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Measuring the Hedge Ratio: A GCC Perspective

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Abstract

In this paper, we examine the effectiveness of minimising the variance of the hedge ratio using different econometric models for the GCC currencies under money-market hedging and cross-currency hedging. Specifically, we determine whether different model specifications and estimation methods yield different hedge-effectiveness results. In other words, does the sophistication of the model improve the effectiveness of the hedge? Our results show that these econometric models fail either to add value or to improve the effectiveness of the hedge.

Keywords: Gulf Co-operation Council (GCC), risk-minimizing hedge ratio, money-market hedging, cross-currency hedging

1. Introduction

After the collapse of the Bretton Woods system and the introduction of flexible exchange rates in the early 1970s—coupled with the tendency of firms to engage in international business—the need has arisen to pay attention to fluctuations in exchange rates. Exchange-rate volatility affects not only firms that operate in international markets, but also domestic firms that compete with other firms that import goods from abroad, as well as purely domestic firms such as utility providers. In other words, even domestic firms that operate in the local market are affected by currency fluctuations (Adler & Dumas, 1984; Aggarwal & Harper, 2010).

This paper is concerned with the management of foreign-exchange risk from the perspective of a domestic firm operating in a member country of the Gulf Co-operation Council (GCC). This is a bloc of countries in the Middle East that includes Kuwait, Kingdom of Saudi Arabia (KSA), United Arab Emirates (UAE), Bahrain, Qatar, and The Sultanate of Oman. Apart from Kuwait, which pegs its currency to a basket of currencies, all of these countries adopt a fixed exchange-rate regime in which they peg their currencies to the US dollar. While a policy of pegging to the dollar keeps the exchange rate against the dollar stable, the exchange rates against other currencies remain volatile. Since these countries trade more with the European Union, Japan, and China than with the United States, exposure to foreign-exchange risk is a major issue of concern for businesses using one of the GCC currencies as a base currency. Given that these countries also lack sophisticated financial markets, hedging exposure to foreign-exchange risk becomes a rather challenging task.

Researchers have been widely estimating the hedge ratio using the ordinary least squares (OLS) estimation method. However, in the financial-econometrics literature, there are many other estimation methods that can be used to estimate the hedge ratio empirically apart from OLS. In this paper, we examine the effectiveness of minimising the variance of the hedge ratio using different econometric models for the GCC currencies under money-market hedging and cross-currency hedging. The purpose of this paper is to determine whether different model specifications and estimation methods yield different hedge-effectiveness results. In other words, does the sophistication of the model improve the effectiveness of the hedge? Our results show that these econometric models fail either to add value or to improve the effectiveness of the hedge. The results from this paper may be beneficial for the managers of firms engaged in international trade, as well as researchers interested in foreign-exchange risk management. In addition, the results will add value to those agents who employ hedging techniques using the currencies of developing countries that lack sophisticated financial markets. This paper starts with a literature review in Section 2, followed by discussion of the methodology in Section 3, data and empirical results are in Section 4 and the conclusion is in Section 5.

2. Literature Review

Firms that are involved in international-business transactions should always employ the best model to estimate the optimal hedge ratio. A perfect hedge in which the loss (profit) in the unhedged position is completely offset by the profit (loss) in the hedged position may not occur in real-life situations. (Note 1) Therefore, firms will have greater concern about minimising the variance of the rate of return in the hedged position to avoid the adverse effect of exchange-rate changes. The estimation of a minimum-variance hedge ratio depends on the econometric model employed to estimate it (Ghosh, 1993). According to Wang et al. (2015), given that numerous sophisticated estimation methods have been utilised aside from OLS estimation to estimate the hedge ratio, the best estimation method is still unclear. However, Lence (1995), Lien et al. (2002), and Moosa (2011) find that using a simple econometric model to estimate the hedge ratio can provide similar results to those obtained with sophisticated ones. Alexander and Barbosa (2007) find that neither a complex model (such as time-varying conditional covariance), nor the error-correction model (ECM) can outperform the simple OLS model. Copeland and Zhu (2006) and Alexander and Barbosa (2007) also argue that there is no value added when using a sophisticated model to estimate the hedge ratio compared with simple OLS. In fact, according to Moosa (2003a), the success and failure of estimating hedging effectiveness depends on the correlation between the price of the unhedged position and the price of the hedged instrument, not on model specifications.

According to Ederington (1979), the relationship between cash price and future price is represented by a regression model, and a slope coefficient represents the hedge ratio with the objective of minimising the risk of the portfolio (risk-minimising hedge ratio). From a theoretical point of view, this optimal hedge ratio with the objective of minimising the variance of the hedged portfolio is a form of an expected-utility maximisation framework (Johnson, 1960; Ederington, 1979; Myers & Thompson, 1989, Lien & Tse, 2002). This minimum-variance framework is widely used because it is simple to compute and easy to understand (Chen et al., 2003).

The first problem is related to model specification. The conventional OLS model that uses levels or changes in the exchange rates (the unhedged asset such as a spot rate being a dependent variable and the hedged asset such as a forward or futures rate being the independent variable) has been widely used in the literature (Ederington, 1979; Junkus & Lee, 1985; Malliaris & Urrutia, 1991; Benet, 1992). However, the problem arises in determining which of the specifications (price level or price change) is more appropriate than the other to estimate the hedge ratio. For example, Witt et al. (1987) support the price-level model, whereas Hill and Schneeweis (1981) and Wilson (1983) support the price-change (return) model. Ghosh (1993, 1995, 1996) argues that these methods are misspecified, as using a price-level hedge ratio ignores short-term dynamics, whereas using a price-changes (return) hedge ratio ignores long-term relationships. Ghosh added an error-correction term to improve the model, as the first-difference model ignores the long-term relationship implied by the error-correction term. In addition, he argues that the omission of a cointegration relationship between variables (spot and forward rates) represented by the error-correction term produces a smaller hedge ratio than the optimal ratio. Lien (1996) was the first to prove this mathematically by showing that when estimating the hedge ratio using a first-difference model, agents will be under-hedged.

The use of the ECM of Engle and Granger (1987) for estimating the optimal hedge ratio for corn, soybeans, and wheat is found in Myers and Thompson (1989). Moreover, Chou et al. (1996) find that hedging under the ECM model outperforms the conventional model for Nikkei spot and futures indices. In the literature, OLS is criticised as being inappropriate to use in estimating the hedge ratio, due to the serial correlation and heteroskedasticity in the error term arising from the relationship between spot and forward rates (Hill & Schneeweis, 1981; Herbst et al., 1993; Kenourgios et al., 2008).

The second problem that arises in the literature relates to the dynamics of the hedge ratio. It is associated with the view of whether the hedge ratio is constant or changing over time and the question of whether a conditional or unconditional probability distribution (moments) should be used to estimate it. (Note 2) For example, the static hedge ratio based on unconditional moments has been studied by Ederington, (1979), Howard and D'Antonio (1984), Benet (1992), Ghosh (1993, 1995, 1996), and Kolb and Okunev (1992, 1993). Alternatively, a dynamic (changing) hedge ratio based on conditional moments such as the ARCH and GARCH family of models—in which it is assumed that covariance and variance of returns are time-varying—has been studied in Cecchetti et al. (1988), Baillie and Myers (1991), Kroner and Sultan (1993), Sephton (1993), Brooks and Chong (2001), Hatemi-J and Roca (2006), Park and Jei (2010), and Hatemi-J and El-Khatib (2012). However, time-varying models also receive criticism, as they introduce too much noise that affects cost-effective hedges (Copeland & Zhu, 2006; Alexander & Barbosa, 2007).

In this paper, we do not investigate this dynamic aspect of the hedge ratio; instead, the scope is limited to comparing different empirical-model specifications and estimation methods that minimise the variance of the hedge ratio, as in Moosa (2011), who shows that financial-econometrics models used to estimate the hedge ratio fail to add value in improving the effectiveness of the hedge. (Note 3) Therefore, he suggests that a naïve hedge ratio of 1 provides similar results to the sophisticated econometric models. The inferences that Moosa obtains suggest that the dominance of the naïve hedge ratio are consistent with those of Jong et al. (1995), Jong et al. (1997), Grant and Eaker (1989), Maharaj et al. (2008), Alexander et al. (2013), and Wang et al. (2015). (Note 4).

3. Methodology

Money-market hedging is based on the covered interest parity (CIP) condition, which suggests that the difference between the spot and the forward rate is related to the interest-rate differential between two countries. CIP implies that a high-interest currency sells at a forward discount, and a low-interest currency sells at a forward premium. In an efficient market in which transaction costs are absent, the interest-rate differential is equal to the forward spread as equilibrium is achieved in the money market (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 replicated by money-market hedging, given that CIP holds (Khoury & 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 1 summarises the money-market hedging decision for both payables and receivables.

Table 1. 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).

Al-Loughani and Moosa (2000) find that there is no difference between hedging by forward contract and hedging by money-market hedge when they examine whether the CIP holds or not indirectly. They find that the CIP does hold and these two hedging techniques are equivalent to each other, as both of them reduce the variability of the return.

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.

As stated above, we follow Moosa (2011) in estimating the optimal hedge ratio. We use nine different econometric models for comparison. After that, we measure the effectiveness of the hedge ratio by examining the effectiveness of the no-hedge decision against the hedge decision where we test the equality of variances for the returns under each position.

$$H_0: \sigma^2(R_U) = \sigma^2(R_H) \tag{1}$$

$$H_a: \sigma^2(R_U) > \sigma^2(R_H) \tag{2}$$

where $\sigma^2(R_U)$ is the variance rate of the return under the no-hedge decision and $\sigma^2(R_H)$ is the variance of the rate of return under the hedge decision. The test statistic is

$$VR = \frac{\sigma^2(R_U)}{\sigma^2(R_H)} \geq F_\alpha(n-1, n-1) \tag{3}$$

which will be accompanied by the variance reduction

$$VD = 100\left[1 - \frac{\sigma^2(R_H)}{\sigma^2(R_U)}\right] = 100\left[1 - \frac{1}{VR}\right] \tag{4}$$

First-difference model using (OLS)

The conventional hedge ratio under OLS is estimated by

$$\Delta p_{u,t} = \alpha + h\Delta p_{a,t} + \varepsilon_t. \tag{5}$$

This OLS model is called ‘conventional’ as it uses historical data, and the R^2 obtained from the regression represents the effectiveness of the hedge. We use the OLS because of its simplicity, and because it is widely used among researchers. The OLS model can also be estimated using level data instead of first differences as

$$p_{u,t} = \alpha + hp_{a,t} + \varepsilon_t \tag{6}$$

First-difference model using Cochrance-Orcutt method with AR(1)

The Cochrance-Orcutt method overcomes the problem of serial correlation in the residuals—if it existed. This is because if we run a simple OLS estimation and there is serial correlation, our OLS will still provide the unbiased estimator but will not be the best linear unbiased efficient estimator (BLUE) (Brooks, 2014). In addition, the confidence interval and hypothesis testing become misleading, as they will depend on incorrect standard errors estimated from the OLS. This method consists of two iterative steps, which are (i) estimating first-order correlation τ; and (ii) estimating the generalised least squares (GLS) equation using $\hat{\tau}$ (Studenmund, 2011; Hill et al., 2011). Suppose that there is an equation similar to Equation (5). First, we run a regression of lagged errors with AR(1)

$$\varepsilon_t = \tau\varepsilon_{t-1} + u_t \qquad -1 < \tau < 1 \tag{7}$$

Then, the estimated $\hat{\tau}$ from Equation (7) is multiplied by Equation (5) and used in a lagged version of the equation as

$$\hat{\tau}\Delta p_{u,t-1} = \hat{\tau}b_0 + \hat{\tau}h\Delta p_{a,t-1} + \hat{\tau}\varepsilon_{t-1} \tag{8}$$

Subtracting Equation (8) from Equation (5) we get

$$\Delta p_{u,t} - \hat{\tau}\Delta p_{u,t-1} = \alpha(1-\hat{\tau}) + h\left(\Delta p_{a,t} - \hat{\tau}\Delta p_{a,t-1}\right) + u_t \tag{9}$$

or it can be written in this form:

$$\Delta p_{u,t}^* = \alpha^* + h\Delta p_{a,t}^* + u_t^* \tag{10}$$

The use of an autoregressive model means that the dependent variable is related to its lag value. Coffey et al. (2000) use the Cochrance-Orcutt method in estimating the hedge ratio for some grains that are used to feed livestock.

Maximum-likelihood method with an MA (1)

A moving-average process combines both the average of the current period's random error and the previous period's random error (Gujarati, 2003). It is used whenever serial correlation exists. The error process is

$$\varepsilon_t = \theta u_{t-1} + u_t \tag{11}$$

This model suggests that error term follows a first-order moving average, and this process is short-lived with no memory of previous levels.

First-difference model using instrumental variables (IV) with an AR (1)

Instrumental variable (IV) is also used to estimate the hedge ratio. Given that the OLS is based on the assumption that the independent variable and the error term are uncorrelated, this means that the independent variable is exogenous. However, if the covariance between the independent variable and the error term is not equal to zero, the independent variable becomes endogenous. According to Wooldridge (2009), there are three causes for endogeneity (i) omitted variables; (ii) error in the variables; and (iii) measurement error in the independent variable. As a result, OLS becomes unreliable, because the coefficient is biased and inconsistent. To solve this problem, IV is proposed. For example, if we have omitted a variable from the regression model, this omitted variable will definitely affect the error term, and if at the same time this omitted variable is correlated with $\Delta p_{a,t-1}$, OLS will be biased and inconsistent. Under IV, we add a new variable that is uncorrelated with the error term but is correlated with $\Delta p_{a,t-1}$. In this case the IV becomes consistent. The use of IV to estimate the hedge ratio of the returns of securities listed in the NYSE and the ASE was used by Scholes and Williams (1977).

First-difference model using a nonlinear quadratic specification

We also estimate the hedge ratio using a nonlinear regression first-difference model as

$$\Delta p_{u,t} = \alpha + h\Delta p_{a,t} + \gamma\Delta p_{a,t}^2 + \varepsilon_t \tag{12}$$

where we have a linear parameter γ and a squared term of the independent variable $p_{a,t}^2$. Such a model was proposed by Chow et al. (2000) in their study on the AUD, GBP, CAD, DEM, FRF, and JPY to capture the nonlinear relationship between spot and forward exchange rates.

First-difference model using a linear error-correction model (ECM)

Suppose that there is linear combination in the cointegration regression as in Equation (6)

$$p_{u,t} = \alpha + hp_{a,t} + \varepsilon_t$$

that is $p_{u,t}$ and $p_{a,t}$ to be cointegrated $\varepsilon_t \sim I(0)$ (Engle and Granger 1987). In other words, the residuals are stationary and the two series do not diverge too far from each other. (Note 5) This suggests that Equation (8) is misspecified, because there is a long-run or equilibrium relationship between the two variables. Therefore, it would be better to respecify the model using an ECM to take into account short-term dynamics as in

$$\Delta p_{u,t} = \alpha + \sum_{i=1}^{n}\beta_i\Delta p_{u,t-i} + h\Delta p_{a,t} + \sum_{i=1}^{n}\gamma_i\Delta p_{a,t-i} + \theta\varepsilon_{t-1} + \zeta_t \tag{13}$$

where γ_i defines the short-term relationship between $\Delta p_{u,t}$ and $\Delta p_{a,t-i}$; ε_{t-1} is an error-correction term which is the lagged value of the empirical residual of a regression of $p_{u,t}$ on $p_{a,t}$ (which represents the long-term relationship or the cointegrating regression); θ, which is the coefficient on the error-correction term, is a measure of the speed of adjustment to deviations from the long-run equilibrium condition. For a valid ECM, θ must be significantly negative. If ε_{t-1} is positive, this means that $p_{u,t-1}$ is above the equilibrium; it is too high, and it should fall in the next period so that the equilibrium error is corrected. Lien and Luo (1993) use an ECM as in Equation (13) in estimating the hedge ratio for a number of foreign currencies and stock-index futures. In addition, Alexander (1999) uses as ECM as in Equation (13) to estimate the optimal hedge ratio for equity-index tracking and hedging of international-equity portfolios. The ECM was also used by Hatemi-J and Roca (2010) in their study on the US and UK equity markets.

First-difference model using a nonlinear error-correction model (NECM)

We have NECM with A(L) and B(L) which represent lag polynomials.

$$\Delta p_{u,t} = A(L)\Delta p_{u,t-i} + B(L)\Delta p_{a,t} + \sum_{i=1}^{k} \gamma_i \varepsilon_{t-i}^{i} + \zeta_t \tag{14}$$

This model—proposed by Escribano (1978) to model economic variables that have statistical properties differing from classical linear time series properties—was used empirically by Hendry and Eriscon (1991) to analyse the demand for money in the United Kingdom over the period 1878 to 1970. Chow et al. (2000) also used such a model to capture the nonlinear relationship between the spot and forward rates for a number of currencies.

First-difference model using an autoregressive distributed lag ARDL (1,1)

Autoregressive distributed lag (ARDL) uses a lagged value of both the dependent variable and the independent variable. According to Hill et al. (2011), the ARDL has an advantage in that it eliminates serial correlation in the errors. The hedge ratio is estimated using the following model:

$$\Delta p_{u,t} = \sum_{i=1}^{m} \alpha_i \Delta p_{u,t-i} + \sum_{i=0}^{n} \beta_i \Delta p_{a,t-i} + \zeta_t \tag{15}$$

where the hedge ratio is represented by the long-run coefficient β_0. The number of lagged m and n of the model is based on selection criteria such as the Akaike Information Criterion (AIC) and Schwarz Criterion (SC).

First-difference model using an autoregressive distributed lag ARDL (1,1)

Again, the ARDL in Equation (15) is used here, but the hedge ratio is differently calculated using an impact coefficient as

$$h = \frac{\sum_{i=0}^{n} \beta_i}{1-\sum_{i=1}^{m} \alpha_i} \tag{16}$$

This hedge ratio can also be called a long-run hedge ratio.

4. Data and Empirical Results

We use a sample of end-of-the-month data for the spot exchange rate and the one-month forward rate of the Kuwaiti dinar (KWD), Saudi riyal (SAR), Emirati dirham (AED), Bahraini dinar (BHD) and Qatari riyal (QAR) as base currencies against the US dollar (USD), British pound (GBP), Swiss franc (CHF), and Japanese yen (JPY). The data are obtained from Thomson Reuters' DataStream and the International Monetary Fund's International Financial Statistics CD-ROM for the period 1:2000 to 11:2011. We assign x to the base currency, y to the exposure currency and z for a third currency that is a cross-currency. We assume a domestic firm in the GCC with payables of 100 in the foreign currency (exposure currency y). Table 2 summarises the sample data period for each currency, depending on availability (Note 6).

Table 2. Sample data period for each currency against the CHF, GBP, and JPY

Base Currency (x)	Period (End of the Month)	Number of Observations
KWD	1:2000 - 11:2011	143
SAR	1:2000 - 11:2011	143
AED	5:2000 - 11:2011	139
QAR	7:2004 - 11:2011	89
BHD	12:2006 -11:2011	60

For the money-market hedging, the correlation between $\Delta s(x/y)$ and $\Delta \bar{f}(x/y)$ determines the effectiveness of money-market hedging, whereas the correlation between the exposure-currency exchange rate $\Delta s(x/y)$ and the third-currency exchange rate $\Delta s(x/z)$ determines the effectiveness of cross-currency hedging.

Tables 3 to 13 present the results of estimating the hedge ratio using different econometric models for both money-market hedging and cross-currency hedging. They report goodness of fit, t statistic, variance ratio (VR), and variance reduction (VD). (Note 7) Money-market hedging results (in Tables 3 to 7) show that a perfect hedge is obtained for all of the econometric models, as VD is almost equal to 99 percent. The results also show that a hedge ratio of 1 (naïve model) is obtained. (Note 8) Cross-currency hedging results (in Tables 8 to 12) show that different econometric models under cross-currency hedging produce a hedge ratio that is almost the same in each model, but neither close to unity nor significant in several currency combinations. Comparing the hedge ratio with money-market hedging, we notice that currency combinations under cross-currency hedging do not reduce the variance significantly (no perfect hedge). This is attributed either to no relationship or a weak relationship between the exposure-currency exchange rate $\Delta s(x/y)$ and the third-currency exchange rate $\Delta s(x/z)$.

On the other hand, the perfect hedge for all currency combinations achieved under money-market hedging is attributed to the strong relationship between the spot rate and the implicit forward rate. The results suggest that money-market hedging is preferred to cross-currency hedging. In addition, they suggest that the sophistication of the econometric models used to estimate the hedge ratio does not yield any difference compared with the simple OLS model. The results are approximately the same. The rest of the Tables and Figures are included at the end of this paper.

5. Conclusion

In this paper, we examined the effectiveness of different econometric models in minimising the variance of the hedge ratio for the GCC currencies under money-market hedging and cross-currency hedging. The aim of this examination was to determine whether different model specifications and estimation methods yield different effectiveness results. In other words, does the sophistication of the model improve the effectiveness of the hedge? Our results showed that these econometric models fail either to add value or to improve the effectiveness of the hedge. This implies that there is no need for a sophisticated econometric model to estimate the hedge ratio, because what matters is correlation.

Table 3. Money-market hedging—KWD

	x	*y*	R^2	*h*	*t statistic*	VR	VD (%)
OLS							
	KWD	CHF	0.997	1.019*	211.042	71.510*	98.602
	KWD	GBP	0.987	1.056*	103.125	38.608*	97.410
	KWD	JPY	0.987	1.046*	104.663	53.037*	98.115
Cochrance-Orcutt							
	KWD	CHF	0.986	1.005*	101.993	72.468*	98.620
	KWD	GBP	0.977	0.998*	76.500	43.020*	97.676
	KWD	JPY	0.984	1.000*	95.148	60.121*	98.337
MLE							
	KWD	CHF	0.986	1.004*	101.966	72.466*	98.620
	KWD	GBP	0.977	0.998*	76.995	43.026*	97.675
	KWD	JPY	0.984	0.999*	96.521	60.121*	98.336
IV							
	KWD	CHF	0.978	0.910*	14.144	44.038*	97.729
	KWD	GBP	0.949	1.173*	1.173	19.638*	94.908
	KWD	JPY	0.983	1.013*	19.840	59.464*	98.318
Quadratic							
	KWD	CHF	0.986	1.008*	93.720	72.457*	98.620
	KWD	GBP	0.977	1.002*	75.539	43.073*	97.678
	KWD	JPY	0.983	0.999*	90.864	60.122*	98.337
Linear ECM							
	KWD	CHF	0.987	1.008*	102.119	72.465*	98.620
	KWD	GBP	0.979	0.998*	77.860	43.013*	97.675
	KWD	JPY	0.985	1.006*	92.903	59.938*	98.332
Nonlinear ECM							
	KWD	CHF	0.988	1.007*	102.656	72.470*	98.620

	KWD	GBP	0.979	0.996*	77.835	42.973*	97.673
	KWD	JPY	0.985	1.001*	91.025	60.116*	98.337
ARDL							
	KWD	CHF	0.986	1.007*	98.757	72.469*	98.620
	KWD	GBP	0.978	1.001*	76.930	43.067*	97.678
	KWD	JPY	0.984	1.004*	90.540	60.036*	98.334
ARDL (long-run)							
	KWD	CHF	0.986	1.024*	43.385	70.945*	98.590
	KWD	GBP	0.978	1.045*	41.678	40.226*	97.514
	KWD	JPY	0.984	1.034*	42.650	56.134*	98.219

* Significant at the 5% level.

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Notes

Note 1. In principle, it is possible to obtain a perfect hedge if the prices of two positions are perfectly correlated and the optimal hedge ratio (in this case a hedge ratio of 1) is used. In practice firms are not entirely risk averse, in which case they do not use a hedge ratio of 1, which means that the hedge is not perfect.

Note 2. Given that the hedge ratio equals $h = \frac{Cov(R_U, R_A)}{Var(R_A)}$, time-variant or invariant is related to $Cov(R_U, R_A)$ and $Var(R_A)$.

Note 3. We do not compare a static hedge ratio with a dynamic hedge ratio; instead, we examine different techniques for estimating the hedge ratio that range from conventional models to sophisticated ones.

Note 4. Brooks et al. (2006) argue that a naïve hedge ratio of 1 becomes optimal only if we have perfect correlation between spot and futures, and that it is constant over time.

Note 5. If there is a unit root and both series can be cointegrated.

Note 6. We encountered several limitations related to data availability. This problem is normal for researchers working with data for developing countries. For example, Oman is excluded from this study because of inaccurate exchange-rate data and the unavailability of interest rates. In addition, the sample period for each country in this study is not exactly the same because of a lack of interest-rate data for most of the countries at the time of collecting the data.

Note 7. According to Malliaris and Urrutia (1991), the R^2 obtained from the first-difference model can be used for the effectiveness of the hedge, because the R^2 will be equal to the hedge ratio; whereas, Lindahl (1991) shows that the Mean Absolute Difference (MAD) can be used for the effectiveness of the hedge for risk-minimising the portfolio. Moreover, Graff et al. (1997) show that the Root Mean Square Percentage Error (RMSPE) can be used for the effectiveness of the hedge. In this paper, we use R^2, VR, and VD for the effectiveness of the hedge.

Note 8. The naïve model assumes that the hedge ratio is always a negative one. This means taking an amount equal in value to the spot position, but in the opposite position to the financial derivative or asset (long AUD 1 and short AUD 1, or vice versa).

Appendix

Table 4. Money-market hedging—SAR

	x	*y*	R^2	*h*	*t statistic*	VR	VD (%)
OLS							
	SAR	CHF	0.998	1.016*	256.430	145.068	99.311
	SAR	GBP	0.994	1.028*	151.293	101.231	99.012
	SAR	JPY	0.991	1.054*	127.611	99.477	98.995
Cochrance-Orcutt							
	SAR	CHF	0.994	0.994*	148.104	154.284*	99.352
	SAR	GBP	0.991	1.007*	119.764	105.141*	99.049
	SAR	JPY	0.993	1.012*	141.149	123.604*	99.191
MLE							
	SAR	CHF	0.993	0.993*	147.756	154.296*	99.351
	SAR	GBP	0.990	1.007*	120.821	105.144*	99.048
	SAR	JPY	0.992	1.011*	135.675	123.654*	99.191
IV							
	SAR	CHF	0.992	0.951*	27.876	119.543*	99.163
	SAR	GBP	0.991	1.014*	36.071	104.832*	99.046
	SAR	JPY	0.991	1.043*	27.768	108.983*	99.082

Quadratic							
	SAR	CHF	0.994	0.993*	145.976	154.271*	99.352
	SAR	GBP	0.991	1.005*	120.704	105.034*	99.048
	SAR	JPY	0.992	1.010*	130.819	123.684*	99.191
Linear ECM							
	SAR	CHF	0.994	0.998*	146.804	154.131*	99.351
	SAR	GBP	0.991	1.008*	121.452	105.160*	99.049
	SAR	JPY	0.993	1.016*	133.916	123.121*	99.188
Nonlinear ECM							
	SAR	CHF	0.994	0.998*	145.897	154.080*	99.351
	SAR	GBP	0.991	1.008*	120.997	105.160*	99.049
	SAR	JPY	0.993	1.016*	132.871	123.119*	99.188
ARDL							
	SAR	CHF	0.994	0.997*	148.744	154.240*	99.352
	SAR	GBP	0.991	1.009*	118.434	105.162*	99.049
	SAR	JPY	0.993	1.014*	138.986	123.354*	99.189
ARDL (long-run)							
	SAR	CHF	0.994	1.017*	61.623	143.097*	99.301
	SAR	GBP	0.991	1.022*	70.324	103.431*	99.033
	SAR	JPY	0.993	1.044*	39.187	108.018*	99.074

* Significant at the 5% level.

Table 5. Money-market hedging—AED

	x	*y*	R^2	*h*	*t statistic*	VR	VD (%)
OLS							
	AED	CHF	0.998	0.992*	248.258	201.256*	99.503
	AED	GBP	0.988	1.031*	108.371	100.768*	99.008
	AED	JPY	0.993	1.018*	143.840	158.724*	99.370
Cochrance-Orcutt							
	AED	CHF	0.996	0.992*	209.815	200.688*	99.502
	AED	GBP	0.992	1.004*	131.464	100.440*	99.004
	AED	JPY	0.995	1.008*	185.717	166.189*	99.398
MLE							
	AED	CHF	0.995	0.993*	186.950	201.789*	99.504
	AED	GBP	0.991	1.006*	129.906	100.948*	99.009
	AED	JPY	0.994	1.005*	171.785	166.747*	99.400
IV							
	AED	CHF	0.990	0.929*	24.059	101.290*	99.013
	AED	GBP	0.987	1.075*	29.488	78.314*	98.723
	AED	JPY	0.993	0.964*	30.584	136.585*	99.268
Quadratic							
	AED	CHF	0.995	1.000*	163.120	203.205*	99.507
	AED	GBP	0.991	1.014*	121.989	102.386*	99.023
	AED	JPY	0.994	1.000*	149.347	167.504*	99.403
Linear ECM							
	AED	CHF	0.996	0.999*	190.693	203.168*	99.508
	AED	GBP	0.992	1.011*	128.618	101.974*	99.019
	AED	JPY	0.996	1.010*	167.955	165.222*	99.395
Nonlinear ECM							
	AED	CHF	0.997	0.998*	189.857	203.084*	99.508
	AED	GBP	0.992	1.011*	127.600	101.982*	99.019
	AED	JPY	0.996	1.010*	166.626	165.264*	99.395
ARDL							
	AED	CHF	0.996	0.999*	190.026	203.194*	99.508
	AED	GBP	0.992	1.012*	126.035	102.020*	99.020

	AED	JPY	0.996	1.009*	46.338	165.456*	99.396
ARDL (long-run)							
	AED	CHF	0.996	1.036*	46.553	160.827*	99.378
	AED	GBP	0.992	1.049*	50.571	93.948*	98.936
	AED	JPY	0.996	1.036*	43.459	138.533*	99.278

* Significant at the 5% level.

Table 6. Money-market hedging—QAR

	x	*y*	R^2	*h*	*t statistic*	VR	VD (%)
OLS							
	QAR	CHF	0.995	1.038*	135.890	40.069	97.504
	QAR	GBP	0.986	1.092*	79.500	28.747	96.521
	QAR	JPY	0.997	1.049*	168.700	19.140	94.775
Cochrance-Orcutt							
	QAR	CHF	0.978	0.999*	54.745	44.624*	97.759
	QAR	GBP	0.971	1.019*	53.404	33.921*	97.052
	QAR	JPY	0.955	0.979*	42.393	21.666*	95.384
MLE							
	QAR	CHF	0.978	1.004*	56.895	44.296*	97.742
	QAR	GBP	0.970	1.020*	53.945	33.916*	97.051
	QAR	JPY	0.955	0.987*	44.469	21.573*	95.364
IV							
	QAR	CHF	0.973	0.918*	12.845	37.203*	97.312
	QAR	GBP	0.969	0.984*	19.855	32.784*	96.950
	QAR	JPY	0.951	0.993*	10.101	21.477*	95.344
Quadratic							
	QAR	CHF	0.978	0.990*	61.231	44.951*	97.775
	QAR	GBP	0.971	1.011*	52.187	33.873*	97.048
	QAR	JPY	0.955	0.974*	42.690	21.690*	95.390
Linear ECM							
	QAR	CHF	0.980	0.999*	56.631	44.628*	97.759
	QAR	GBP	0.974	1.009*	53.868	33.846*	97.045
	QAR	JPY	0.961	0.984*	45.026	21.612*	95.373
Nonlinear ECM							
	QAR	CHF	0.981	1.005*	56.247	44.281*	97.742
	QAR	GBP	0.975	1.001*	53.455	33.637*	97.027
	QAR	JPY	0.967	0.987*	48.187	21.578*	95.366
ARDL							
	QAR	CHF	0.981	1.002*	57.432	44.487*	97.752
	QAR	GBP	0.972	1.019*	50.944	33.923*	97.052
	QAR	JPY	0.963	0.977*	46.338	21.675*	95.386
ARDL (long-run)							
	QAR	CHF	0.981	1.047*	50.116	38.562*	97.407
	QAR	GBP	0.972	1.057*	43.999	32.346*	96.908
	QAR	JPY	0.963	1.041*	43.459	19.616*	94.902

* Significant at the 5% level.

Table 7. Money-market hedging—BHD

	x	y	R^2	h	t statistic	VR	VD (%)
OLS							
	BHD	CHF	0.998	1.025*	180.410	289.865*	99.655
	BHD	GBP	0.996	1.061*	120.257	79.451*	98.741
	BHD	JPY	0.999	1.002*	222.024	192.74*	98.998
Cochrance-Orcutt							
	BHD	CHF	0.996	1.016*	149.111	293.144*	99.659
	BHD	GBP	0.990	0.999*	70.538	90.174*	98.891
	BHD	JPY	0.992	1.010*	80.126	125.086*	99.201
MLE							
	BHD	CHF	0.996	1.016*	146.640	293.388*	99.659
	BHD	GBP	0.989	1.003*	70.045	90.987*	98.900
	BHD	JPY	0.992	1.010*	80.300	125.091*	99.200
IV							
	BHD	CHF	0.995	0.977*	26.657	197.000*	99.492
	BHD	GBP	0.988	1.049*	31.861	85.360*	98.828
	BHD	JPY	0.991	0.984*	36.293	115.877*	99.137
Quadratic							
	BHD	CHF	0.997	1.019*	127.759	293.791*	99.660
	BHD	GBP	0.990	1.011*	68.572	92.390*	98.918
	BHD	JPY	0.992	1.000*	74.441	123.784*	99.192
Linear ECM							
	BHD	CHF	0.997	1.017*	137.840	293.581*	99.659
	BHD	GBP	0.992	1.000*	74.810	90.257*	98.892
	BHD	JPY	0.993	1.012*	83.084	124.967*	99.200
Nonlinear ECM							
	BHD	CHF	0.998	1.020*	133.879	293.710*	99.660
	BHD	GBP	0.993	0.992*	74.230	87.415*	98.856
	BHD	JPY	0.995	1.021*	94.216	123.070*	99.187
ARDL							
	BHD	CHF	0.997	1.021*	135.127	293.416*	99.659
	BHD	GBP	0.991	1.007*	74.242	91.708*	98.910
	BHD	JPY	0.992	1.011*	81.984	125.051*	99.200
ARDL (long-run)							
	BHD	CHF	0.997	1.060*	48.080	197.765*	99.494
	BHD	GBP	0.991	1.055*	43.083	82.732*	98.791
	BHD	JPY	0.992	1.043*	51.981	110.330*	99.094

* Significant at the 5% level.

Table 8. Cross-currency hedging—KWD

	x	y	z	R^2	h	t statistic	VR	VD (%)
1) OLS								
	KWD	CHF	JPY	0.068	0.291*	3.185	1.072	6.756
	KWD	CHF	GBP	0.099	0.356*	3.931	1.110	9.941
	KWD	GBP	JPY	0.001	-0.020	0.001	1.000	0.000
	KWD	GBP	CHF	0.163	0.324*	3.931	1.190	15.972
	KWD	JPY	CHF	0.068	0.232*	3.185	1.072	6.756
	KWD	JPY	GBP	0.000	0.000	0.001	1.000	0.000
2) Cochrance-Orcutt								
	KWD	CHF	JPY	0.078	0.311*	3.372	1.072	6.725
	KWD	CHF	GBP	0.175	0.512*	5.357	1.194	16.277
	KWD	GBP	JPY	0.005	-0.021	-0.270	1.001	0.051
	KWD	GBP	CHF	0.160	0.321*	5.128	1.194	16.282
	KWD	JPY	CHF	0.078	0.248*	3.383	1.072	6.726

	KWD	JPY	GBP	0.005	-0.038	-0.405	1.000	0.038
3) MLE								
	KWD	CHF	JPY	0.083	0.316*	3.476	1.072	6.708
	KWD	CHF	GBP	0.179	0.514*	5.431	1.194	16.275
	KWD	GBP	JPY	0.004	-0.016	-0.213	1.000	0.049
	KWD	GBP	CHF	0.163	0.324*	5.205	1.194	16.283
	KWD	JPY	CHF	0.078	0.247*	3.371	1.072	6.729
	KWD	JPY	GBP	0.004	-0.031	-0.333	1.000	0.048
4) IV								
	KWD	CHF	JPY	0.063	0.480*	1.313	1.041	3.912
	KWD	CHF	GBP	0.151	0.515*	1.404	1.194	16.274
	KWD	GBP	JPY	0.000	-0.029	-0.137	1.000	0.042
	KWD	GBP	CHF	0.139	0.254*	1.384	1.184	15.536
	KWD	JPY	CHF	0.078	0.206*	0.678	1.071	6.671
	KWD	JPY	GBP	0.001	-0.023	-0.333	1.001	0.051
5) Quadratic								
	KWD	CHF	JPY	0.075	0.283*	3.082	1.072	6.751
	KWD	CHF	GBP	0.177	0.533*	5.443	1.194	16.224
	KWD	GBP	JPY	0.024	-0.008	-0.109	1.000	0.033
	KWD	GBP	CHF	0.234	0.401*	6.328	1.181	15.359
	KWD	JPY	CHF	0.117	0.160*	2.119	1.065	6.111
	KWD	JPY	GBP	0.033	0.016	0.172	0.999	-0.088
6) Linear ECM								
	KWD	CHF	JPY	0.100	0.325*	3.509	1.071	6.664
	KWD	CHF	GBP	0.179	0.521*	5.295	1.194	16.263
	KWD	GBP	JPY	0.021	-0.029	-0.373	1.000	0.042
	KWD	GBP	CHF	0.196	0.326*	5.234	1.194	16.282
	KWD	JPY	CHF	0.107	0.249*	3.415	1.072	6.721
	KWD	JPY	GBP	0.019	-0.028	-0.290	1.001	0.051
7) Nonlinear ECM								
	KWD	CHF	JPY	0.121	0.315*	3.409	1.072	6.710
	KWD	CHF	GBP	0.185	0.515*	5.211	1.194	16.273
	KWD	GBP	JPY	0.028	-0.031	-0.404	1.000	0.036
	KWD	GBP	CHF	0.223	0.318*	5.140	1.194	16.277
	KWD	JPY	CHF	0.122	0.243*	3.330	1.072	6.742
	KWD	JPY	GBP	0.019	-0.028	-0.293	1.001	0.050
8) ARDL(1,1)								
	KWD	CHF	JPY	0.089	0.301*	3.112	1.072	6.748
	KWD	CHF	GBP	0.201	0.535*	5.512	1.194	16.218
	KWD	GBP	JPY	0.007	-0.014	-0.172	1.000	0.046
	KWD	GBP	CHF	0.206	0.343*	5.512	1.194	16.222
	KWD	JPY	CHF	0.146	0.222*	3.112	1.072	6.744
	KWD	JPY	GBP	0.057	-0.016	-0.172	1.000	0.044
9) ARDL(1,1) long-run								
	KWD	CHF	JPY	0.089	0.462*	3.415	1.047	4.448
	KWD	CHF	GBP	0.201	0.264*	1.886	1.144	12.614
	KWD	GBP	JPY	0.007	-0.009	-0.059	1.000	0.036
	KWD	GBP	CHF	0.206	0.584*	4.326	1.061	5.713
	KWD	JPY	CHF	0.146	0.159*	1.121	1.065	6.088
	KWD	JPY	GBP	0.057	-0.336	-2.133	1.078	7.204

* Significant at the 5% level.

Table 9. Cross-currency hedging—SAR

	x	*y*	*z*	R^2	*h*	*t statistic*	VR	VD (%)
1) OLS								
	SAR	CHF	JPY	0.118	0.435*	4.320	1.133	11.761
	SAR	CHF	GBP	0.280	0.675*	7.386	1.390	28.041
	SAR	GBP	JPY	0.007	0.082	0.987	1.007	0.691
	SAR	GBP	CHF	0.280	0.415*	7.386	1.380	28.041
	SAR	JPY	CHF	0.118	0.270*	4.320	1.133	11.761
	SAR	JPY	GBP	0.007	0.083	0.987	1.007	0.691
2) Cochrance-Orcutt								
	SAR	CHF	JPY	0.137	0.464*	4.611	1.133	11.710
	SAR	CHF	GBP	0.294	0.673*	7.444	1.390	28.040
	SAR	GBP	JPY	0.017	0.077	0.921	1.007	0.687
	SAR	GBP	CHF	0.280	0.407*	7.215	1.389	28.030
	SAR	JPY	CHF	0.122	0.281*	4.469	1.133	11.741
	SAR	JPY	GBP	0.006	0.075	0.885	1.007	0.684
3) MLE								
	SAR	CHF	JPY	0.142	0.466*	4.733	1.133	11.701
	SAR	CHF	GBP	0.297	0.668*	7.530	1.390	28.038
	SAR	GBP	JPY	0.017	0.083	0.995	1.007	0.691
	SAR	GBP	CHF	0.281	0.410*	7.287	1.390	28.037
	SAR	JPY	CHF	0.123	0.283*	4.485	1.133	11.736
	SAR	JPY	GBP	0.007	0.083	0.979	1.007	0.691
4) IV								
	SAR	CHF	JPY	0.095	0.652*	1.499	1.097	8.856
	SAR	CHF	GBP	0.285	0.668*	2.438	1.390	28.037
	SAR	GBP	JPY	0.005	0.072	0.341	1.007	0.678
	SAR	GBP	CHF	0.287	0.425*	2.327	1.389	28.025
	SAR	JPY	CHF	0.045	0.477*	0.942	1.051	4.848
	SAR	JPY	GBP	0.001	0.138	0.594	1.004	0.400
5) Quadratic								
	SAR	CHF	JPY	0.130	0.443*	4.402	1.133	11.757
	SAR	CHF	GBP	0.313	0.728*	7.910	1.386	27.870
	SAR	GBP	JPY	0.017	0.077	0.923	1.007	0.688
	SAR	GBP	CHF	0.312	0.439*	7.848	1.388	27.949
	SAR	JPY	CHF	0.162	0.242*	3.902	1.132	11.633
	SAR	JPY	GBP	0.052	0.133	1.558	1.005	0.451
6) Linear ECM								
	SAR	CHF	JPY	0.157	0.487*	4.752	1.131	11.595
	SAR	CHF	GBP	0.321	0.725*	7.838	1.387	27.892
	SAR	GBP	JPY	0.037	0.082	0.977	1.007	0.691
	SAR	GBP	CHF	0.344	0.428*	7.824	1.389	28.013
	SAR	JPY	CHF	0.164	0.285*	4.606	1.133	11.724
	SAR	JPY	GBP	0.007	0.080	0.922	1.007	0.689
7) Nonlinear ECM								
	SAR	CHF	JPY	0.165	0.489*	4.742	1.131	11.584
	SAR	CHF	GBP	0.331	0.720*	7.777	1.387	27.920
	SAR	GBP	JPY	0.042	0.092	1.081	1.007	0.682
	SAR	GBP	CHF	0.388	0.445*	8.288	1.387	27.896
	SAR	JPY	CHF	0.176	0.288*	4.651	1.133	11.709
	SAR	JPY	GBP	0.013	0.078	0.897	1.007	0.688
8) ARDL(1,1)								
	SAR	CHF	JPY	0.144	0.449*	4.302	1.133	11.749
	SAR	CHF	GBP	0.308	0.738*	7.812	1.385	27.798
	SAR	GBP	JPY	0.025	0.086	0.999	1.007	0.690
	SAR	GBP	CHF	0.353	0.422*	7.812	1.390	28.034

	SAR	JPY	CHF	0.159	0.269*	4.302	1.133	11.760
	SAR	JPY	GBP	0.028	0.085	0.999	1.007	0.690
9) ARDL(1,1) long-run								
	SAR	CHF	JPY	0.144	0.608*	4.392	1.110	9.901
	SAR	CHF	GBP	0.308	0.444*	3.332	1.329	24.761
	SAR	GBP	JPY	0.025	0.081	0.460	1.007	0.690
	SAR	GBP	CHF	0.353	0.669*	5.057	1.213	17.587
	SAR	JPY	CHF	0.159	0.320*	2.734	1.128	11.361
	SAR	JPY	GBP	0.028	-0.070	-0.466	1.016	1.607

* Significant at the 5% level.

Table 10. Cross-currency hedging—AED

	x	*y*	*z*	R^2	*h*	*t statistic*	VR	VD (%)
1) OLS								
	AED	CHF	JPY	0.120	0.440*	4.310	1.137	12.021
	AED	CHF	GBP	0.287	0.690*	7.394	1.402	28.677
	AED	GBP	JPY	0.006	0.076	0.912	1.006	0.608
	AED	GBP	CHF	0.287	0.415*	7.394	1.402	28.677
	AED	JPY	CHF	0.120	0.273*	4.311	1.137	12.021
	AED	JPY	GBP	0.006	0.079	0.912	1.006	0.608
2) Cochrance-Orcutt								
	AED	CHF	JPY	0.143	0.469*	4.656	1.136	11.970
	AED	CHF	GBP	0.303	0.684*	7.511	1.402	28.674
	AED	GBP	JPY	0.019	0.076	0.911	1.006	0.608
	AED	GBP	CHF	0.287	0.409*	7.231	1.402	28.670
	AED	JPY	CHF	0.126	0.288*	4.477	1.136	11.987
	AED	JPY	GBP	0.006	0.078	0.897	1.006	0.607
3) MLE								
	AED	CHF	JPY	0.145	0.472*	4.741	1.136	11.959
	AED	CHF	GBP	0.304	0.682*	7.564	1.402	28.673
	AED	GBP	JPY	0.018	0.075	0.902	1.006	0.607
	AED	GBP	CHF	0.288	0.410*	7.295	1.402	28.672
	AED	JPY	CHF	0.125	0.285*	4.457	1.136	11.999
	AED	JPY	GBP	0.006	0.079	0.908	1.006	0.608
4) IV								
	AED	CHF	JPY	0.150	0.516*	1.286	1.132	11.664
	AED	CHF	GBP	0.267	0.765*	2.812	1.396	28.348
	AED	GBP	JPY	0.001	0.024	0.130	1.003	0.323
	AED	GBP	CHF	0.279	0.410*	1.994	1.402	28.673
	AED	JPY	CHF	0.137	0.398*	1.135	1.105	9.513
	AED	JPY	GBP	0.004	0.169	0.685	1.001	[0.169]
5) Quadratic								
	AED	CHF	JPY	0.130	0.448*	4.390	1.137	12.017
	AED	CHF	GBP	0.318	0.739*	7.881	1.399	28.537
	AED	GBP	JPY	0.024	0.069	0.818	1.006	0.601
	AED	GBP	CHF	0.322	0.440*	7.888	1.400	28.577
	AED	JPY	CHF	0.163	0.245*	3.902	1.135	11.898
	AED	JPY	GBP	0.052	0.125	1.441	1.004	0.401
6) Linear ECM								
	AED	CHF	JPY	0.168	0.502*	4.872	1.134	11.782
	AED	CHF	GBP	0.325	0.735*	7.823	1.400	28.557
	AED	GBP	JPY	0.041	0.082	0.982	1.006	0.604
	AED	GBP	CHF	0.348	0.430*	7.815	1.401	28.639
	AED	JPY	CHF	0.178	0.295*	4.689	1.136	11.946

	AED	JPY	GBP	0.006	0.082	0.918	1.006	0.607
7) Nonlinear ECM								
	AED	CHF	JPY	0.174	0.500*	4.799	1.134	11.796
	AED	CHF	GBP	0.335	0.730*	7.752	1.400	28.583
	AED	GBP	JPY	0.044	0.090	1.055	1.006	0.590
	AED	GBP	CHF	0.392	0.447*	8.276	1.399	28.513
	AED	JPY	CHF	0.196	0.295*	4.716	1.136	11.941
	AED	JPY	GBP	0.014	0.080	0.887	1.006	0.608
8) ARDL(1,1)								
	AED	CHF	JPY	0.142	0.449*	4.280	1.137	12.016
	AED	CHF	GBP	0.313	0.749*	7.832	1.398	28.475
	AED	GBP	JPY	0.026	0.087	1.001	1.006	0.598
	AED	GBP	CHF	0.357	0.426*	7.832	1.402	28.658
	AED	JPY	CHF	0.157	0.273*	4.280	1.137	12.021
	AED	JPY	GBP	0.031	0.088	1.001	1.006	0.601
9) ARDL(1,1) long-run								
	AED	CHF	JPY	0.142	0.611*	4.362	1.114	10.204
	AED	CHF	GBP	0.313	0.463*	3.402	1.343	25.555
	AED	GBP	JPY	0.026	0.097	0.547	1.006	0.564
	AED	GBP	CHF	0.357	0.660*	5.015	1.230	18.725
	AED	JPY	CHF	0.157	0.336*	2.876	1.129	11.389
	AED	JPY	GBP	0.031	-0.079	-0.517	1.018	1.779

* Significant at the 5% level, [ ] inverted.

Table 11. Cross-currency hedging—QAR

	x	*y*	*z*	R^2	*h*	*t statistic*	VR	VD (%)
1) OLS								
	QAR	CHF	JPY	0.129	0.495*	3.568	1.148	12.895
	QAR	CHF	GBP	0.232	0.622*	5.102	1.303	23.241
	QAR	GBP	JPY	0.001	0.035	0.301	1.001	0.105
	QAR	GBP	CHF	0.232	0.373*	5.102	1.303	23.241
	QAR	JPY	CHF	0.119	0.071*	3.412	1.135	11.925
	QAR	JPY	GBP	0.001	0.030	0.301	1.001	0.105
2) Cochrance-Orcutt								
	QAR	CHF	JPY	0.163	0.521*	3.813	1.148	12.860
	QAR	CHF	GBP	0.264	0.611*	5.288	1.303	23.233
	QAR	GBP	JPY	0.033	0.079	0.698	1.000	[0.059]
	QAR	GBP	CHF	0.243	0.353*	4.913	1.302	23.174
	QAR	JPY	CHF	0.135	0.271*	3.652	1.148	12.876
	QAR	JPY	GBP	0.001	0.029	0.285	1.001	0.105
3) MLE								
	QAR	CHF	JPY	0.164	0.515*	3.832	1.148	12.874
	QAR	CHF	GBP	0.264	0.601*	5.315	1.302	23.214
	QAR	GBP	JPY	0.026	0.066	0.584	1.000	0.021
	QAR	GBP	CHF	0.239	0.358*	4.960	1.302	23.203
	QAR	JPY	CHF	0.134	0.270*	3.648	1.148	12.880
	QAR	JPY	GBP	0.001	0.027	0.268	1.001	0.104
4) IV								
	QAR	CHF	JPY	0.123	0.439*	0.809	1.146	12.734
	QAR	CHF	GBP	0.205	0.700*	2.417	1.297	22.876
	QAR	GBP	JPY	0.001	0.027	0.148	1.001	0.101
	QAR	GBP	CHF	0.230	0.362*	1.463	1.302	23.218
	QAR	JPY	CHF	0.111	0.284*	1.002	1.147	12.788
	QAR	JPY	GBP	0.001	0.024	0.148	1.001	0.100

5) Quadratic								
	QAR	CHF	JPY	0.142	0.496*	3.579	1.148	12.895
	QAR	CHF	GBP	0.252	0.682*	5.355	1.299	23.030
	QAR	GBP	JPY	0.047	0.034	0.298	1.001	0.105
	QAR	GBP	CHF	0.294	0.392*	5.521	1.302	23.186
	QAR	JPY	CHF	0.190	0.244*	3.425	1.147	12.841
	QAR	JPY	GBP	0.053	0.100	0.957	1.004	[0.436]
6) Linear ECM								
	QAR	CHF	JPY	0.221	0.554*	4.070	1.146	12.714
	QAR	CHF	GBP	0.289	0.669*	5.338	1.301	23.109
	QAR	GBP	JPY	0.093	0.046	0.402	1.001	0.095
	QAR	GBP	CHF	0.317	0.386*	5.360	1.302	23.213
	QAR	JPY	CHF	0.180	0.297*	3.996	1.145	12.638
	QAR	JPY	GBP	0.019	0.046	0.432	1.001	0.078
7) Nonlinear ECM								
	QAR	CHF	JPY	0.285	0.565*	4.272	1.145	12.638
	QAR	CHF	GBP	0.335	0.641*	5.192	1.302	23.219
	QAR	GBP	JPY	0.107	0.049	0.431	1.001	0.087
	QAR	GBP	CHF	0.328	0.390*	5.359	1.302	23.194
	QAR	JPY	CHF	0.211	0.326*	4.306	1.137	12.075
	QAR	JPY	GBP	0.024	0.056	0.517	1.000	0.028
8) ARDL(1,1)								
	QAR	CHF	JPY	0.174	0.515*	3.616	1.148	12.874
	QAR	CHF	GBP	0.285	0.698*	5.574	1.297	22.900
	QAR	GBP	JPY	0.060	0.078	0.671	1.000	[0.061]
	QAR	GBP	CHF	0.321	0.397*	5.574	1.301	23.145
	QAR	JPY	CHF	0.173	0.270*	3.616	1.148	12.879
	QAR	JPY	GBP	0.029	0.071	0.671	1.000	[0.078]
9) ARDL(1,1) long-run								
	QAR	CHF	JPY	0.174	0.608*	3.314	1.139	12.217
	QAR	CHF	GBP	0.285	0.374*	2.426	1.243	19.553
	QAR	GBP	JPY	0.060	-0.109	-0.404	1.017	1.670
	QAR	GBP	CHF	0.321	0.727*	3.568	1.024	2.380
	QAR	JPY	CHF	0.173	0.302*	1.951	1.144	12.569
	QAR	JPY	GBP	0.029	-0.195	-1.145	1.057	5.369

* Significant at the 5% level, [ ] inverted.

Table 12. Cross-currency hedging—BHD

	x	*y*	*z*	R^2	*h*	*t statistic*	VR	VD (%)
1) OLS								
	BHD	CHF	JPY	0.053	0.436*	1.777	1.110	5.252
	BHD	CHF	GBP	0.160	0.530*	3.291	1.190	15.970
	BHD	GBP	JPY	0.039	-0.120	-1.515	1.010	3.874
	BHD	GBP	CHF	0.160	0.300*	3.291	1.190	15.970
	BHD	JPY	CHF	0.053	0.135*	1.777	1.055	5.252
	BHD	JPY	GBP	0.039	-0.154	-1.515	1.040	3.874
2) Cochrance-Orcutt								
	BHD	CHF	JPY	0.084	0.362*	1.716	1.055	5.229
	BHD	CHF	GBP	0.216	0.527*	3.587	1.190	15.968
	BHD	GBP	JPY	0.073	-0.215	-1.262	1.039	3.799
	BHD	GBP	CHF	0.182	0.270*	3.052	1.188	15.801
	BHD	JPY	CHF	0.072	0.116*	1.598	1.054	5.147
	BHD	JPY	GBP	0.058	-0.136	-1.314	1.040	3.820
3) MLE								
	BHD	CHF	JPY	0.093	0.378*	1.854	1.055	5.249

	BHD	CHF	GBP	0.221	0.517*	3.724	1.190	15.958
	BHD	GBP	JPY	0.067	-0.225	-1.353	1.040	3.834
	BHD	GBP	CHF	0.174	0.276*	3.096	1.188	15.859
	BHD	JPY	CHF	0.074	0.128*	1.730	1.055	5.235
	BHD	JPY	GBP	0.056	-0.143	-1.372	1.040	3.853
4) IV								
	BHD	CHF	JPY	0.048	0.399*	0.939	1.055	5.247
	BHD	CHF	GBP	0.150	0.687*	2.026	1.171	14.591
	BHD	GBP	JPY	0.035	-0.290	-0.705	1.039	3.776
	BHD	GBP	CHF	0.158	0.348*	1.555	1.184	15.572
	BHD	JPY	CHF	0.044	0.177*	1.004	1.050	4.751
	BHD	JPY	GBP	0.048	-0.168	-0.989	1.040	3.846
5) Quadratic								
	BHD	CHF	JPY	0.071	0.245*	0.955	1.048	4.542
	BHD	CHF	GBP	0.171	0.588*	3.370	1.187	15.782
	BHD	GBP	JPY	0.117	-0.029	-0.155	1.009	0.852
	BHD	GBP	CHF	0.231	0.316*	3.570	1.189	15.930
	BHD	JPY	CHF	0.104	0.126*	1.672	1.055	5.223
	BHD	JPY	GBP	0.092	-0.080	-0.743	1.031	2.979
6) Linear ECM								
	BHD	CHF	JPY	0.170	0.473*	2.160	1.045	4.289
	BHD	CHF	GBP	0.256	0.590*	3.600	1.187	15.771
	BHD	GBP	JPY	0.127	-0.234	-1.384	1.040	3.858
	BHD	GBP	CHF	0.286	0.329*	3.660	1.188	15.832
	BHD	JPY	CHF	0.134	0.171*	2.205	1.052	4.900
	BHD	JPY	GBP	0.080	-0.148	-1.401	1.040	3.867
7) Nonlinear ECM								
	BHD	CHF	JPY	0.216	0.515*	2.354	1.049	4.682
	BHD	CHF	GBP	0.329	0.537*	3.348	1.190	15.968
	BHD	GBP	JPY	0.224	-0.221	-1.330	1.040	3.820
	BHD	GBP	CHF	0.303	0.321*	3.534	1.189	15.897
	BHD	JPY	CHF	0.170	0.197*	2.486	1.044	4.188
	BHD	JPY	GBP	0.081	-0.140	-1.235	1.040	3.841
8) ARDL(1,1)								
	BHD	CHF	JPY	0.119	0.446*	2.005	1.054	5.132
	BHD	CHF	GBP	0.207	0.609*	3.563	1.185	15.624
	BHD	GBP	JPY	0.102	-0.186	-1.081	1.038	3.621
	BHD	GBP	CHF	0.267	0.322*	3.563	1.189	15.889
	BHD	JPY	CHF	0.066	0.161*	2.005	1.053	5.068
	BHD	JPY	GBP	0.044	-0.118	-1.081	1.038	3.657
9) ARDL(1,1) long-run								
	BHD	CHF	JPY	0.119	0.460*	1.938	1.053	5.069
	BHD	CHF	GBP	0.207	0.308*	1.627	1.152	13.158
	BHD	GBP	JPY	0.102	-0.452	-1.377	1.014	1.373
	BHD	GBP	CHF	0.267	0.690*	2.382	1.107	9.655
	BHD	JPY	CHF	0.066	0.375*	1.763	1.111	10.006
	BHD	JPY	GBP	0.044	-0.332	-1.628	1.012	1.175

* Significant at the 5% level.