alternative

\[ H_1 : \sigma^2(R_U) > \sigma^2(R_H) \] (11)

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2 The exchange rate between two currencies, \( x \) and \( y \), can be measured either as the price of one unit of currency \( x \) or the price of one unit of currency \( y \). \( s(x/y) \) is the (logarithm of) the spot exchange rate measured as the \( x \) currency price of one unit of currency \( y \).
where $R_H$ is equal to $R_F$, $R_M$ or $R_C$, depending on the type of hedge used, and $\sigma^2(.)$ is the variance of the rate of return on the underlying position. The null is rejected if

$$VR = \frac{\sigma^2(R_U)}{\sigma^2(R_H)} > F(n-1, n-1)$$

where $VR$ is the variance ratio and $n$ is the sample size. This test can be complemented by the variance reduction, which is calculated as

$$VD = 1 - \frac{\sigma^2(R_H)}{\sigma^2(R_U)}$$

This methodology is applied to various currency combinations involving the Kuwaiti dinar as the base currency.

**Data and Empirical Results**

This empirical exercise is based on a sample of monthly data covering the period March 1992 to December 2002 and five currencies: the Kuwaiti dinar (KWD), which is the base currency, the U.S. dollar (USD), the Japanese yen (JPY), the British pound (GBP) and the Swiss franc (CHF). An explanation for the choice of the sample period is perhaps warranted at this stage. The data were obtained from the Dealing Room of the National Bank of Kuwait, which has no records for the period between August 1990 and December 1991 because of the invasion and occupation of Kuwait by the Iraqi forces. The decision to end the sample in December 2002 was motivated by the desire to carry out this investigation under one exchange rate arrangement, the one
that was in place in Kuwait until the end of 2002 (pegging the Kuwaiti dinar to a
basket of currencies with unknown components).³

The variables are the spot exchange rates, the one-month forward exchange rates, and
the one-month interest rates, all measured at the end of the month. The exchange rates
are measured in direct quotation from a Kuwaiti perspective, whereas the interest
rates are taken to be the deposit rates measured in per cent per annum. The empirical
work consists of two stages: (i) estimating the hedge ratios and associated correlations
from the data over the period January 1992 to December 2002; and (ii) estimating the
variances, the variance ratios and variance reductions from the remainder of the
sample period by applying the hedge ratios estimated in stage (i).⁴ The hedging period
is taken to be one month, extending between the end of each month and the end of the
subsequent month.

Table 1 shows the results pertaining to measuring the effectiveness of cross-currency
hedging. The table reports (for 12 currency combinations) the estimated correlation
coefficient between the rates of return, \( \rho \), the hedge ratio, \( h \), the variance of the rate
of return on the unhedged position, \( \sigma^2(R_U) \), the variance of the rate of return on the

³ Since January 2003, the Central Bank of Kuwait has shifted to a policy of pegging the dinar to the
U.S. dollar. Prior to that, the exchange rate regime was one of pegging the dinar to a basket of
currencies with no declared structure. In essence, the Central Bank of Kuwait determined the exchange
rate of the Kuwaiti dinar against the U.S. dollar by using a secret formula that reflected the structure of
the basket. The exchange rates against the other currencies were subsequently calculated as cross rates.
Those rates were then transmitted to commercial banks, which used them to determine the bid and offer
rates that they used with their customers. For details on the policy shift and the former exchange rate
regime, see Moosa (2005, Chapter 9) and references therein.

⁴ It is typically argued that it is more appropriate to measure hedging effectiveness out of sample by
dividing the sample into two parts, using the first part to estimate the hedge ratios and the second part
to measure hedging effectiveness. Likewise, it has become the norm to evaluate the forecasting out of
sample by estimating the model over the first part of the sample, then evaluating the forecasting power
over the second part of the sample. While Inoue and Kilian (2004) justify the use of in-sample tests of
forecasting power, it is not straightforward to extrapolate this justification to the case of measuring
hedging effectiveness. Hence, hedging effectiveness is measured out of sample in this paper.
hedged position, $\sigma^2(R_{hr})$, the variance ratio, $VR$, and variance reduction, $VD$.\(^5\) An effective cross-currency hedge appears in three cases only, producing a maximum variance reduction of about 69 per cent.\(^6\)

It is also important to observe the effect of the exchange rate arrangement. Because the Kuwaiti dinar was, during the sample period, pegged to a basket of currencies with a dominant dollar component, the currency moved in opposite directions against the dollar, on one hand, and against other currencies, on the other.\(^7\) This is why the hedge ratio turned out to be negative in all six currency combinations involving the U.S. dollar. This, for example, means that a USD1,000,000 long exposure can be hedged by buying GBP113,000. The idea, then, is that if the Kuwaiti dinar appreciates (depreciates) against the dollar, it will depreciate (appreciate) against the pound, and so any profit (loss) on the dollar position will be partially offset by the loss (profit) on the pound position. The word “partially” is used here because this is not a perfect hedge, given that the exchange rates are not perfectly correlated (-0.48).

Now, compare the results presented in Table 1, with those presented in Table 2, which show the effectiveness of forward and money market hedging. In this case, only two currencies are involved, and so we have four possible currency combinations. It can

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\(^5\) The hedge ratios were estimated from the OLS regression (1). Although some economists argue strongly for the use of more sophisticated models and methods to estimate the hedge ratio (as surveyed in Moosa, 2003a), it has been found that the underlying model or method makes little difference, if any, for hedging effectiveness. In fact, Moosa (2003b) found that the estimated hedge ratio is not that sensitive to model specification. In any case, what we are investigating in this paper is the effectiveness of the hedging instrument after controlling for the estimation of the hedge ratio. Therefore, using OLS to estimate the hedge ratio is quite sound, at least for the purpose of this paper.

\(^6\) An effective hedge is indicated by a statistically significant $VR$, which has a 5 per cent critical value of 1.48.

\(^7\) Although the Central Bank of Kuwait never declared the components of the basket or their weights, it is not hard to uncover the structure of the basket through an exchange rate regime verification model. For example, Moosa (2005) estimated the components of the basket to have been as follows: dollar (0.801), yen (0.062), mark/euro (0.061) and pound (0.076).
be seen that, for all practical purposes, forward and money market hedging produce
perfect performance, simply because the spot exchange rates are highly correlated
with the actual and interest parity forward rates. The finding that forward hedging and
money market hedging produce, more or less, similar results is an indication that
covered interest parity holds (see, for example, Al-Loughani and Moosa, 2000; Moosa, 2001).8

Some Extensions
The results presented in Table 1 can be used to find out how the hedge ratio, variance
ratio and variance reduction are related to the correlation coefficient. Let $\rho$ and $\sigma_{y,z}$
be the correlation coefficient between and the covariance of $\Delta s(x/y)$ and $\Delta s(x/z)$
respectively. Also let $\sigma_y^2$ and $\sigma_z^2$ be their variances respectively. Thus, we have

$$\rho = \frac{\sigma_{y,z}}{\sigma_y \sigma_z}$$

(14)

$$h = \frac{\sigma_{y,z}}{\sigma_z^2}$$

(15)

$$VR = \frac{\sigma_y^2}{\sigma_y^2 + h^2 \sigma_z^2 - 2h \sigma_{y,z}}$$

(16)

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

(17)

From equation (14) we have

$$\sigma_{y,z} = \rho \sigma_y \sigma_z$$

(18)

8 The high correlation between the spot rate, on the one hand, and the actual and interest parity forward
rates, on the other, follows from the fact that covered interest parity is a hedging condition that must
hold by necessity. On this issue, see Moosa (2004b, 2004c).
By substituting equation (18) into equation (15), we obtain

\[ h = \frac{\rho \sigma_y \sigma_z}{\sigma_z^2} = \rho \left( \frac{\sigma_y}{\sigma_z} \right) \]  \hspace{1cm} (19)

which shows the relation between the hedge ratio and the correlation coefficient. If \( \sigma_y = \sigma_z \), then \( h = \rho \), and for constant variances, the hedge ratio is proportional to the correlation coefficient. This relation is represented in Figure 1, which shows that the hedge ratio is not generally equal to the correlation coefficient because \( \sigma_y / \sigma_z \neq 1 \).

By combining equations (16) and (19), we obtain

\[ VR = \frac{\sigma_y^2}{\sigma_y^2 + \rho^2 \left( \frac{\sigma_y^2}{\sigma_z^2} \right) \sigma_z^2 - 2 \rho \left( \frac{\sigma_y}{\sigma_z} \right) \rho \sigma_y \sigma_z} \]  \hspace{1cm} (20)

which can be simplified to

\[ VR = \frac{1}{1 - \rho^2} \]  \hspace{1cm} (21)

Hence,

\[ VD = 1 - \frac{1}{VR} = \rho^2 \]  \hspace{1cm} (22)

which shows that variance reduction is equivalent to the coefficient of determination of the regression of \( \Delta s(x/y) \) on \( \Delta s(x/z) \). These relations, which are all quadratic, are represented graphically in Figures 2, 3 and 4. It can be seen that if \( \rho = 0 \), then \( VR = 1 \) and \( VD = 0 \), whereas if \( \rho = 1 \), then \( VR = \infty \) and \( VD = 1 \) (a perfect hedge). This is how crucial correlation is for hedging effectiveness; and this is why money market and forward hedging are far superior to cross hedging.
Conclusion

This study examined the effectiveness of cross-currency hedging compared to that of forward hedging and money market hedging by using the Kuwaiti dinar as a base currency. By using 12 currency combinations, it was found that cross-currency hedging is ineffective except in three cases, all of which involve the U.S. dollar.

This exercise demonstrates how the exchange rate arrangement of a country affects the business operations of firms located in that country and dealing with the rest of the world. The exchange rate arrangement adopted by the Central Bank of Kuwait during the period under study led to the following: (i) low correlations between the Kuwaiti dinar exchange rates as compared to what would be the case under floating exchange rates, and (ii) negative correlations between the exchange rate of the Kuwaiti dinar against the U.S. dollar and those of the dinar against the other currencies. The implications of these observations for Kuwaiti dinar-based firms are the following: (i) cross-currency hedging is ineffective and (ii) negative hedge ratios would arise, implying that (if cross-currency hedging is possible at all) a long position can be hedged by taking a long position on another currency and vice versa.

The results of this study also raises an important policy issue. Since cross-currency hedging is not effective, whereas forward hedging and money market hedging are effective, Kuwaiti dinar-based firms will perform the hedging function much more easily if sophisticated financial markets exist. These firms will benefit if a wide range of derivatives are available for a wide range of currencies, and if credit lines are available in a variety of currencies for a wide range of maturities. Thus, the Central
Bank of Kuwait and other relevant government bodies ought to create environments that are conducive to the development of more sophisticated financial markets.
References


### Table 1: Results for Cross-Currency Hedging

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* Significant at the 5 per cent level.

### Table 2: Results for Forward and Money Market (MM) Hedging

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<td>0.99</td>
<td>0.999</td>
<td>61.40</td>
<td>0.01</td>
<td>6048.89*</td>
<td>99.98</td>
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| MM | | | | | | | | | | | | | | | | | | |
| KWD | USD | 0.99 | 1.010 | 1.48 | 0.01 | 265.55* | 99.62 |
| KWD | JPY | 0.99 | 0.998 | 111.83 | 0.11 | 1027.99* | 99.90 |
| KWD | GBP | 0.99 | 1.002 | 27.94 | 0.01 | 4586.38* | 99.98 |
| KWD | CHF | 0.99 | 0.999 | 61.40 | 0.01 | 5867.04* | 99.98 |

* Significant at the 5 per cent level.
Figure 1: The Hedge Ratio as a Function of Correlation
Figure 2: The Variance Ratio as a Function of Correlation
Figure 3: Variance Reduction as a Function of Correlation
Figure 4: Variance Reduction as a Function of the Variance Ratio