Operational Hedging of Transaction Exposure to Foreign Exchange Risk Arising from International Trade Contracts

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Abstract

A hybrid operational hedging technique is proposed to shift some of the foreign exchange risk from the importer to the exporter when the currency of the exporter is the currency of invoicing. This technique requires the conversion of the cash flows at a range of exchange rates calculated as some weighted average of the rates used under the risk-shifting techniques of risk sharing arrangements and currency collars. The problem of choosing the value of the parameter that determines how much of the risk is to be shifted to the exporter can be resolved by fine tuning the weights in such a way as to eliminate the sensitivity of the cash flows to the value of this parameter. The theoretical results are demonstrated with the use of monthly data on the exchange rate between the British pound and the U.S. dollar over the period January 1993-October 2006.

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Introduction

Transaction exposure to foreign exchange risk results from the effect of (unanticipated) changes in the spot exchange rate on the base currency value of foreign currency cash flows (contractual payables and receivables).[1] Financial hedging of transaction exposure is implemented by taking an opposite position (to the spot position) on a currency derivative (such as forwards, futures and options) or by using money market hedging. In some cases, however, financial hedging may not be possible or it may be too expensive. For example, forwards, futures and options may not be available for some currencies or for long maturities, and it may not be possible to obtain credit lines in certain currencies (which precludes money market hedging). This observation is particularly valid for countries where financial markets are rudimentary.

If a firm facing (transaction) exposure to foreign exchange risk cannot indulge in financial hedging, it may resort to the operational hedging techniques of risk sharing and currency collars, which can be implemented by using customised hedge contracts embedded in the underlying trade contracts.[2] Under a risk sharing arrangement, the benefits accruing to one party of a transaction as a result of a favourable change in the exchange rate (which is necessarily an unfavourable change for the other party) are shared by the two parties.[3] A currency collar, on the other hand, is used to set a minimum

[1] The word "contractual" is used here to distinguish between transaction exposure and economic exposure to foreign exchange risk.
[2] Furthermore, a firm may not wish to eliminate the exposure completely (by taking a perfect financial hedge) in anticipation of a favourable change in the exchange rate. Exposure cannot be eliminated completely by using operational hedging, except when the base currency is the currency of invoicing.
[3] This is equivalent to saying that the cost to one party resulting from an unfavorable change in the exchange rate is shared by the two parties.

value for the base currency value of cash flows at the expense of setting a maximum value. Thus, it involves a trade-off between potential loss and potential gain.

If the currency of invoicing is that of the exporter, the full burden of the foreign exchange risk will be borne by the importer while the exporter bears no risk. Under this kind of arrangement, some of the risk will be transferred to the exporter, depending on what may be called the risk sharing threshold parameter (Lien and Moosa, 2004). This parameter is a measure of the width of the range (the difference between the prespecified upper and lower values of the exchange rate) in which cash flows are converted at a fixed exchange rate in the case of a risk sharing arrangement and at the market rate in the case of a currency collar.

A problem may arise in negotiating the terms of the contract if the exporter and importer have different degrees of risk tolerance. In particular, each party would want to choose the value of the parameter that gives them more stability of receipts in own currencies. One way to circumvent the negotiation problem is to develop a hybrid hedging technique that reduces the sensitivity of the base currency value of the cash flows to the value of the risk sharing threshold parameter. This technique requires the conversion of the cash flows at a rate that is some average of the two rates implied by risk sharing and currency collars. We will find out that this kind of arrangement does not only reduce the sensitivity of the base currency value of the cash flow to the risk sharing threshold parameter but also to the market exchange rate prevailing when the cash flows are realised.

A Look at the Literature

The literature on the practical (as opposed to the theoretical and statistical) aspects of hedging exposure to foreign exchange risk deals primarily with three questions: (i) Do firms hedge?; (ii) If they do, which exposure do they hedge?; and (iii) If they do, what hedging instruments and techniques do they use? This paper is primarily concerned with the third question, particularly whether firms use financial hedging or operational hedging (also called internal hedging and external hedging, respectively).[4] In general, it has been found that firms use a wide variety of techniques to hedge exposure (for example, Hakkarainen et al, 1988).

The questions can be answered by surveying the actual practices of firms with respect to hedging. Following their survey, Jesswein et al (1995) documented the extent of knowledge and use of foreign exchange risk management products by 500 U.S. firms. The results of the survey showed that 93 per cent of the respondents used forward contracts followed by swaps and options. Only 5.1 per cent and 3.8 per cent used lookback options and compound options, respectively. Joseph (2000) obtained a measure of the degree of utilisation of hedging techniques on the basis of a survey of 109 companies belonging to the top 300 category of *The Times 1000: 1994*. The results showed that (i) British firms utilise a narrow set of techniques to hedge exposure; and (ii) they place much more emphasis on currency derivatives than on internal hedging techniques. Marshall (2000) surveyed the foreign exchange risk practices of 179 large British, American and Asia-Pacific multinational firms to find that: (i) the most popular

[4] For some reason, Hommel (2003) refers to operational hedging as “operative” hedging. But then he talks about *operative* hedging through the creation of *operational* strategy.

external method for managing translation and transaction exposure is the forward contract, although swaps are popular with British firms; (ii) the majority of firms do not favour exchange-traded instruments, such as currency futures and options on currency futures; (iii) the industry sector is an important determinant of the use of derivatives, particularly exchange-traded derivatives; and (iv) pricing strategies and the currency of invoicing are the most widely used methods to deal with economic exposure. In a survey of the hedging practices of New Zealand companies, Chan et al (2003) found out that forward contracts are the most frequently used derivatives in hedging transaction exposure to foreign exchange risk.

The use of futures and options to hedge foreign exchange risk has been examined extensively. Giddy and Dufey (1995) argue that options are not ideal hedging instruments because the gains/losses arising from their use are not linearly related to changes in exposure in an optimal manner if managerial decisions regarding inputs and outputs are fixed, otherwise options are more appropriate. Based on an analysis of the foreign exchange exposure of the Australian equity market, De Iorio and Faff (2000) present some evidence for asymmetry, which they attribute to the use of currency options, as they limit the downside exposure while permitting the potential upside gains. van Capelleveen and Wijckmans (2005) show that uncertain foreign currency cash flows can be hedged effectively by using a combination of currency futures and options.

Other papers have dealt with the controversy of using options to hedge foreign exchange risk. For example, Broll et al (2001) argue that the optimality of options being a hedging instrument remains largely unexplained. On the one hand, it is argued by Lapan et al (1991) that currency options are useful for hedging only if the forward market and/or option premiums are biased. However, Moschini and Lapan (1995) show that production flexibility of the competitive firm under price certainty leads to an *ex post* profit function that is convex in prices, thereby inducing the firm to use options for hedging. Sakong et al (1993) and Moschini and Lapan (1995) show that production uncertainty provides another rationale for using options, because it is related to the multiplicative interaction between price and yield uncertainty, which affects the curvature of the firm's profit function. Lence et al (1994) show that forward-looking firms would use options as a hedging instrument because they are concerned about the effects of future prices on profit from future production cycles. Finally, Broll et al (2001) offer yet another rationale for the hedging role of options when the underlying uncertainty is nonlinear.

But even if options and futures provide excellent hedging performance, they may not be available for a particular currency or a particular maturity, or not at all in the case of developing countries (for example, Broll and Wahl, 1998; Abor, 2005). This is a reason (but not the only reason) why firms resort to operational or external hedging. For example, Abor (2005) argues that the foreign exchange risk faced by Ghanian firms involved in international trade is mainly managed by adjusting prices to reflect changes in import prices resulting from exchange rate fluctuations (which is operational hedging). Using cross-currency hedging with futures and options, as advocated by Chang and Wong (2003), is not a straightforward alternative, as adverse results may arise out of correlation considerations (see, for example, Moosa, 2003; Schwab and Lusztig, 1978).

There seems to be a mixture of views on the issue of the extent to which firms use operational as opposed to financial hedging. In its 1995 annual report, Schering-Plough argues in support of the exclusive use of operational hedging by saying that "to date, management has not deemed it cost effective to engage in a formula-based program of hedging the profitability of these operations using derivative financial instruments", adding that "some of the reasons for this conclusion are: the company operates in a large number of foreign countries; the currencies of these countries generally do not move in the same direction at the same time". On the other hand, it is well known that many companies with large worldwide networks, such as IBM and Coca Cola, make extensive use of derivative financial instruments. The academic literature has produced evidence and justification for the extensive use of operational hedging (for example, Hommel, 2003). Bradley and Moles (2002) found out from a survey of large publicly-listed British firms a considerable use of operational hedging.

Operational hedging encompasses a wide variety of instruments and techniques, but in general it can be argued that it encompasses any technique that does not depend on taking a position on a financial asset (actual or synthetic, as in the case of money market hedging). A number of studies involve a comparison between financial hedging and operational hedging, including Davies et al (2006), Carter and Vickery (1988), Carter et al (1993), and Allayannis et al (2001). Classified as operational hedging techniques are what Capstaff and Marshall (2005) call "cash management methods", which include matching, netting and pricing policies. The latter include the currency of pricing (invoicing), as it determines whether the exporter or the importer bears the risk. Schwab and Lusztig (1978) show that "the contracting parties can minimise this [foreign exchange] risk most effectively through some mix of their own currencies". If the currency of invoicing is that of the exporter, the importer may request the protection offered by the instruments described in this paper.

Work on risk sharing as an operational hedging technique is rather limited, although Carter and Vickery (1988) show that 55 per cent of the firms participating in their survey used "risk-sharing contract arrangements", compared with 15 per cent for forward contracts and 20 per cent for futures contracts. Carter and Vickery (1988) and Carter et al (1993) describe what they call contractual risk sharing types I and II. In type I contracts, foreign exchange losses and gains are shared equally by both parties (which is what is called a risk sharing arrangement in this paper). In type II contracts, the price is adjusted if the exchange rate moves outside a prespecified range, which is similar (but not exactly the same as) what is called a currency collar in this paper. A currency collar does not involve price changes but rather the use of fixed exchange rates for conversion outside the range.[5]

McDonald and Moosa (2003) and Moosa and McDonald (2005) show that risk sharing and currency collars can be as effective as forward hedging in reducing transaction exposure to foreign exchange risk. However, they reveal that the effectiveness of these techniques depends crucially on some parameters, specifically the upper and lower values of the

[5] The techniques are called risk sharing arrangement and currency collar following Shapiro (2002, pp 283-287). Both may be called risk-shifting (or risk-transfer) agreements or arrangements. It will be demonstrated later that the so-called type II contract can produce exactly the same result as a currency collar if the price is adjusted by an amount that reflects the actual exchange rate from the prespecified range.

exchange rate in the case of a currency collar and the range within which foreign exchange cash flows are converted at the market rate in the case of a risk sharing arrangement (both of which can be referred to as the risk sharing threshold parameter). Lien and Moosa (2004) used a bargaining approach to examine currency collars, working out the Nash equilibrium in a game involving two parties with different degrees of risk tolerance. They presented some simulation results to show that, as long as one of the parties is more risk averse than the other, both parties would gain from a currency collar. Their simulation results also reveal that (for a given degree of risk aversion), the risk threshold parameter increases with the standard deviation of the underlying exchange rate.

A Description of Risk Sharing Arrangements and Currency Collars

Let *x* and *y* be the currencies of the importer and exporter, respectively, and assume that *y* is the currency of invoicing. Given the *y*-currency value of the cash flow (V_y), its *x*-currency value (V_x) when converted at the market exchange rate is $V_x = KS_t$, where *K* is the *y*-currency value of the cash flow ($V_y = K$) and S_t is the market spot exchange rate at time *t* when the payment by the importer to the exporter is due. Therefore, the importer is subject to foreign exchange risk resulting from fluctuations in S_t, whereas the exporter is not because what he receives in his base currency is independent of S_t.

One way to shift some of the risk to the exporter is to use a risk sharing arrangement, whereby the cash flow is converted at a range of exchange rates. Following the determination of a base rate, $\bar{S}$, a neutral zone is set around this rate, say between

$\bar{S}(1-\theta)$ and $\bar{S}(1+\theta)$, where $0<\theta<1$ is the risk sharing threshold parameter. Within the neutral zone, the cash flow is converted at $\bar{S}$, which means that the *x*-currency value of the cash flows is $V_x = K\bar{S}$. Formally, if $\bar{S}(1-\theta) < S_t < \bar{S}(1+\theta)$, then $V_x = K\bar{S}$ and $\partial V_x / \partial S_t = 0$.

If the exchange rate falls below the lower limit of the neutral zone (that is, $S_t < \bar{S}(1-\theta)$), the cash flow is converted at a rate that is equal to the base rate less half the difference between the lower limit and the actual exchange rate. In this case, the *x*-currency value of the cash flow is greater than what it would be in the absence of a risk sharing arrangement. On the other hand, if the exchange rate rises above the upper limit of the neutral zone (that is, $S_t > \bar{S}(1+\theta)$), then the cash flow is converted at a rate that is equal to the base rate plus half the difference between the actual exchange rate and the upper limit of the neutral zone. This means that the *x*-currency value of the cash flow is lower than what it would be in the absence of a risk sharing arrangement. Thus, the exporter receives more (in terms of *x*) than in the absence of a risk sharing arrangement when *y* depreciates. Conversely, the importer pays less than what is required in the absence of a risk sharing arrangement when *y* appreciates.

The outcome of a risk-sharing arrangement in terms of *x*-currency value of the cash flow can be written as

$$\left.\begin{aligned} V_x &= \frac{K}{2}\left[\bar{S}(1+\theta)+S_t\right] \\ V_x &= K\bar{S} \\ V_x &= \frac{K}{2}\left[\bar{S}(1-\theta)+S_t\right] \end{aligned}\right\} \quad \text{if} \quad \left.\begin{aligned} & S_t < \bar{S}(1-\theta) \\ & \bar{S}(1-\theta) < S_t < \bar{S}(1+\theta) \\ & S_t > \bar{S}(1+\theta) \end{aligned}\right\} \tag{1}$$

In this case, the higher the value of θ, the wider will be the neutral zone and the higher will be the likelihood that the cash flow will be converted at a fixed rate, $\bar{S}$. Hence, a risk averse importer would demand a higher value for θ.

From the perspective of the exporter, the situation is completely the opposite. The best course of action for the exporter is not to enter a risk sharing arrangement as long as the currency of invoicing is *y*, because only the importer is exposed to foreign exchange risk in this case. Howeve, if the exporter agrees to enter a risk sharing arrangement, he will negotiate a low value of θ because this would produce a narrow range in which the cash flow is converted at the fixed rate, $\bar{S}$ .Therefore, the higher the value of θ, the greater will be the proportion of risk that is shifted from the importer to the exporter. Unlike the importer, the exporter will negotiate a low value of θ.

Just like a risk sharing arrangement, a currency collar involves a range for the exchange rate extending between a lower limit, $\bar{S}(1-\theta)$, and an upper limit, $\bar{S}(1+\theta)$.[6] If the

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[6] The upper and lower limits do not have to be symmetric. However, this is a simplifying assumption that enables us to analyse the performance of risk sharing and currency collars in terms of a single parameter, θ.

exchange rate falls below the lower limit, the rate used to convert cash flows is the lower limit itself, and this is how the minimum value of V_x is obtained. If the exchange rate falls within the range, the conversion rate is the current exchange rate, S_t, which means that the base currency value of the cash flow rises with the exchange rate. Finally, if the exchange rate rises above the upper limit, the conversion rate is the upper limit, and this is how the maximum value of V_x is obtained. The *x*-currency value of the cash flow under a currency collar is given by

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

In this case, the importer would negotiate a low value of θ to avoid converting the cash flow at the market exchange rate, but the exporter would negotiate a high value of θ to maximise the probability that the cash flow is converted at the market exchange rate to give him K units of *y*. The exporter will be exposed to foreign exchange risk if the exchange rate assumes values falling in the ranges $S_t < \bar{S}(1-\theta)$ and $S_t > \bar{S}(1+\theta)$, and this is why the exporter would want to negotiate a high value of θ.

It can be demonstrated that what Carter and Vickery (1988) call type II contracts, which involve changing K ($=V_y$) if $S_t < \bar{S}(1-\theta)$ or $S_t > \bar{S}(1+\theta)$, would produce identical results (in terms of V_x) to those of a currency collar. If $S_t < \bar{S}(1-\theta)$, then the price is adjusted (raised) to K' where

$$K' = \frac{K\bar{S}(1-\theta)}{S_t} \tag{3}$$

such that $V_x = K\bar{S}(1-\theta)$, which is exactly what is obtained under a currency collar.

Likewise, if $S_t > \bar{S}(1+\theta)$, the price is adjusted (reduced) to K'', where

$$K' = \frac{K\bar{S}(1+\theta)}{S_t} \tag{4}$$

which is again identical to what is obtained under a currency collar.

Proposing a Hybrid Operational Hedging Technique

Given the description of risk sharing arrangements and currency collars, difficulties with respect to striking a deal would arise if the exporter and importer have different degrees of risk tolerance. The negotiations would be around the value of the parameter θ, as we have seen from the previous discussion.[7] This would be particularly important if the outcome, in terms of V_x, is highly sensitive to the value of θ. By scrutinising equations (1) and (2), we find that changing the value of θ has the opposite effect on the stability of V_x in the case of a risk sharing arrangement to that resulting under a currency collar. For example, when $S_t < \bar{S}(1-\theta)$, $\partial V_x / \partial\theta > 0$ in the case of a risk sharing arrangement and $\partial V_x / \partial\theta < 0$ in the case of a currency collar. Conversely, when $S_t > \bar{S}(1+\theta)$, $\partial V_x / \partial\theta < 0$ in the case of a risk sharing arrangement and $\partial V_x / \partial\theta > 0$

[7] There could also be some negotiation about the value of $\bar{S}$, but this is can be easily determined as some sort of a "fair value" of the exchange rate. Exchange rates typically move in cycles, in which case a fair value of the exchange rate is the mean or median over a period covering episodes of appreciation and depreciation of both currencies. Choosing a PPP-determined value for $\bar{S}$ is also possible. Last, but not least, it could be based on the strike prices (rather, exchange rates) of call options and put options on the same currency with time to expiry that is close enough to the duration of the contract.

in the case of a currency collar. Therefore, a hybrid arrangement, whereby the cash flow is converted at a rate that is some average of the rates implied by risk sharing and currency collars, should reduce the sensitivity of V_x to changes in θ. This would make the two parties less worried about the value of θ. By initially assuming equal weights for risk sharing and currency collars the *x*-currency value of the cash flow paid by the importer is

$$\left.\begin{array}{l} V_x = \frac{K}{4}\left[\bar{S}(1+\theta)+S_t\right]+\frac{K}{2}\left[\bar{S}(1-\theta)\right] \\ V_x = \frac{K}{2}\left[\bar{S}+S_t\right] \\ V_x = \frac{K}{4}\left[\bar{S}(1-\theta)+S_t\right]+\frac{K}{2}\left[\bar{S}(1+\theta)\right] \end{array}\right\} \quad \text{if} \quad \left.\begin{array}{l} S_t < \bar{S}(1-\theta) \\ \bar{S}(1-\theta) < S_t < \bar{S}(1+\theta) \\ S_t > \bar{S}(1+\theta) \end{array}\right\} \qquad (5)$$

Let us now consider the properties of the hybrid arrangement as compared with the properties of risk sharing and currency collars. Table 1 provides a summary of the sensitivity of V_x to θ and S_t under the conditions of no hedging, risk sharing, currency collar and the hybrid arrangement. If the importer and exporter do not reach an agreement on operational hedging, they will operate under the condition of no hedging, in which case the importer pays KS_t units of *x* whereas the exporter receives *K* units of *y*. In this case, $\partial V_x / \partial S_t = K$ and $\partial V_y / \partial S_t = 0$, which explains why the exporter prefers the no-hedge situation (provided, of course, that the currency of invoicing is *y*).[8] Under any of the three arrangements of operational hedging, $\left|\partial V_x / \partial S_t\right| < K$ and $\left|\partial V_y / \partial S_t\right| > 0$. As to

[8] $\partial V_x / \partial S_t$ defines exposure to foreign exchange risk. If V_x is plotted against S_t, the exposure is measured by the slope of the exposure line.

the comparison between the hedging techniques, we can see immediately that the hybrid arrangement reduces the sensitivity of V_x with respect to θ to half its level under a risk sharing arrangement and to one quarter of its level under a currency collar. The same is true of the sensitivity of V_x with respect to S_t, except for the ranges in which the cash flow is translated at a fixed exchange rate where $\partial V_x / \partial S_t = 0$.

We can see clearly that the outcome depends not only on the value of θ but also on the value of S_t, because the outcome under any form of operational hedging depends on S_t. Assume that the probabilities of S_t taking the low, intermediate and high values (the range shown in Table 1) are p_1, p_2 and p_3, respectively. In this case, we have

$$\left.\begin{aligned} E\left(\left|\frac{\partial V_x}{\partial S_t}\right|_{RS}\right) &< E\left(\left|\frac{\partial V_x}{\partial S_t}\right|_{HY}\right) \\ E\left(\left|\frac{\partial V_x}{\partial S_t}\right|_{CC}\right) &< E\left(\left|\frac{\partial V_x}{\partial S_t}\right|_{HY}\right) \end{aligned}\right\} \quad \text{if} \quad \left.\begin{aligned} p_2 &> \frac{1}{2}(p_1 + p_3) \\ p_2 &< \frac{1}{2}(p_1 + p_3) \end{aligned}\right\} \tag{6}$$

where E is the expected value operator and *RS*, *CC* and *HY* respectively denote risk sharing, currency collars and the hybrid arrangement. In certain ranges, the expected value of the exposure can be lower under risk sharing and currency collar than under the hybrid arrangement. However, given the random walk behaviour of exchange rates, it is rather difficult to anticipate whether or not the conditions given by (6) will materialise. The hybrid arrangement is not as blunt as risk sharing or currency collar in terms of the effect of S_t on the outcome in terms of V_x, which is what hedgers seek (that is, avoiding extremes). Remember also that S_t is not negotiable, as it is determined by the market.

What is important to realise here is the following. If there is no agreement on operational hedging, the exporter will not bear any risk whereas the importer will bear the whole risk. If the importer is in a position to convince the exporter to enter some sort of an agreement whereby some of the risk is shifted to the exporter, the exporter's main worry will be how much of the risk will be shifted to him, as determined by the value of θ. Since exchange rates move in random walk and can be anywhere, both will be exposed to the same risk, which they share by entering into an agreement. The negotiation would be on the value of θ. Since the outcome under a risk sharing arrangement and currency collar are highly sensitive to the value of θ, whereas the outcome under a hybrid arrangement is not, the exporter will be more inclined to enter a hybrid arrangement than any of the other two (which themselves are better for the importer than the no-hedge situation). After all, the essence of hedging is to minimise the variance of the outcome, an objective that is accomplished more effectively under a hybrid arrangement than under risk sharing or currency collar.

Choosing equal weights to construct the hybrid arrangement makes it closer to a currency collar than to a risk sharing arrangement. In the range $S_t < \bar{S}(1-\theta)$, $\partial V_x / \partial \theta < 0$ under the currency collar and the hybrid arrangement, whereas $\partial V_x / \partial \theta > 0$ under a risk sharing arrangement. The opposite is true in the range $S_t > \bar{S}(1+\theta)$. This means that increasing the weight of the risk sharing arrangement in the construction of the hybrid arrangement may reduce further the sensitivity of V_x to θ. It should be possible, by choosing a certain set of weights, to eliminate completely the sensitivity of V_x to θ. The objective, therefore, is to find the set of weights that satisfy the condition $\partial V_x / \partial \theta = 0$.

Assume that the weights assigned to the risk sharing arrangement and the currency collar are β and $1-\beta$, respectively. In this case, equation (5) can be re-written as

$$\left.\begin{aligned} V_x &= \frac{\beta K}{2}\left[\bar{S}(1+\theta)+S_t\right]+(1-\beta)K\bar{S}(1-\theta) \\ V_x &= \beta K\bar{S}+(1-\beta)KS_t \\ V_x &= \frac{\beta K}{2}\left[\bar{S}(1-\theta)+S_t\right]+(1-\beta)K\bar{S}(1+\theta) \end{aligned}\right\} \quad \text{if} \quad \left.\begin{aligned} &S_t < \bar{S}(1-\theta) \\ &\bar{S}(1-\theta) < S_t < \bar{S}(1+\theta) \\ &S_t > \bar{S}(1+\theta) \end{aligned}\right\} \tag{7}$$

Consider the range $S_t < \bar{S}(1-\theta)$, in which we have

$$\frac{\partial V_x}{\partial \theta} = \frac{\beta K\bar{S}}{2} - (1-\beta)K\bar{S} \tag{8}$$

If V_x is not sensitive to θ, it follows that $\partial V_x / \partial \theta = 0$, which gives

$$\frac{\beta K\bar{S}}{2} - (1-\beta)K\bar{S} = 0 \tag{9}$$

By solving equation (9) for β, we find that $\beta = 2/3$. By substituting this value of β in equation (7) over the range $S_t < \bar{S}(1-\theta)$, we find that

$$V_x = \frac{K}{3}(2\bar{S} + S_t) \tag{10}$$

This means that assigning a weight of 2/3 to the risk sharing arrangement and a weight of 1/3 to the currency collar produces a hybrid arrangement whereby V_x is independent of θ, in which case the risk sharing threshold parameter is irrelevant. The exposure in this case is given by $\partial V_x / \partial S_t = K/3$, which is one third of the exposure under the no-hedge situation. Likewise, it can be shown that this result holds over the range $S_t > \bar{S}(1+\theta)$. Therefore, constructing the hybrid arrangement in this manner circumvents the problem of negotiating the value of θ.

Empirical Results

The empirical results presented in this paper are based on a sample of monthly observations covering the period January 1993-October 2006 on the exchange rate between the U.S. dollar and the British pound, being currency x and currency y respectively. The data were obtained from www.google.com (Asia Pacific Exchange Rate Service). Initially, we assume that equal weights are assigned to risk sharing and currency collar in the construction of the hybrid arrangement. For the purpose of this empirical exercise, $\bar{S}$ is taken to be the sample mean of S_t (1.6185).

Figures 1-3 display the behaviour of V_x as S_t increases under risk sharing, currency collar and the hybrid arrangement, respectively, using two values for θ (0.02 and 0.10, represented by the dashed and solid and lines, respectively). For this purpose, the values of the spot exchange rate in the sample are arranged in an ascending order and measured on the horizontal axis, whereas V_x is measured on the vertical axis under the assumption that $K = 1$. We can see from the graphs that V_x is less sensitive with respect to θ under the hybrid arrangement than under either risk sharing or currency collar.

Table 2 confirms this finding by displaying the (i) the maximum value of V_x, V_x (Max), which corresponds to the highest value of S_t; (ii) the variance of V_x, $\sigma^2(V_x)$; (iii) the variance ratio (*VR*) relative to the unhedged position, which is the ratio of $\sigma^2(V_x)$ without hedging (=0.0168) to what is obtained under the three hedging arrangements; and (iv) variance reduction relative to the unhedged position (in per cent), which is calculated as $VD = 1-(1/VR)$. The variance ratio has an F distribution with a 5 per cent critical value of 1.29. From the results displayed in Table 2, we observe that the three hedging arrangements are effective in reducing the variance of the cash flow significantly, except for the currency collar when $\theta = 0.12$. To gauge the sensitivity of V_x to the value of θ, we examine the ranges of V_x (Max), $\sigma^2(V_x)$, *VR* and *VD*, which are lower under the hybrid arrangement than under risk sharing and currency collar. Depending on the value of θ, the hybrid arrangement reduces the variance of V_x by between 92.4 and 77.4 per cent, whereas the currency collar (which produces the most extreme outcomes) reduces the variance by between 98.6 and 18 per cent. The hybrid arrangement makes V_x less sensitive to the value of θ.

Another observation about the results reported in Table 2 is that when $\beta = 0.5$ (equal weights are assigned to risk sharing and currency collar in the construction of the hybrid arrangement), the hybrid arrangement's behaviour is closer to that of a currency collar. For example, as the value of θ increases from 0.01 to 0.12, $\sigma^2(V_x)$ increases under risk sharing but declines under the currency collar and the hybrid arrangement. This observation is consistent with the theoretical result showing that when $\beta = 2/3$, the hybrid arrangement makes V_x completely independent of θ.

To find out what happens to the performance of the hybrid arrangement as the value of β changes, consider the results presented in Table 3. The table reports V_x(Max), $\sigma^2(V_x)$, *VR* and *VD* under the hybrid arrangement as the value of β increases from 0.1 to 0.9. Specifically, β is allowed to assume the values, 0.10, 0.30, 0.50, 0.666, 0.80 and 0.90. We can see immediately that when $\beta < 2/3$, the hybrid arrangement behaves like a currency collar (as the value of β rises, V_x(Max) rises, $\sigma^2(V_x)$ rises, *VR* falls and *VD* falls). When $\beta > 2/3$, the hybrid arrangement behaves like a risk sharing arrangement (as the value of β falls, V_x(Max) declines, $\sigma^2(V_x)$ falls, *VR* rises and *VD* rises). But when $\beta = 2/3$, these items do not change as θ increases. Figures 4-7 show plots of these statistics against θ under the hybrid arrangement for three values of β (0.10, 0.666 and 0.90). We can see clearly that when $\beta = 2/3$, the lines representing V_x(Max), $\sigma^2(V_x)$, *VR* and *VD* are horizontal. The outcome is completely independent of the value of θ if the hybrid arrangement is constructed such that a weight of 2/3 is assigned to risk sharing and 1/3 to currency collar.

Conclusions

Financial hedging of transaction exposure to foreign exchange risk, which is undertaken by the importer only if the currency of involving is the base currency of the exporter, can be replaced with the operational hedging techniques of risk sharing and currency collars, whereby some of the risk is shifted to the exporter. If the exporter accepts to enter such an agreement, a problem remains as to determining the value of the risk sharing threshold parameter, which is a measure of how much of the risk is shifted to the exporter.

To resolve the problem of agreeing on a value of the underlying parameter, this paper suggests the introduction of a hybrid operational hedging technique, which requires the conversion of the cash flows at exchange rates calculated as some sort of a weighted average of the exchange rates used for the same purpose under a risk sharing arrangement and a currency collar. It is demonstrated that, by using equal weights, that the hybrid arrangement reduces the sensitivity of the value of the converted cash flows to the value of the risk sharing threshold parameter. By changing the weights, it is possible to eliminate the sensitivity of the cash flows to the value of the parameter, which solves the problem of negotiations. For the specific data used in this study on the exchange rate between the U.S. dollar and the British pound, the results reveal that a hybrid arrangement with a weight of 0.666 assigned to risk sharing completely eliminates the sensitivity of the variance of U.S. dollar cash flows with respect to the parameter.

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Table 1: The Sensitivity of V_x to θ and S_t

Range	$\partial V_x / \partial\theta$	$\partial V_x / \partial S_t$
<u>No Hedging</u>		
$S_t < \bar{S}(1-\theta)$	0	K
$\bar{S}(1-\theta) < S_t < \bar{S}(1+\theta)$	0	K
$S_t > \bar{S}(1+\theta)$	0	K
<u>Risk Sharing</u>		
$S_t < \bar{S}(1-\theta)$	$\frac{K\bar{S}}{2}$	$\frac{K}{2}$
$\bar{S}(1-\theta) < S_t < \bar{S}(1+\theta)$	0	0
$S_t > \bar{S}(1+\theta)$	$-\frac{K\bar{S}}{2}$	$\frac{K}{2}$
<u>Currency Collar</u>		
$S_t < \bar{S}(1-\theta)$	$-K\bar{S}$	0
$\bar{S}(1-\theta) < S_t < \bar{S}(1+\theta)$	0	K
$S_t > \bar{S}(1+\theta)$	$K\bar{S}$	0
<u>Hybrid (Equal Weights)</u>		
$S_t < \bar{S}(1-\theta)$	$-\frac{K\bar{S}}{4}$	$\frac{K}{4}$
$\bar{S}(1-\theta) < S_t < \bar{S}(1+\theta)$	0	$\frac{K}{2}$
$S_t > \bar{S}(1+\theta)$	$\frac{K\bar{S}}{4}$	$\frac{K}{4}$

Table 2: The Hedging Performance of Risk Sharing, Currency Collars and the Hybrid Arrangement ($\beta = 0.5$)

	θ	Risk Sharing	Currency Collar	Hybrid
V_x (Max)	0.01	1.7637	1.632	1.6978
	0.02	1.7556	1.6481	1.7019
	0.05	1.7314	1.6966	1.714
	0.08	1.7071	1.7451	1.7261
	0.10	1.691	1.7774	1.7342
	0.12	1.6748	1.8097	1.7423
	Range	0.0889	0.1777	0.0445
$\sigma^2(V_x)$	0.01	0.00343	0.00024	0.00127
	0.02	0.00277	0.00086	0.00151
	0.05	0.00134	0.00408	0.00227
	0.08	0.00053	0.00846	0.00302
	0.10	0.00025	0.01134	0.00346
	0.12	0.00010	0.01377	0.00379
	Range	0.00333	0.01353	0.00252
VR	0.01	4.90	70.00	13.23
	0.02	6.06	19.53	11.13
	0.05	12.54	4.12	7.40
	0.08	31.70	1.99	5.56
	0.10	67.20	1.48	4.86
	0.12	168.00	1.22	4.43
	Range	163.10	68.78	8.80
VD	0.01	79.6	98.6	92.4
	0.02	83.5	94.9	91.0
	0.05	92.0	75.7	86.5
	0.08	96.8	49.6	82.0
	0.10	98.5	32.5	79.4
	0.12	99.4	18.0	77.4
	Range	19.8	80.5	15.0

Table 3: The Hedging Performance of the Hybrid Arrangement for Various Values of β

	V_x (Max)	$\sigma^2(V_x)$	VR	VD
$\beta = 0.10$				
$\theta = 0.01$	1.6451	0.00035	48.00	97.9
$\theta = 0.02$	1.6589	0.00094	17.87	94.4
$\theta = 0.05$	1.7001	0.00365	4.60	78.3
$\theta = 0.08$	1.7413	0.00714	2.35	57.5
$\theta = 0.10$	1.7687	0.00939	1.79	44.1
$\theta = 0.12$	1.7962	0.01127	1.49	32.9
Range	0.1511	0.01092	46.51	65.00
$\beta = 0.30$				
$\theta = 0.01$	1.6715	0.00072	23.33	95.7
$\theta = 0.02$	1.6804	0.00118	14.24	93.0
$\theta = 0.05$	1.707	0.00289	5.81	82.8
$\theta = 0.08$	1.7337	0.00485	3.46	71.1
$\theta = 0.10$	1.7515	0.00601	2.80	64.2
$\theta = 0.12$	1.7692	0.00703	2.39	58.2
Range	0.0977	0.00631	20.94	37.56
$\beta = 0.50$				
$\theta = 0.01$	1.6978	0.00127	13.23	92.4
$\theta = 0.02$	1.7019	0.00151	11.13	91.0
$\theta = 0.05$	1.714	0.00227	7.40	86.5
$\theta = 0.08$	1.7261	0.00302	5.56	82.0
$\theta = 0.10$	1.7342	0.00346	4.86	79.4
$\theta = 0.12$	1.7423	0.00379	4.43	77.4
Range	0.0445	0.00252	8.80	15.00
$\beta = 0.666$				
$\theta = 0.01$	1.7181	0.00186	9.03	88.9
$\theta = 0.02$	1.7181	0.00186	9.03	88.9
$\theta = 0.05$	1.7181	0.00186	9.03	88.9
$\theta = 0.08$	1.7181	0.00186	9.03	88.9
$\theta = 0.10$	1.7181	0.00186	9.03	88.9
$\theta = 0.12$	1.7181	0.00186	9.03	88.9
Range	0	0	0	0

Table 3: The hedging Performance of the Hybrid Arrangement for Various values of β (Continued)

	V_x (Max)	$\sigma^2(V_x)$	VR	VD
$\beta = 0.80$				
$\theta = 0.01$	1.7373	0.00243	6.91	85.5
$\theta = 0.02$	1.7341	0.00220	7.64	86.9
$\theta = 0.05$	1.7244	0.00161	10.43	90.4
$\theta = 0.08$	1.7147	0.00118	14.24	93.0
$\theta = 0.10$	1.70082	0.00097	17.32	94.2
$\theta = 0.12$	1.7018	0.00083	20.24	95.1
Range	0.0355	0.0016	13.33	9.52
$\beta = 0.90$				
$\theta = 0.01$	1.7505	0.00291	5.77	82.7
$\theta = 0.02$	1.7448	0.00247	6.80	85.3
$\theta = 0.05$	1.7279	0.00146	11.51	91.3
$\theta = 0.08$	1.7109	0.0008	21.00	95.2
$\theta = 0.10$	1.6996	0.00052	32.31	96.9
$\theta = 0.12$	1.6883	0.00034	49.41	98.0
Range	0.0622	0.00257	43.64	15.30

Figure 1: V_x under a Risk Sharing Arrangement ($\theta = 0.02, 0.10$)

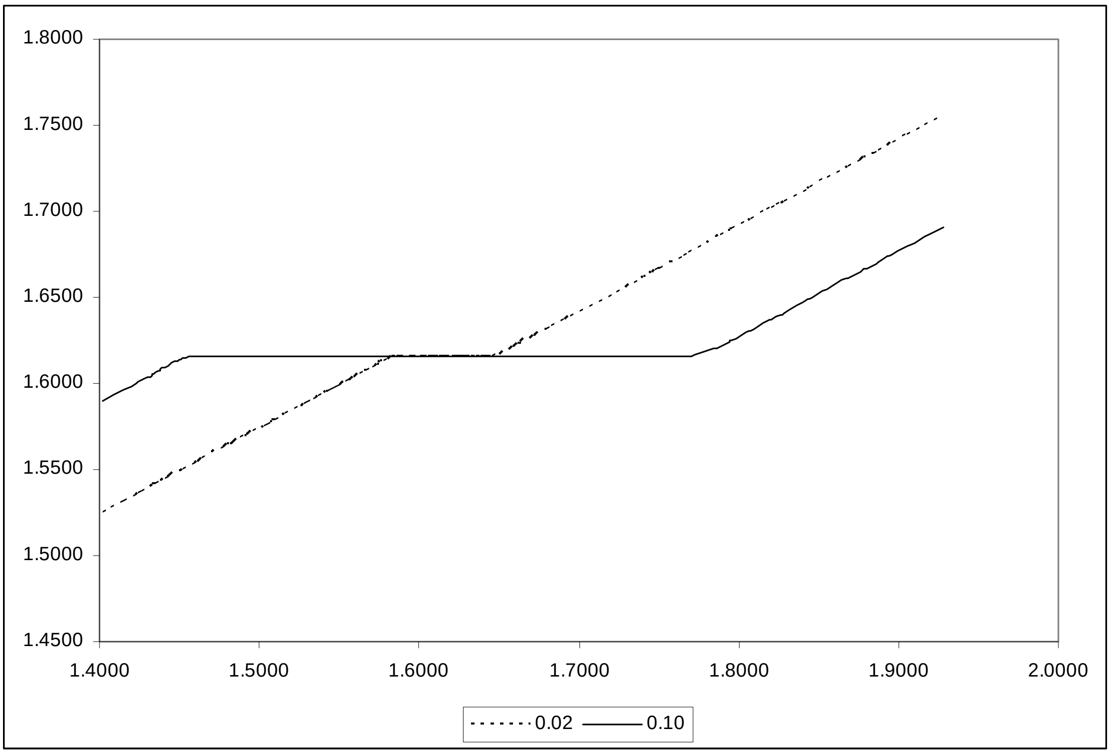

Figure 1: V_x under a Currency Collar ($\theta = 0.02, 0.10$)

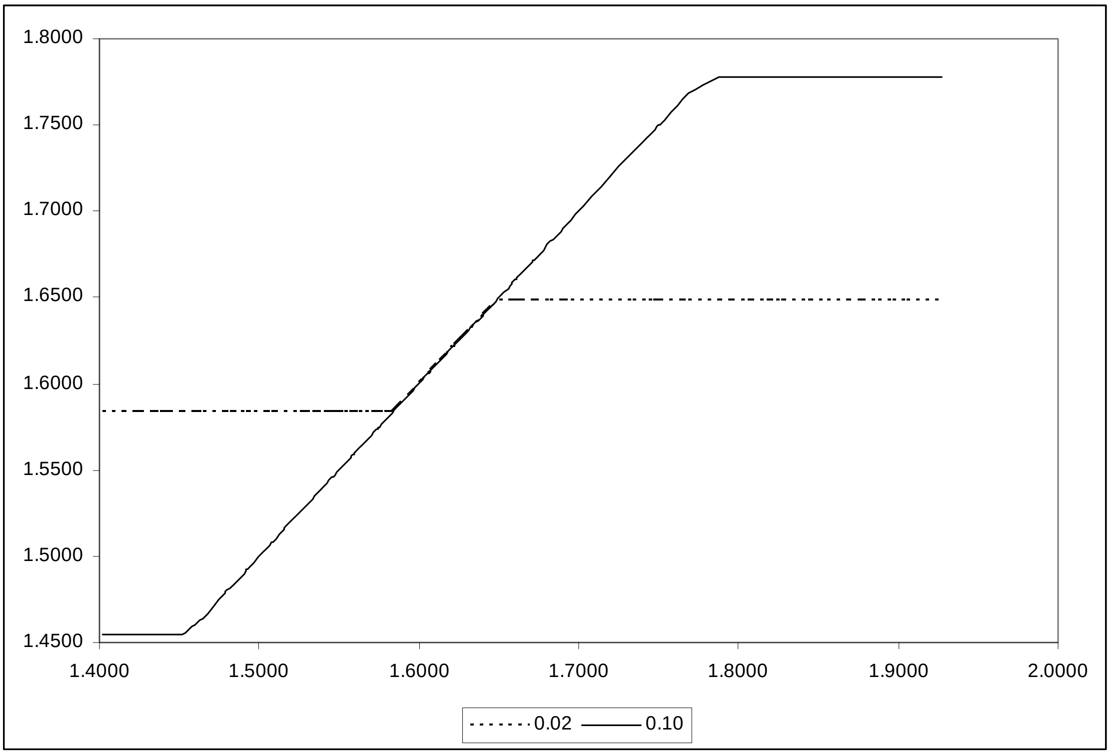

Figure 1: V_x under a Hybrid Arrangement with Equal Weights ($\theta = 0.02, 0.10$, $\beta = 0.50$)

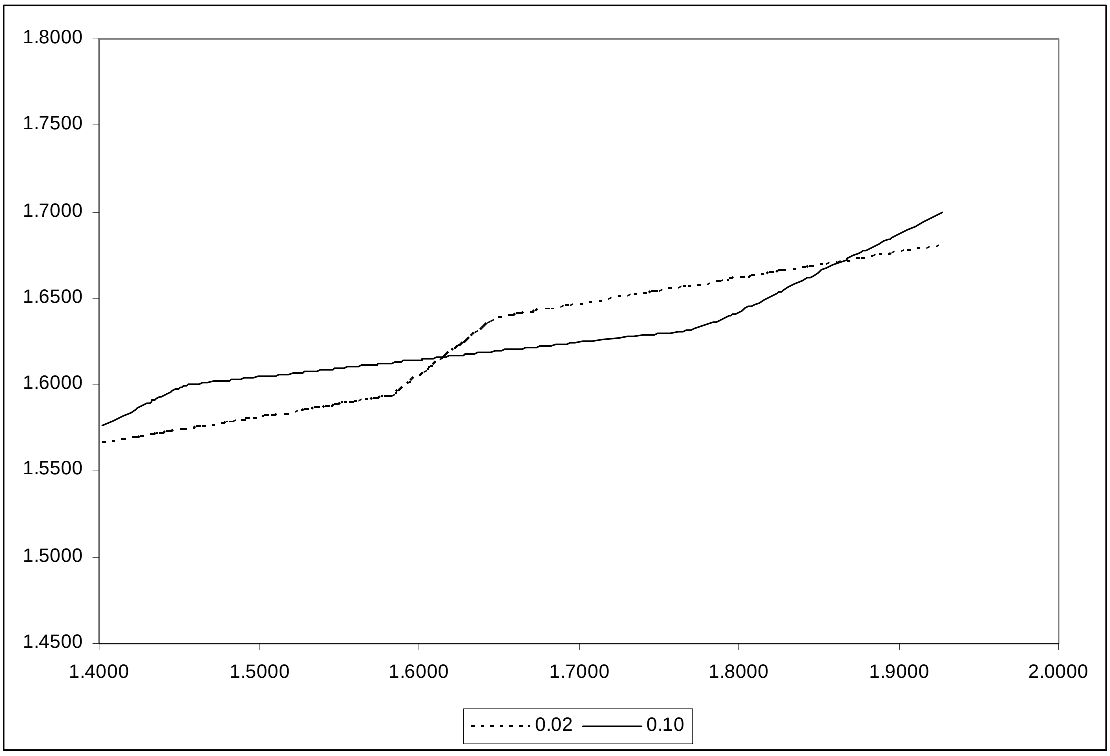

Figure 4: V_x (Max) under a Hybrid Arrangement for Three Values of β

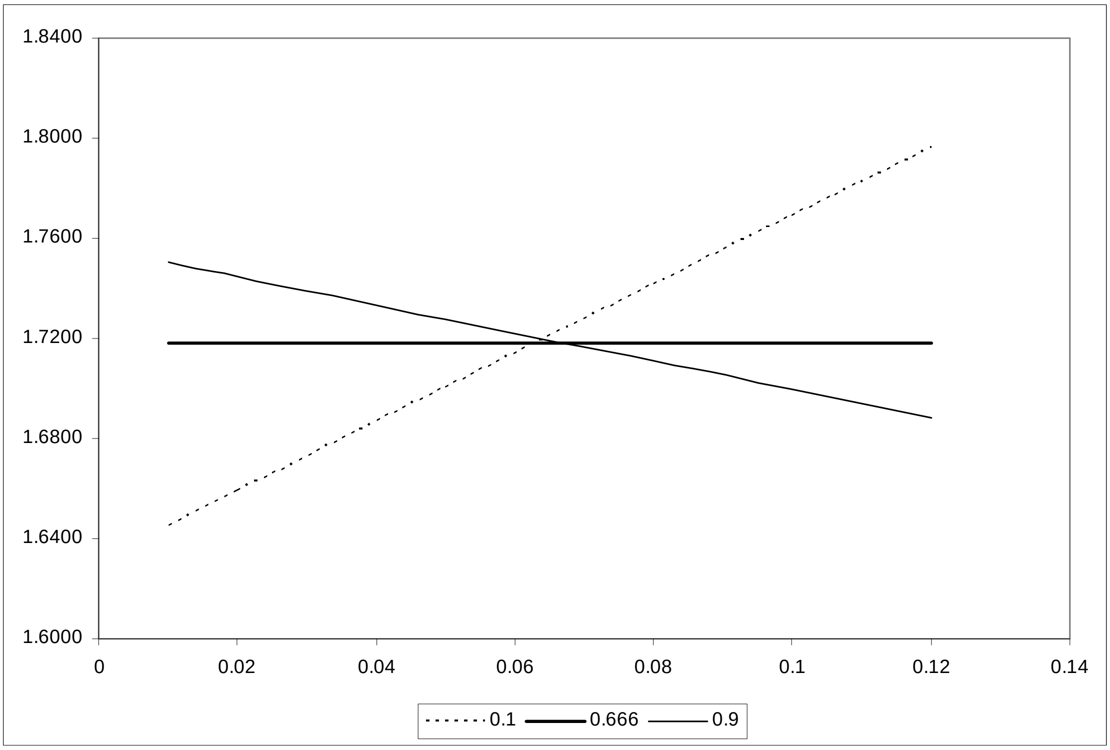

Figure 5: $\sigma^2(V_x)$ under a Hybrid Arrangement for Three Values of β

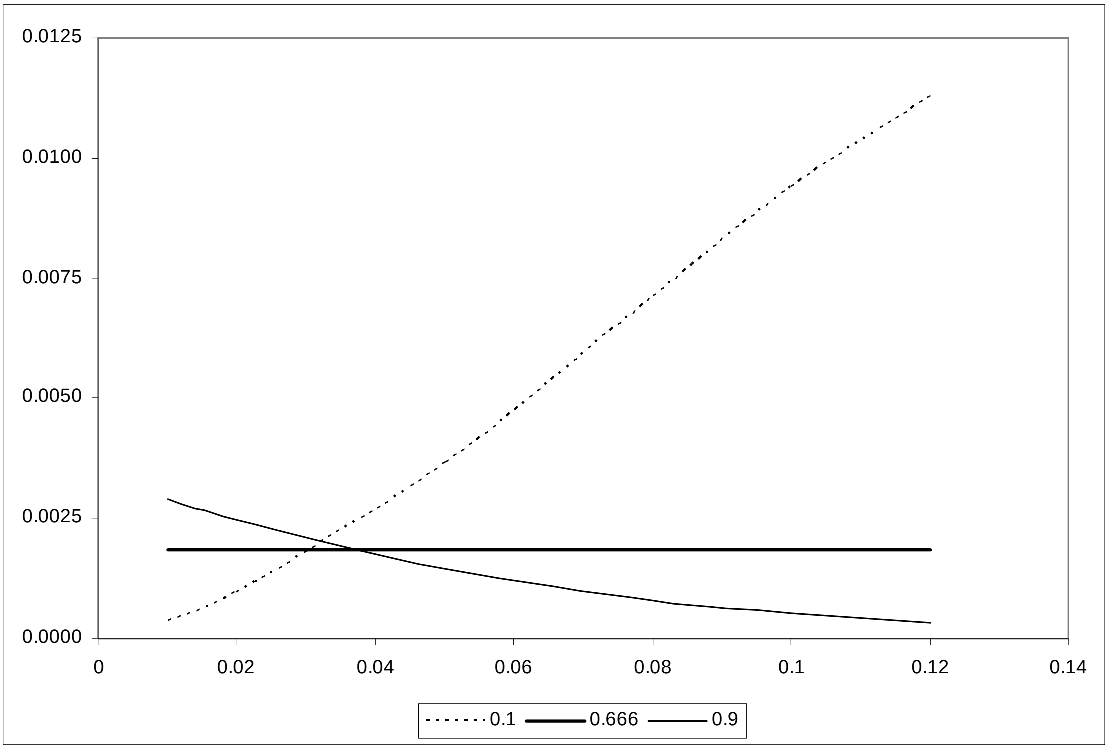

Figure 6: *VR* under a Hybrid Arrangement for Three Values of β

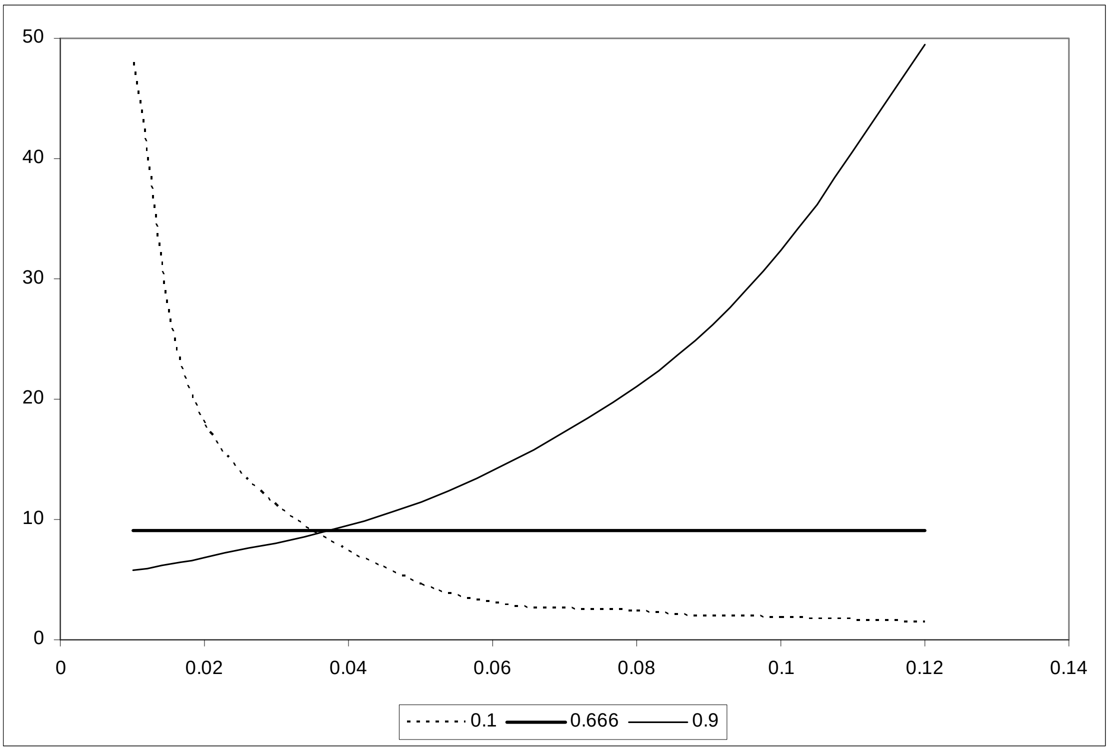

Figure 7: *VD* under a Hybrid Arrangement for Three Values of β