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RISK SHARING PARAMETER IN OPERATIONAL CURRENCY HEDGING

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Abstract: Operational hedging techniques such as risk sharing, currency collars, and a hybrid arrangement can be used when transactions are subject to unexpected changes in the nominal exchange rate. These hedging devices utilise a risk sharing parameter and the market exchange rate of a currency pair. Negotiation over the former would be more straightforward if an exogenous threshold risk sharing parameter existed. This paper proposes a tool to measure a risk sharing parameter that based on the generalized autoregressive conditionally heteroskedastic model, might be acceptable to both exporters and importers. The method might be particularly effective in cases where both invoicing and settlement currency are highly volatile.
Keywords: Foreign Exchange Risk, Currency Collars, Risk Sharing Arrangements, GARCH Model

Introduction

Exchange rate fluctuations in multinational business activities affect cash flows and firm values through economic, transaction, and translation exposure of currency risk. [1] Uncertain foreign currency cash flows can be hedged by taking an opposite position to the spot position on forwards, futures, and options, or by money-market hedging (Pantzalis et al., 2001). A combination of currency futures and options can also be used for hedging transaction exposure, in addition to the most frequently used forward contracts (Hommel, 2003, Moosa, 2004; Capstaff and Marshall, 2005; Davies et al., 2006).[2]

However, in some cases, small-sized exporters and importers do not often have in-house expertise to use financial derivatives. In other cases, currency derivatives may not be available for currencies with rudimentary financial derivatives markets. In such circumstances, firms may resort to operational hedging, as opposed to financial hedging in departing from international trade contracts.

The operational hedging techniques of 'risk sharing', 'currency collar', and 'hybrid arrangement' are discussed in McDonald and Moosa (2003), Lien and Moosa (2004), and Moosa, (2006). Under a 'risk sharing' arrangement, the benefit or loss accruing to one party of a transaction as a result of a change in exchange rate of the base currency used for invoicing is shared between the two contractual parties. A 'currency collar', on the other hand, sets a minimum value for the base currency value of cash flows at the expense of setting a maximum value. Both risk sharing and currency collar involve a risk-sharing parameter (θ). In the case of risk sharing, the parameter (θ) is a measure of the range in which cash flows are converted at a fixed exchange rate; in the case of a currency collar, the conversion is at the market rate. A hybrid technique suggested by Moosa (2006) minimises variations in the outcomes.

The fundamental difficulties in reaching an agreement in operational hedging are the different degrees of risk tolerance between two parties, exporter and importer, although a base rate can be easily determined as a fair value of the exchange rate such as the mean or a PPP based rate. If exchange rates follow a random walk, exporter and importer will be exposed to the same risk, and the negotiation would address the value of the risk sharing parameter. In this paper, an estimation of risk sharing parameters rather than arbitrary settings is proposed. The estimate as a threshold risk sharing parameter is the risk factor from the Generalized Autoregressive Conditional Heteroskedasticity in mean

[1] The three standard forms of currency exposure are: (i) economic exposure, which depends on both the value of receivables and the effect of foreign exchange rate movements on future sales; (ii) transaction exposure, which results from the variation in the spot exchange rate of the base currency value of foreign currency cash flows which are incurred prior to a change in the exchange rate but are not due to be settled until after the exchange rate change; and (iii) translation exposure, which arises when fluctuations in foreign exchange values affect the translation of the accounts of foreign subsidiaries into the currency of their parent company. In relationship to foreign exchange exposure, Miller and Reuer (1998) used multiple exchange rates to examine foreign direct investment and its impact on economic exposure to foreign exchange rate movements. Choi and Prasad (1995) investigated the sensitivity of firm valuation to exchange rates, and found that 60% of U.S. multinational firms benefited from the depreciation of the dollar. Jorion (1990) examined the cross-section variation in exposure. Of course, the size and magnitude of the exposure depends on the nature of a firm's firm-specific factors—its involvement in foreign operations and the currency denomination of its competition, for example.

[2] For example, financial hedging with financial futures and options were extensively discussed in Sakong et al. (1993), Lence et al (1994), Giddy and Dufey (1995), Moschini and Lapan (1995), Broll and Wahl (1998), De Iorio and Faff (2000), Broll et all (2001), and Chang and Wong (2003) among others.

(GARCH-M) method that can be shared by both parties is based on the realised volatility of a currency pair, which therefore would be more persuasive and fair in reaching an agreement for international trade contracts.
The numerical results indicate that replacing an arbitrary risk-sharing parameter with an estimate would be particularly beneficial when the volatility of the currency pair is highly sensitive to the outcome. In such a case, both exporter and importer would have similar degrees of risk tolerance on the volatility, the risk factor, to the return of the currency pair. The estimate also links the risk-sharing parameter and the volatility of market rates of foreign exchange in which the latter is non-negotiable, although the outcome under any form of operational hedging depends on the market rate.
In the following section, the hedging models and method of estimating the risk-sharing parameter are described. The theoretical results using daily exchange rate between home currencies and the invoicing currency, the U.S. dollar base, over the period January 2000-December 2008 are reported in section 3. Section 4 concludes.

Model and Methodology

It has been shown that contractual risk sharing and currency collars can be as effective as forward hedging in reducing transaction exposure to foreign exchange risk (McDonald and Moosa, 2003; Lien and Moosa, 2004). The effectiveness of these techniques depends on certain parameters, namely the risk sharing threshold parameter and the upper and lower limits of exchange rate.
We consider three hedging models: risk sharing, currency collar and Moosa's (2006) hybrid model. These are described in equations 1, 2, and 3 respectively. Only the importer is exposed to foreign exchange risk from volatility in the spot rate (S_t), where t denotes the time period. A risk averse importer would demand a higher value for the risk sharing parameter (θ: 0<θ<1) with risk sharing arrangement in contrast the importer would be preferred a low value of θ if the proportion of risk would be shifted from the importer to the exporter.
The outcome of a risk-sharing arrangement is written in (1) in terms of the x-currency value of the cash flow ($V_x = K\bar{S}_t$ where K ($=V_y$)) paid by the importer at time *t*. If S_t moves outside the upper or lower limit, the V_x would converted at a rate that is equal to the base fixed rate ($\bar{S}$) less at least half of the difference between the limit and S_t. Hence V_x is given by $K\bar{S}_t$, if $\bar{S}(1-\theta) < S_t < \bar{S}(1+\theta)$.

$$\left\{ \begin{array}{l} V_x = \frac{K}{2}[\bar{S}(1+\theta) + S_t], \\ if\ S_t < \bar{S}(1-\theta); \\ V_x = \frac{K}{2}[\bar{S}(1-\theta) + S_t], \\ if\ S_t > \bar{S}(1+\theta). \end{array} \right\} \quad (1)$$

Equation (2) shows the outcome of a currency collar in terms of the x-currency value of the cash flow paid by the importer at time *t*. When S_t rises or falls above or below the limits, the conversion rate is the lower or upper limit and accordingly the minimum value or the maximum value of V_x is obtained. The V_x term is thus given by KS_t if $S(1-\theta) < S_t < S(1+\theta)$.

$$\left\{ \begin{array}{l} V_x = K\bar{S}(1-\theta), \\ if\ \ S_t < \bar{S}(1-\theta); \\ V_x = K\bar{S}(1+\theta), \\ if\ \ S_t > \bar{S}(1+\theta). \end{array} \right\} \quad (2)$$

Equations (1) and (2) indicate that a change in the value of θ has the opposite effect on the stability of V_x in the case of a risk sharing arrangement to that under a currency collar. The sensitivity of V_x to changes in θ can be reduced by assigning the weights to risk sharing (β) and currency collars (1-β). This is the basis of the hybrid arrangement proposed by Moosa (2006). In equation (3), the outcome of the cash flow paid by the importer at time *t* where $\beta K\bar{S} + (1-\beta)KS_t$, if $\bar{S}(1-\theta) < S_t < \bar{S}(1-\theta)$ is given by:

$$\left\{ \begin{array}{l} V_x = \frac{\beta K}{2}[\bar{S}(1+\theta) + S_t] \\ \qquad + (1-\beta)K[\bar{S}(1-\theta)], \\ \qquad if\ \ S_t < \bar{S}(1-\theta); \\ V_x = \frac{\beta K}{2}[\bar{S}(1-\theta) + S_t] \\ \qquad + (1-\beta)K[\bar{S}(1+\theta)], \\ \qquad if\ \ S_t > \bar{S}(1+\theta). \end{array} \right\} \quad (3)$$

The weights are implicitly given by the condition $\partial V_x / \partial\theta = 0$. In the range $S_t < \bar{S}(1-\theta)$, $\partial V_x / \partial\theta$ = $\beta K\bar{S}/2 - (1-\beta)K\bar{S}$ which yields β =2/3. Substituting this β value in (3) for the range $S_t < \bar{S}(1-\theta)$ gives V_x = $K/3(2\bar{S} + S_t)$. As Moosa demonstrated, the hybrid arrangement circumvents the problem of negotiating the value of θ. Using the hybrid arrangement as in (3) with agreed weights of two third in the risk sharing arrangement and one third in the currency collar, then the outcome would be $\partial V_x / \partial \theta = 0$. The assignment of the weight from the two hedging arrangements to the hybrid model is still, however, dependent on the relative bargaining strength of the two parties.

Instead of applying the weights from the two hedging arrangements to the hybrid model, a more direct method would be to estimate a risk sharing parameter using the generalized autoregressive conditionally heteroskedastic in the mean (GARCH-M) model. The outcome ∂V_x depends not only on the value of θ but also on the value of S_t which is the non-negotiable spot market rate and both parties (importer and exporter) would seek to limit exposure to the volatility of S_t and the volatility (risk factor) of the return on S_t. The GARCH-M model generates efficient estimators of the risk and return of S_t by allowing risk to vary over time in the conditional mean. By replacing the risk sharing parameter θ with the risk factor parameter for S_t the risk factor parameter at time *t* in the mean equation (4) can be used rather than the time-invariant component of risk in the conditional variance term in (5).

Allowing the conditional mean to depend on its own conditional variance which may enter the conditional mean function as specified in (4) which can capture risk by using the standard deviation of the series in the mean equation:

$$S_t = a + \phi S_{t-1} + \theta\sqrt{h_t} + \varepsilon_t \quad (4)$$

$$h_t = \gamma_0 + \sum_{i=1}^{p} \delta_i h_{t-i} + \sum_{j=1}^{q} \gamma_j \varepsilon_{t-j}^2 \quad (5)$$

where S_t is the log differenced daily bivariate exchange rate (x) against the invoicing currency (y) at time *t*. The term $\theta\sqrt{h_t}$ measures the risk factor at time *t*. The innovation ε_t at time *t* is assumed to be serially uncorrelated with mean zero and $\varepsilon_{t-1} \mid \Omega_{t-1}$ is an information set. The conditional mean of a currency pair is expressed as a function of past returns and the two other markets' past returns. The parameter ϕ measures the effect of a change in the return of exchange rates and α is the constant term. In (5), the value of the variance scaling parameter, h_t, depends both on past values of the shocks captured by the lagged squared residual terms and on past values of itself captured by lagged h_t terms.[3]

Data and Results

The data comprise 2258 daily bivariate exchange rates over the period 1 January 2000 to 31 December 2008, for two importers (the UK and Japan) and two exporters (the US and UK). The following abbreviations are used: GBP for the UK, USD for the US, and JPY for Japan. The daily currency returns were calculated as the log of the difference in daily foreign exchange rates per unit based currency, the US dollar. Descriptive statistics for the sample are presented in Table 1. The sample means of returns are positive indicating that the GBP and JPY depreciated during 2000-2008. The standard deviation indicates that Japanese yen is more risky than the GBP in terms of volatility. Jarque-Bera tests reveal that the returns are normally distributed for the GBP/USD but not for JPY/GBP. This is also evident from the conventional measures of kurtosis. The Ljung-Box (LB) statistics for up to 10 lags on returns and squared returns suggest the possible presence of linear and non-linear dependencies; the latter may reflect autoregressive conditional heteroscedasticity. The unit root test (Augmented Dickey Fuller) with exogenous constant and linear trend rejected the null hypothesis on the first differenced returns, thus indicating that the series are stationary.

Table 2 shows the results for each of three different hedging arrangements where the θs is set at (0.01, 0.05, and 0.10) and the β is set at 0.5 where with the maximum value of V_x (V_x (max)), the VR, the ratio of the variance of V_x ($\sigma^2 V_x$), and the variance reduction (VD). The VR without hedging (=0.0168) to that under the three hedging arrangements and the VD is calculated as 1-(1/VR). The three hedging arrangements effectively reduce the variance of the cash flow. Depending on the value of θ, for the importer with GBP against invoicing currency USD, the risk sharing arrangement reduces the variance of V_x by between 97 and 77 per cent whereas the currency collar reduces the variance by between 99 and 51 percent and the hybrid arrangement reduces the variance by 98 between 99 and 91percent. For the importer with JPY against invoicing currency GBP, the risk sharing, currency collar and hybrid arrangements reduce the variance by between 93 and 76 percent; between 99 and 76 percent, and between 93 and 86 percent respectively. For both importers, the sensitivity of V_x to the value of θ is lower under the hybrid arrangement than under risk sharing and currency collar. The results also suggest that the hybrid arrangement's behaviour is closer to that of a currency collar than the

[3] The model has been extensively used in the context of asset-pricing (see Hall, Miles and Taylor, 1990; Campbell, Lo and MacKinley, 1997 among many others).

risk sharing arrangement as the $\sigma^2 V_x$ under the currency collar and the hybrid arrangement increases when the value of θ increases, but decrease under risk sharing.

The performance of the hybrid arrangement for various values of β and θ are presented in Table 3. The table reports the V_x (max), the VR and the VD for each of the three different hedging arrangements when the θ s are set at (0.01, 0.05, and 0.10) and the β_s are set at (0.1, 0.5, 0.666, and 0.9). The results show that when the value of β rises, V_x (max) rises, $\sigma^2 V_x$ rises VR falls and VD falls. But when β =0.666, the outcome is almost independent of the value of θ that the weight of two third is assigned to risk sharing and two third to currency collar.

Table 4 shows the estimated values of θ_s based on equations 4-5 for different values of β. The V_x (max), the VR and the VD are shown for each of three different hedging arrangements. When β is set at 0.5, the estimated θ_s are 0.2397 for the UK importer and 0.1080 for the Japan importer against invoicing currency of the USD and GBP respectively. The variance estimates suggest that both the UK and Japan importers would better off with risk sharing arrangement than with other two operational hedging arrangements. In particular the UK importer would worse off with a currency collar than with other two arrangements. The hybrid arrangement would reduce the variances for both importers.

In summary, the simulated results in Tables 2 (equations 1-3) and the hybrid currency hedge in Table 3 (equation 3) demonstrate that these techniques can be effective in reducing transaction exposure to foreign exchange risk. The main findings are similar to those in McDonald and Moosa, (2003), Lien and Moosa (2004), and Moosa and McDonald (2005) with a risk sharing threshold parameter. In Table 2, importers are better off with a risk sharing than the other two arrangements in reducing the cost of import payment with base currency to exporters and the variability from sudden exchange rate movements. Table 3 shows that the results of a hybrid arrangement with a β =0.666 to eliminate the sensitivity of the variance of a base currency. Existing literature, however, does not resolve the problem of a risk sharing parameter (θ); instead the parameter is set between 0 and 1 with the various weight between 0 and 1 or β =0.666 in a hybrid case. In Table 4, the value of the risk sharing parameter can be estimated for any currency pair and the estimate is time variant. Also, the parameter is estimated utilising the volatility innovation (equation 5), therefore the variance reduction (VD) is achieved to reduce the sensitivity of the value of the converted cash flows to the estimate of the risk sharing parameter.

Conclusion

Two of the standard operational techniques for hedging against currency exposure in international transactions are risk sharing arrangements and currency collars (McDonald and Moosa, 2003; Lien and Moosa, 2004; Moosa and McDonald, 2005). Moosa (2006) has shown that the sensitivity of the risk sharing parameter to cash flows can be reduced by using a hybrid scheme. In this paper we suggest that the risk sharing parameter can be imputed using a risk factor estimated from a GARCH-M model. This objective measure with the variance reduction may be persuasive in negotiations between the importer and exporter as two trading parties know the value of the risk sharing parameter and also minimise the variance of the outcome which is the essence of currency hedging. Replacing an arbitrary risk sharing parameter with an estimate would be particularly beneficial where the invoicing currency and the importer's settlement currency are highly volatile and the volatility of the currency pair is sensitive to the outcome of the returns. The estimate also links by utilising the volatility innovation (equation 5) between the risk sharing parameter and the volatility of a non-negotiable market rate of currency.

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Table 1- Descriptive statistics of currency returns series (1:1: 2000-31:12: 2008)

Importer/Exporter	*Mean*	*Std. Dev.*	*Skewness*	*Kurtosis*	*Jarque-Bera*	*LB(10)*	*LB2(10)*	*ADF*
GBP/USD	0.5909	0.0707	0.261	1.661489	1.94E+02	34.94	22234	-46.1461
JPY/GBP	0.0012	0.6304	-0.3801	6.9	4.97E+00	14.638	12.236	-47.9444

Notes: LB (10) critical values: 18.31 (5%) and 23.21(1%). * Indicates significance at the 1% level or better. MacKinnon (1996) one sided p-values with test critical values:1% level -3.962115 is used for the ADF test.

Table 2- The Hedging performance of risk sharing, currency collars and the hybrid arrangement (β=0.5)

	β=0.5	Importer (x=GBP) vs Expoter (y=USD)			Importer (x=JPY) vs Exporter (y=GBP)		
	θ	Risk	Currency	Hybrid	Risk	Currency	Hybrid
V_x(max)	0.0100	0.6567	0.5969	0.6268	221.75	197.09	209.42
	0.0500	0.6449	0.6205	0.6327	217.85	204.90	211.37
	0.1000	0.6301	0.6501	0.6401	212.97	214.65	213.81
	Range(0.01≤θ≥0.1	0.0414	0.0827	0.0207	13.66	27.32	6.83
σ^2 (V_x)	0.0100	0.0074	0.0001	0.0006	1691.79	7.62	481.61
	0.0500	0.0048	0.0017	0.0011	1268.21	190.40	610.35
	0.1000	0.0023	0.0070	0.0019	824.42	761.60	792.70
	Range(0.01≤θ≥0.1	0.0066	0.0156	0.0023	1215.97	1705.98	517.24
VR	0.0100	4.40	463.52	50.50	4.27	949.17	15.01
	0.0500	6.79	18.54	28.55	5.70	37.97	11.84
	0.1000	13.95	4.64	16.63	8.77	9.49	9.12
	Range(0.01≤θ≥0.1	39.09	461.46	39.63	10.92	944.95	7.77
VD	0.0100	0.7727	0.9978	0.9802	0.7660	0.9989	0.9334
	0.0500	0.8526	0.9461	0.9650	0.8246	0.9737	0.9156
	0.1000	0.9283	0.7843	0.9399	0.8860	0.8946	0.8903
	Range(0.01≤θ≥0.1	0.2043	0.4833	0.0722	0.1682	0.2360	0.0716

Table 3- The hedging performance of the hybrid arrangement for various values of β

	Importer (x=GBP) vs Expoter (y=USD)				Importer (x=JPY) vs Exporter (y=GBP)			
	V_x (max)	σ(Vx)	VR	VD	V_x (max)	σ(V_x)	VR	VD
β =0.1								
θ=0.01	0.6029	0.0003	124.89	0.9920	199.56	43.52	166.11	0.994
0.0500	0.6230	0.0020	16.34	0.9388	206.19	255.36	28.31	0.964
0.1000	0.6481	0.0064	5.05	0.8021	214.49	767.77	9.42	0.893
Range(0.01≤θ≥0.15)	0.0703	0.0131	122.47	0.4044	23.22	1511.79	161.46	0.209
β =0.5								
θ=0.01	0.6268	0.0022	14.61	0.9316	209.42	481.61	15.01	0.933
0.0500	0.6327	0.0031	10.54	0.9051	211.37	610.35	11.84	0.915
0.1000	0.6401	0.0043	7.46	0.8660	213.81	792.70	9.12	0.890
Range(0.01≤θ≥0.15)	0.0207	0.0036	9.05	0.1115	6.83	517.24	7.77	0.071
β =0.666								
θ=0.01	0.6367	0.0036	9.02	0.8891	213.51	801.75	9.02	0.889
0.0500	0.6367	0.0036	9.01	0.8890	213.52	802.38	9.01	0.889
0.1000	0.6368	0.0036	8.99	0.8888	213.53	803.16	9.00	0.888
Range(0.01≤θ≥0.15)	0.0001	0.0000	0.03	0.0004	0.02	1.80	0.02	0.000
β =0.9								
θ=0.01	0.6507	0.0061	5.32	0.8119	219.28	1390.86	5.20	0.807
0.0500	0.6424	0.0044	7.36	0.8640	216.55	1117.61	6.47	0.845
0.1000	0.6321	0.0027	12.10	0.9174	213.14	818.03	8.84	0.886
Range(0.01≤θ≥0.15)	0.0290	0.0047	18.22	0.1456	9.56	825.77	7.59	0.114

Table 4- The Hedging performance of risk sharing, currency collars and the hybrid arrangement (β=0.5)

β=0.5			Risk sharing	Currency collar	Hybrid
V_x(max)	θ (GBPUSD)	0.2397	0.5888	0.7326	0.6268
	θ (JPYGBP)	0.1080	0.0096	0.0098	0.0097
σ(V_x)	θ (GBPUSD)	0.2397	0.0001	0.0401	0.0024
	θ (JPYGBP)	0.1080	0.0000	0.0000	0.0000
VR	θ (GBPUSD)	0.2397	310.9950	0.8067	13.3113
	θ (JPYGBP)	0.1080	78.1681	1.6702	5.0853
VD	θ (GBPUSD)	0.2397	0.9968	-0.2397	0.9249
	θ (JPYGBP)	0.1080	0.9872	0.4013	0.8034