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**Hedging Efficiency of Forward and
Option Currency Contracts**

by

P.E. Korsvold

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ABSTRACT

This paper compares the foreign exchange hedging efficiency of forward and option currency contracts. Previous studies tend to concentrate on the risk reducing aspect only. They suggest that options seldom are more efficient in reducing foreign exchange risk than forwards or futures. The hypothesis of this paper is that this is due to:

- 1) the use of the variance as a risk measure, or
- 2) the assumption that foreign cash flows are non-contingent and certain.

This paper reports the results of an analysis which evaluates hedging alternatives in an expected value - risk space. Risk is measured by a probability-weighted function of deviations below a specific target level. Furthermore, both contingent and non-contingent uncertain foreign currency cash flows are analysed. The analysis shows that options tend to dominate forward contracts. Hence options tend to be preferable if the investor is concerned about avoiding returns below the target level, while forward contracts tend to be preferable if the investor measures risk by the variance. Finally, the maximum risk reduction from using options or forward contracts is not very large, except if the foreign currency cash flow and the exchange rate are highly (positively or negatively) correlated.

This paper was written while the author was visiting Professor, Department of Economics, The University of Sydney

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I. INTRODUCTION

Why might a firm want to use foreign currency options rather than forward contracts in managing foreign exchange risk? Though one may question whether the firm should undertake any foreign exchange risk hedging at all if individual shareholders may do so themselves, firms in fact do undertake such hedging.¹ Furthermore, forward and option contracts have quite different risk hedging properties, and presumably this is a major factor in choosing the appropriate hedging instrument. It therefore seems relevant to investigate the conditions which make the various instruments efficient in managing foreign exchange risk.

Options give the owner (buyer) the right, but not the obligation, to exchange two currencies at a predetermined exchange rate (the exercise or strike price). Forward contracts, on the other hand, give the owner both the right and the obligation to exchange the currencies. Hence one would expect options to be especially useful in hedging the risk associated with contingent foreign currency cash flows.² However, options account only for a very small portion of total world foreign exchange turnover. A study undertaken by the Bank for International Settlements (1990) indicates that gross average daily turnover in foreign currency options in April 1989 counted for only 2.3% of total gross turnover in world foreign exchange markets. During the same period, spot transactions counted for 58.1% while forward transactions counted for 39.6% (of which only 0.4% consisted of futures). However, only about 15% of the turnover consists of business with customers (the remaining consisting of interbank operations). It is therefore unclear what proportion of commercial transactions are undertaken in options, but it is most likely very low.

The kinked payoff profile of an option suggests that the variance of return is not a useful measure of foreign exchange risk when options are used as the hedging instrument. In fact, the variance is probably not a useful measure of risk even for forward hedges because it assumes either that exchange rates are normally distributed or that the investor has a quadratic utility function.³ Hence the purpose of

this paper is to indicate the efficiency of options and forward hedges when some other measure of risk than the variance is used. Specifically, we shall consider the risk measure suggested by Fishburn (1977).⁴

The effectiveness of futures and options as hedging instruments for currency risk has been studied by Ahmadi, Sharp and Walther (1986). Their measure of hedging effectiveness is one-dimensional in that they only consider the risk-reducing ability of the various hedging alternatives. The risk of a hedged position is measured by its Fishburn-risk value. They furthermore assume that the hedger is going to receive a certain foreign currency denominated cash flow in the future. The effectiveness of options and futures are evaluated by using market prices from the Philadelphia Stock Exchange. It is assumed that the hedger engages in naive 1:1 hedges (that is, the hedge amount equals the certain foreign currency cash flow) and that the hedger has a zero target return (that is, the hedger is only concerned about the risk of having a negative return).

Ahmadi et al find that futures provide significantly more effective hedging than single options for the three currencies considered (British Pounds, Deutsche Marks and Japanese Yen). When combined options are allowed (for instance, simultaneously buying a call and selling a put), options provided more effective hedges than futures in a few cases (only for the pound and only for low degrees of risk aversion), but in general there were little differences between options and futures. This result is not very surprising since the payoffs from combined options are very similar to the payoffs from futures. After all, buying a call and selling a put with a common exercise price equal to the forward rate is the same as buying the currency forward (which in itself is similar to buying a future). However, it may seem surprising that single options do so poorly. The main reason is probably that single options are most suited to deal with contingent cash flows, while Ahmadi et al assume that the foreign currency cash flow is certain.

The present paper is similar to that of Ahmadi et al in that it uses the Fishburn measure of risk. There are some differences, however, the major one being that hedging effectiveness in this paper is measured by the expected value-risk dominance of the various alternatives rather than just risk alone. Furthermore, we shall explicitly consider uncertain contingent cash flows. Finally, forward contracts are considered in this paper while Ahmadi et al considered futures. Forward contracts are chosen because most commercial hedging in fact is done by the means of such contracts rather than by futures.

The remainder of the paper is organised as follows: Section 2 determines the domestic currency cash flows from forward and option hedging. Section 3 presents the model for skewed preference analysis. Section 4 determines the expected value-risk dominance of forward and option contracts by means of a scenario analysis. Section 6 contains some concluding remarks.

II. HEDGING FOREIGN EXCHANGE RISK

II.1. Hedging with forward contracts

We have a domestic exporter who expects to receive an uncertain cash flow in foreign currency (L) at some fixed future point in time (we are only considering a one-period analysis). The exporter makes a currency hedge with a forward contract of size F (denominated in the foreign currency). Note that we do not here specify whether the exporter buys or sells the foreign currency forward because this is determined in the solution to the model. The consequent cash flow in domestic currency depends on the value of the uncertain foreign cash flow and the uncertain exchange rate. If the local currency cash flow (L) is negative, we have an importer.

The total amount received in domestic currency (D) is the sum of the unhedged cash flow and the cash flow from the naked forward contract (D_0), or:

$$(1) \quad D = D_u + D_f = L \cdot s + F(f - s)$$

where s is the time t spot exchange rate and f is the present exchange rate for a forward contract with delivery at time t (both rates in direct quote). The expected value and variance of D equal:

$$(2) \quad E(D) = E(D_u) + F(f - E(s))$$

$$(3) \quad V(D) = V(D_u) + F^2 \cdot V(s) - 2F \text{Cov}(D_u, s)$$

We may determine the value of F that minimises the variance by setting the partial derivative of $V(D)$ with respect to F equal to zero. The resulting risk-minimising hedge F^* equals⁵:

$$(4) \quad F^* = \text{Cov}(D_u, s) / V(s)$$

The minimum value for $V(D)$ is found by substituting (4) into (3) and solving for $V(D^*)$:

$$(5) \quad V(D^*) = V(D_u) - \text{Cov}^2(D_u, s) / V(s)$$

From (5) we see that risk is completely eliminated ($V(D^*) = 0$) if either or both of the following two conditions hold:

- 1) If $V(D_u) = 0$ and therefore also $\text{Cov}(D_u, s) = 0$.
- 2) If $\text{Corr}(D_u, s) = \pm 1$, in which case $V(D_u) = \text{Cov}^2(D_u, s) / V(s)$.

The risk-reducing effectiveness of hedging is usually measured as the reduction in home currency variance due to hedging:

$$(6) \quad HE = 1 - V(D) / V(D_u)$$

For the risk-minimising hedge (F^*), we substitute (5) for $V(D)$, which gives:

$$(7) \quad HE^* = \text{Corr}^2(D_u, s)$$

i.e., the absolute value of the correlation coefficient is a measure of the maximum risk reducing hedging efficiency.⁶

Finally, if s and L follow a multivariate normal distribution, it can be shown (see Bohmstedt and Goldberger, 1969) that:

$$(8) \quad F^* = E(L) + E(s) \{ \sigma(L) / \sigma(s) \} \text{Corr}(L, s)$$

where $\sigma(\cdot)$ is the standard deviation. Hence the risk-minimising hedge will be greater than, equal to or less than the expected local cash flow ($E(L)$) according to the sign of the correlation coefficient: $F^* \geq E(L)$ as $\text{Corr}(L, s) \geq 0$.

II.2. Hedging with options

The cash flow in domestic currency from purchasing European call options to receive C foreign currency units (and deliver Cx_c in domestic currency) at time t equals:

$$(9) \quad D_c = C[\max((s - x_c), 0) - c(1 + r)]$$

where x_c is the call's exercise price, c is the premium for a call option contract to purchase one unit of the foreign currency, and r is the domestic risk-free interest rate between time 0 and t .⁷ Since we are evaluating cash flows at time t , we must deduct the compound value of the premium, which is paid at the time the contract is purchased (i.e., at time 0). The cash flow from selling (writing) C call contracts of foreign currency units (i.e., receiving domestic currency) is found by multiplying (9) by -1 and replacing \max with \min .

The cash flow in domestic currency from purchasing European put options to deliver P foreign currency units (and receive $P x_p$ domestic currency) at time t equals:

$$(10) \quad D_p = P[\max((x_p - s), 0) - p(1 + r)]$$

where x_p is the exercise price of the put contract and p is the premium for a put option contract of one unit of the foreign currency. The cash flow from selling (writing) P put contracts of foreign currency units (i.e., delivering domestic currency) is found by multiplying (10) by -1 and replacing \max with \min .

The purpose of purchasing options in our set-up is to hedge against unfavourable future spot exchange rates (i.e., exchange rates below the expected value with a call option and above the expected value with a put option) while at the same time benefiting from favourable exchange rates. Hence the pay-off profile of an option, and the option-hedged cash flow, has a kinked shape. This means that mean-variance analysis is not very meaningful when analysing the consequences of hedging with options. We shall therefore in the next section compare forward and option hedging by using a skewed preference analysis.

III. A SKEWED PREFERENCE ANALYSIS OF HEDGING ALTERNATIVES

III.1. The Fishburn risk measure

Use of options is most likely to be relevant if the firm's shareholders have skewed preferences. However, a mean-variance analysis does not correctly reflect such preferences. An alternative to the mean-variance analysis is to utilise a mean-risk dominance model suggested by Fishburn (1977). In this model "risk is measured by a probability-weighted function of deviations below a specific target return" (Fishburn, p.116).

$$(11) \quad R(\alpha, T) = \sum_i \max(0, T - D_i)^\alpha \text{Prob}_i$$

where:

- $R(\alpha, T)$: The measure of risk with target domestic currency cash flow T and risk-aversion parameter α ;
- α : A measure of risk-aversion for outcomes below the target cash flow T , where $0 < \alpha < 1$ implies risk-seeking behaviour with regard to outcomes below T , $\alpha > 1$ implies risk-averse behaviour, and $\alpha = 1$ implies risk-neutral behaviour;⁸
- T : The target cash flow in domestic currency;
- D_i : The observed domestic currency cash flows.

Hedging alternative A has a lower perceived risk than B if $R_A(\alpha, T) < R_B(\alpha, T)$. Furthermore, alternative A dominates B if $E(D_A) \geq E(D_B)$ and $R_A(\alpha) \leq R_B(\alpha)$ (with at least one inequality holding). This is the relationship we shall use in comparing options and forward contracts. Finally, Fishburn also shows that the α -T efficient set is a subset of the stochastic dominance efficient sets.⁹

In their study of the hedging effectiveness of futures and options, Almadí et al (1986) use the Fishburn measure $R(\alpha, T)$ as a measure of risk. However, they only consider situations where the hedge equals the entire exposure, that is $E(L)$ in our case. They furthermore assume that the hedger wishes to avoid exchange rate losses, and hence the target rate of return is zero.¹⁰ In this study we first use the Fishburn risk measure to calculate the hedge amount in foreign currency which minimises perceived risk $R(\alpha, T)$ for different values of α and option exercise price x . We then determine the expected value-risk efficient set for simple hedge alternatives. A simple hedge alternative is one which only contains the use of one hedging instrument, that is, no combinations of instruments are considered. This allows us to determine which instrument is most efficient in the expected value-risk space.

III.2. Scenario analysis

We shall determine the expected value-variance efficient set of forward and option contracts by utilising a scenario analysis. Various efficient sets are determined by assuming four different states of the world which describe the distributions of the spot exchange rate s and the foreign currency cash flow L . The assumed distribution of s and two alternative distributions of L are shown in Table 1. Furthermore, the distributions of L in Table 1 are assumed to be conditional on the probability that the cash flow will materialise in the first place. This is similar to the situation facing a firm which has submitted a bid for an export order in local currency. The local cash flow will be zero if the bid is rejected by the foreign customer. If the bid is accepted, the local cash flow is stochastic with a positive expected value.¹¹ Hence the distribution of L is conditional on the probability q of having the bid accepted and the probability of the various general economic events.

We shall analyse alternative states of the world by altering the probability of the bid being accepted (q) and the distribution of the unconditional local cash flow (L). Two alternative values of q and L will be used: $q = .2$ (as in our example above), $q = 1$ (that is, the domestic firm has a certain export contract), L certain and L uncertain. We hence get the following four states of the world:

	Certain L	Uncertain L
$q = 1.0$	State I	State III
$q = 0.2$	State II	State IV

IV. EXPECTED VALUE - RISK DOMINANCE

Two sets of calculations are undertaken: First, for each state of the world and for a limited set of risk-aversion parameters (α) and option exercise prices (x). Second, for a given state of the world (State IV) with a variety of risk-aversion parameters (α), probability of bid being accepted (q), and correlations between the domestic cash flow and the spot exchange rate ($\text{Corr}(L,s)$).

IV.1. Varying states, risk-aversion and exercise price

The efficient set is calculated for each hedging alternative (forward and European calls and puts) for each of the four states of the world. Two targets (T) are initially used:

- 1) **Low value:** This is 140 for State I, 32 for State II (equals $E(D_u)$ for this state of the world), 120 for State III, and 32.192 for State IV (equals $E(D_u)$ for this state of the world).
- 2) **High value:** This is 160 for States I, II, and IV (equals $E(D_u)$ for State I) and 160.96 for State III (equals $E(D_u)$).

Values of α range from 1.0 to 2.0, and option exercise prices range from 1.50 to 1.80.

Option premia are calculated by using the European currency option model developed in Garman and Kohlhagen (1983). The version used here is the one given in Hull (1989).¹² The analysis uses the distribution of s given in Table 1 (i.e., $E(s) = 1.60$). It is assumed that the forward rate is 1.60, which equals the expected spot rate (i.e., uncovered interest parity is assumed to hold).¹³ Furthermore, the foreign risk-free interest rate is calculated by assuming that covered interest parity prevails (this gives a foreign risk-free one-period interest rate of 26.19% p.a.) with our data. Finally, the option premia are calculated by using the option program EUROPR accompanying the teacher's manual to Hull (1989). The following input values are used:

Current spot exchange rate = 1.70

Domestic risk-free interest rate = 10% p.a.

Volatility of exchange rate = 10% p.a.

Maturity = 4 months

This gives the option premia shown in Table 2

The minimum-risk hedge for each of the three instruments are shown in Figures 1A and 1B for State IV, target level 160 ($\alpha = 1$ in Figure 1A and $\alpha = 2$ in Figure 1B).¹⁴ The calculations indicate that options are superior risk-minimising instruments compared with forward contracts. In fact, in the cases shown in the figures, the risk-minimising forward contract only marginally reduces risk from the unhedged position (= 100 on the vertical axis). The reason for this is the low value of the covariance between the unhedged cash flow and the spot exchange rate (the term $\text{Cov}(D_w, s)$ in expression (5) above) which again is primarily due to the low probability that the bid will be accepted ($q = .2$). Finally, put options provide the greatest risk reduction for exercise prices equal to or below the forward rate, while call options provide the greatest risk reduction for exercise prices above the forward rate.

The superiority of call options for high exercise prices may seem surprising given that the expected foreign currency cash flow is positive (i.e., the firm expects to receive foreign currency). The explanation is that the risk minimising call option hedges for high exercise prices require very large hedges (1350 foreign currency units for $x = 1.8$ in Figure 1A and 1267 in Figure 1B). Given the high target level and the low probability of getting the bid ($q = .2$), this implies that even the horizontal portion of the call pay-off profile dominates the downward sloping portion of the pay-off profile of the put.

The next set of calculations determine the single instrument (simple hedge) efficient sets for the following combinations of parameter values:

States of the world: I, II, III, IV

Target: Low value, high value (see above)

Alpha: 1.0, 1.5, 2.0

Exercise price: 1.5, 1.6, 1.8

Combinations of these values give a total of 72 scenarios, though only 9 are shown here in Figures 2 - 5.¹⁵

Changing the exercise price:

Figures 2A - C show the effect on the simple hedge efficient sets as we increase the exercise price. With a low exercise price the put option dominates the call option, and with a high exercise price the call dominates the put. The forward contract is dominated by the options in every instance.

Changing the alpha:

Figures 3A - C show the effect on the simple efficient sets as we change the risk aversion to outcomes below the target. With the exercise price set at 1.6, the dominance of the put over the call is maintained as we decrease α . In fact, the put dominance increases as α decreases. Similarly, the dominance of the call at the exercise price of 1.8 is maintained as we decrease α (the relevant figures are not shown).

Changing the state of the world:

Figure 4A shows the simple hedge efficient sets for State I (Target = 160, $\alpha = 2$, Exercise = 1.6). The similar efficient sets for states II and III are shown in Figures 4B and 4C (note the target is 160.96 in Figure 4C). The efficient

set for State IV is shown in Figure 3A above. As for State IV, the options clearly dominate the forward contracts in State II. However, in State I and III the forward contracts dominate for low risk levels, though only barely so. This confirms the intuition presented in the introduction that options ought to be preferable to forward contracts for contingent cash flows, that is, for low values of q (States II and IV).

Changing the target level:

Figure 5A and B indicate that options dominate forward contracts as we change the target level. However, the dominance of the put over the call contracts is reduced as we reduce the target level for State IV (the exercise price is set at 1.6). In fact, as the target level becomes low, there is no difference between the two options (Figure 5B). Finally, for exercise prices 1.5 and 1.8 (these are not shown here) the dominance of respectively the put contract and the call contract is not changed.

IV.2. Varying risk-aversion, probability of bid and correlation L and s

The calculations are performed under the following assumptions:

- 1) The common option exercise price (x), the forward rate (f), the expected spot rate ($E(s)$), and the current spot rate (s_0):
 $x = f = E(s) = s_0 = 1.6$
- 2) The risk-aversion parameter (α): 1.0, 1.5, 2.0
- 3) The probability of the bid (q): 1.0, .8, .6, .4, .2
- 4) The distribution of local cash flows are altered by assuming the following values for the correlation between local cash flows and the spot exchange rate ($\text{Corr}(L,s)$): 1.0, .5, 0, -.5

- 5) The target level (T) is set equal to the expected value of the unhedged domestic currency cash flow: $T = F(D_0)$

These assumptions give different expected values for unhedged cash flows ($E(D_0)$) and therefore different target values (T), depending on the combination of $\text{Corr}(L,s)$ and q . The target values used in the analysis are shown in Table 3.

A number of efficient sets are calculated to determine the order of dominance between hedging the foreign exchange risk with puts, calls or forward contracts (or doing nothing). Though the efficient set has been calculated for a large number of scenarios, only a few are shown below in Figures 6 - 9. We may draw the following conclusions:

1. Changes in probability of bid (q) (Figures 6A - C):
Puts dominate calls for high q and equal calls for low q . Puts generally also dominate forwards, except for high values of $\text{Corr}(L,s)$ and small risk levels (see Figure 6A).
2. Changes in risk-aversion (α) (Figures 7A - C):
The value of α does not alter the order of dominance of the various hedging instruments. This order is primarily determined by the value of q (as shown above).
3. Changes in the correlation between local cash flow and the spot rate ($\text{Corr}(L,s)$) (Figures 8A - C):
The value of $\text{Corr}(L,s)$ does not alter the order of dominance of the various hedging instruments.

4. Changes in target level (T) (Figures 9A - C):

For our chosen level of q ($= .2$), α ($= 2.0$), and $\text{Corr}(L,s)$ ($= .5$), puts dominate forwards for all target levels, and they dominate calls for high target levels.

Finally, a quick examination of Figures 6A - C indicates that the risk-reducing effect of hedging is very small, except for high values of $\text{Corr}(L,s)$. Typically the risk-minimising hedge has a risk level of at least 90% of the no hedge strategy. Significant reductions in risk are only achieved for very high absolute levels of $\text{Corr}(L,s)$ (compare for instance Figure 6A with 6B and 6C). This is similar to the condition for risk minimisation in a mean-variance framework, where it was shown in (7) that the risk-reducing effectiveness of hedging equals $\text{Corr}^2(D,s)$.

V. CONCLUSIONS

Comparisons of forward with option hedging of foreign currency denominated cash flows has been undertaken by scenario analysis. Hedging of both contingent and non-contingent cash flows were considered. Traditional analysis shows that forward contracts are more efficient than options in reducing risk, even for contingent foreign cash flows, if investors measure risk by the variance. However, the variance is probably not an appropriate measure of risk for investors who use options. Hence expected value-risk calculations are performed where risk is measured by a probability-weighted function of deviations below a specified domestic currency target level. In this case the options tend to dominate both for contingent and non-contingent cash flows. However, the level of risk reduction is not very high even for the risk-minimising hedge. The exception is when the absolute level of $\text{Corr}(L,s)$ is close or equal to 1.

The analyses are only performed for simple hedges, that is, no combinations of put and call options are allowed. This is probably not a very serious restriction, however, for two reasons:

- 1) The simple option hedges tend to dominate forward contracts;
- 2) Combinations of options (put plus call) are very similar to forward hedges. Some put-call combinations may dominate forward contracts even more than the simple hedges, of course, but that only reinforces the argument that option contracts are efficient hedging instruments.

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FOOTNOTES

1. Froot, Scherfstein and Stein (1992) develop a model where firms find hedging desirable:
"The basic force that drives all our results is a capital market imperfection that makes externally-obtained funds more expensive than those generated internally." (p. 2)

They furthermore suggest that hedging by firms may be explained by various managerial motives, taxes and costs of financial distress and debt capacity.
2. Some examples are given in Giddy (1983)
3. Shapiro and Titman (1985) present arguments for the use of the variance as a measure of risk.
4. The Fishburn measure of risk will be discussed in detail in section 3 below, but briefly it assumes that the investor is only concerned about the risk of an investment's return falling below some given target level.
5. The risk-minimizing hedge F^* is identical to the value determined by Adler and Dumas (1984), who use the following index model:
$$D_u = a + bs + e$$
where e is a random error term with zero expected value and covariance with s .

The risk-minimizing hedge equals the regression coefficient b :
$$b = \text{Cov}(D_u, s) / V(s) = F^*$$

Kerkvliet and Moffett (1991) develop similar expressions to those in this paper for futures contracts.
6. A richer measure of hedging effectiveness would also have to consider the effects on expected domestic cash flow ($E(D)$). This is in effect done in this paper by evaluating the expected value-risk dominance characteristics of various hedges.
7. It is assumed in the paper that one option contract involves the option to purchase or deliver one foreign currency unit.
8. "Given T , α is supposed to reflect the decision maker's feeling about the relative consequences (personal, corporate, etc.) of falling short of T by various amounts. If his main concern is failure to meet the target return without particular regard to the amount, then a small value of α is appropriate. On the other hand, if small deviations below target are relatively harmless when compared to large deviations, then a large value of α is indicated"(Fishburn, 1977, p. 119). Note that the values $\alpha = 2$ and $T = E(D)$ give the semivariance.

9. "Except for distributions with equal means and equal risks, the efficient set for the α - t (Fishburn uses t for the target value) model is a subset of the PSD efficient set for all $\alpha \geq 0$, the α - t efficient set is a subset of the SSD efficient set for all $\alpha \geq 1$, and the α - t efficient set is a subset of the TSD efficient set for all $\alpha \geq 2$." (Fishburn, 1977, pp 123-124).
10. In our context this amounts to setting the target equal to $E(L)s_0$, i.e., the expected cash flow in domestic currency assuming no exchange rate change.
11. There is always a possibility that the exporter does not receive the full (expected) value of the export order. This might happen if, for instance, there is some fault with the quality of the exported product or if the foreign importer goes bankrupt. The exporter may insure itself against such commercial risks by using a letter of credit (at a cost), but this is not considered in this paper.
12. The call and put premia, assuming that covered interest parity prevails, equal:
$$c = e^{-rt}(f \cdot N(d_1) - x_c \cdot N(d_2))$$

$$p = e^{-rt}(x_f(1 - N(d_1)) - f(1 - N(d_2)))$$
where $N(d)$ is the cumulative probability distribution function for the standardized normal variable d , and:
$$d_1 = \frac{(\ln(s_0/x_c) + (r - r_f + \sigma^2/2)t)}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

 $r_f =$ the foreign risk-free interest rate at time 0 with maturity date t ,
 $s_0 =$ the spot exchange rate at time 0,
 $\sigma =$ the volatility of the spot exchange rate s (at time t).
13. This is done to simplify the comparisons with option hedges. The effect of the assumption is that the expected value in domestic currency ($E(D)$) for a forward hedge is unaffected by the size of the hedge F . Only the risk is hence affected by F .
14. The results for the other three states of the world, and for other target levels, are quite similar to those shown in Figures 1A and 1B. Though not shown here, they may be obtained from the author upon request.
15. Results for other combinations may be obtained from the author upon request.

TABLE 1:
THE PROBABILITY DISTRIBUTIONS OF THE SPOT EXCHANGE RATE (s)
AND THE LOCAL CASH FLOW (L)

Event	Probability	Spot rate (s)	Certain local cash flow	Uncertain local cash flow
1	.1	1.28	100	90
2	.2	1.44	100	95
3	.4	1.60	100	100
4	.2	1.76	100	105
5	.1	1.92	100	110
		$E(s) = 1.60$		

TABLE 2:
OPTION PREMIA

Exercise price:	1.50	1.55	1.60	1.65	1.70	1.75	1.80
Call	.1031	.0649	.0359	.0172	.0070	.0024	.0007
Put	.0058	.0162	.0359	.0658	.1044	.1485	.1955

TABLE 3:
TARGET VALUES (T) AS A FUNCTION OF CORR(L,s) and q

Corr(L,s):	1.0	.5	0	-.5
q:				
1.0	160.960	160.480	160	159.520
.8	128.768	128.384	128	127.616
.6	96.576	96.288	96	95.712
.4	64.384	64.192	64	63.808
.2	32.192	32.096	32	31.904

FIGURE 1A: RISK DOMINANCE - STATE IV
TARGET = 160, ALPHA = 1
Data points: Expected values

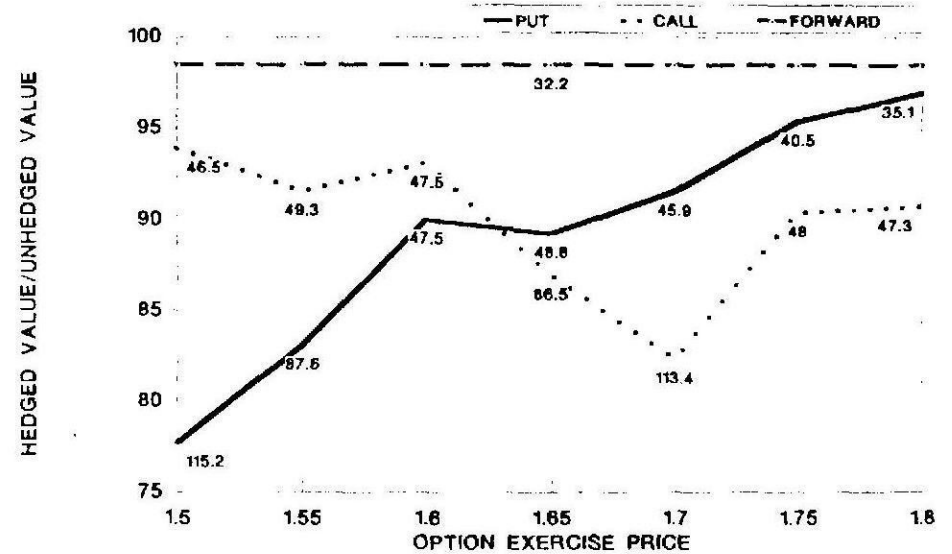


FIGURE 1B: RISK DOMINANCE - STATE IV
TARGET = 160, ALPHA = 2
 Data points: Expected values

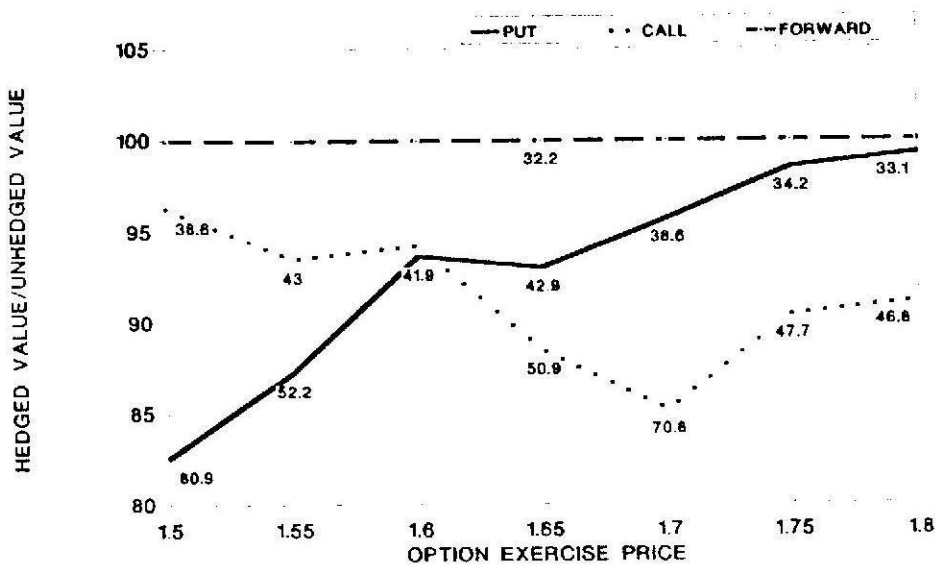


FIGURE 2A: EXERCISE = 1.5
STATE = IV
TARGET = 160, ALPHA = 2

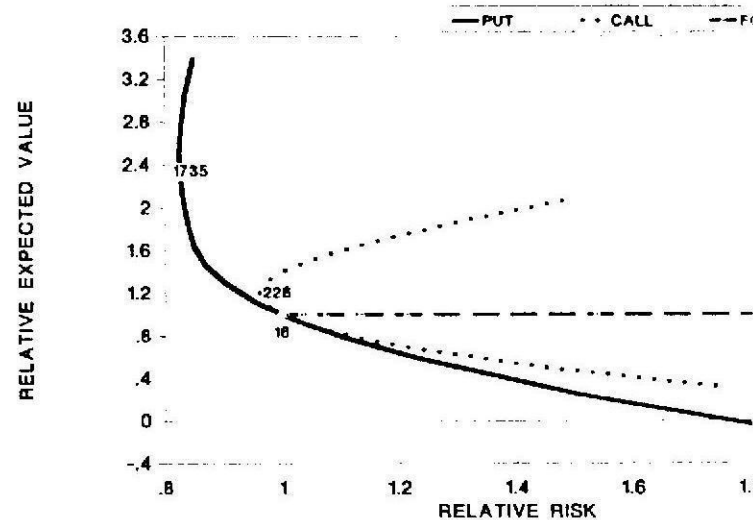


FIGURE 2B: EXERCISE = 1.6
STATE IV
TARGET = 160, ALPHA = 2

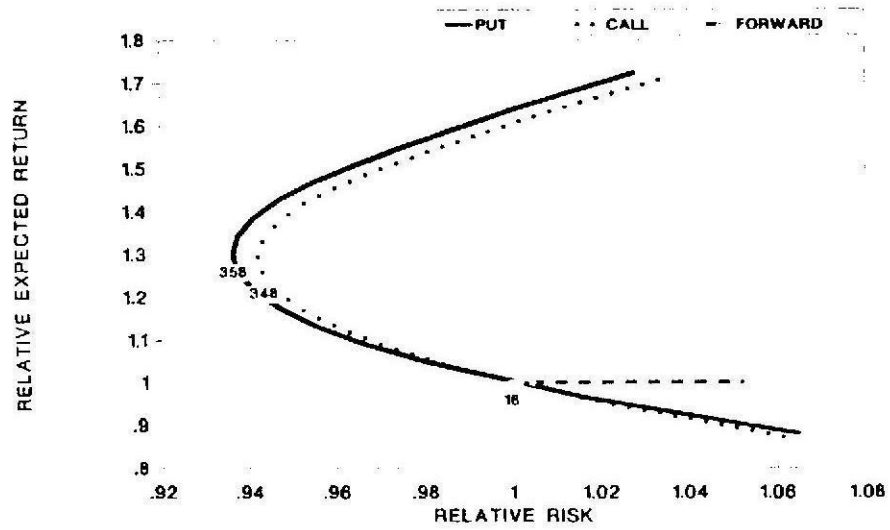


FIGURE 2C: EXERCISE = 1.8
STATE IV
TARGET = 160, ALPHA = 2

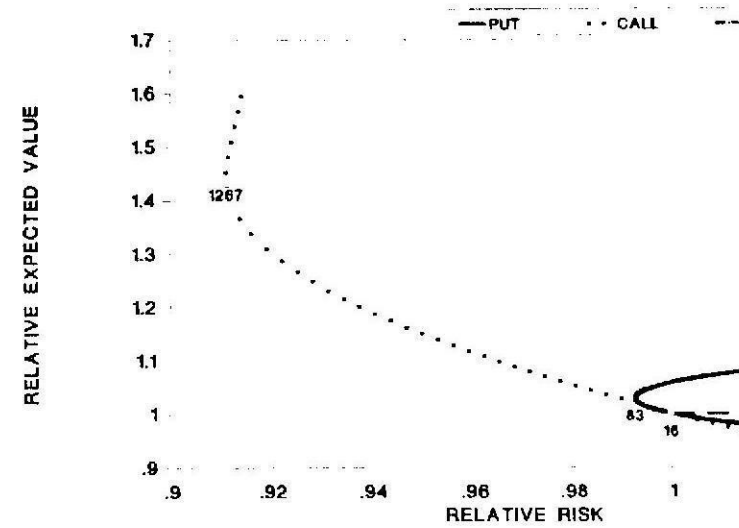


FIGURE 3A: ALPHA = 2
 STATE IV
 EXERCISE = 1.6, TARGET = 160

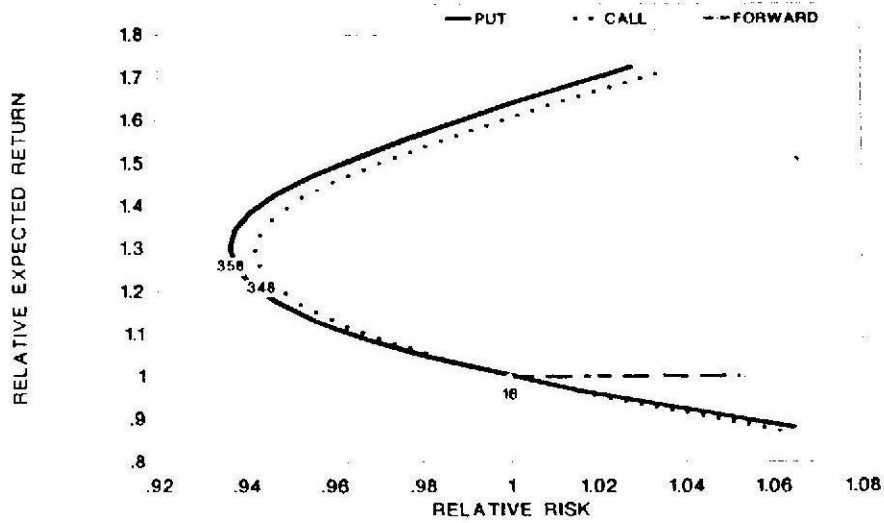


FIGURE 3B: ALPHA = 1.5
 STATE IV
 EXERCISE = 1.6, TARGET = 160

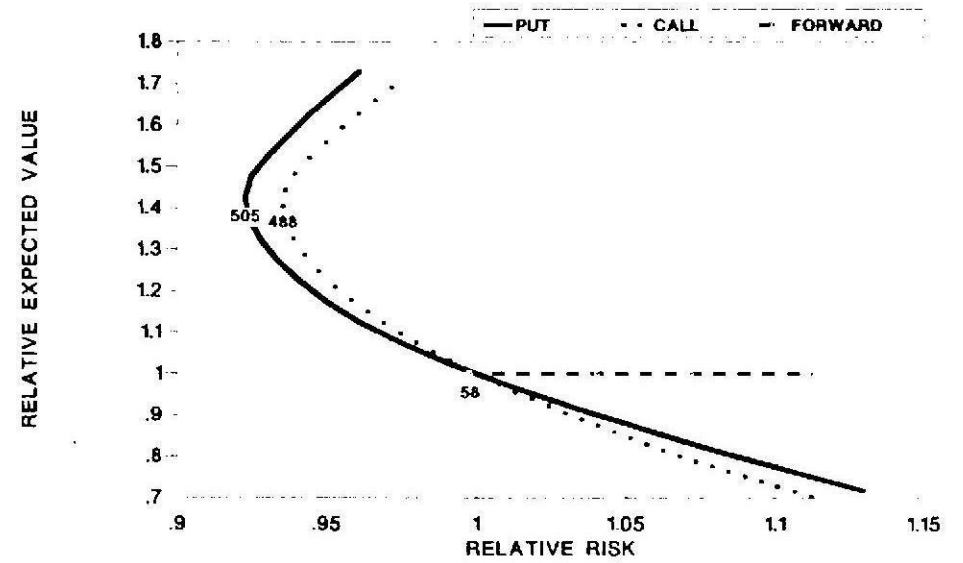


FIGURE 3C: ALPHA = 1
STATE IV
EXERCISE = 1.6, TARGET = 160

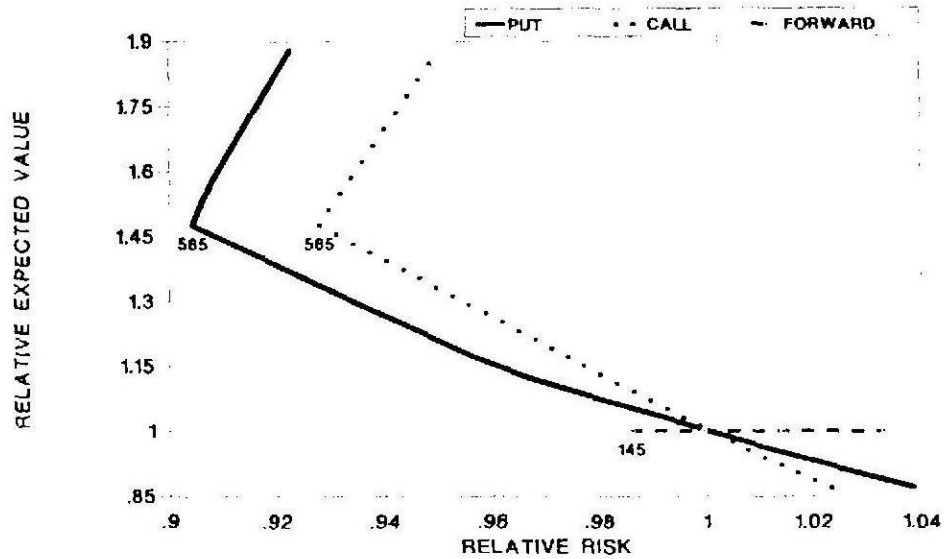


FIGURE 4A: STATE I
TARGET = 160
EXERCISE = 1.6, ALPHA = 2

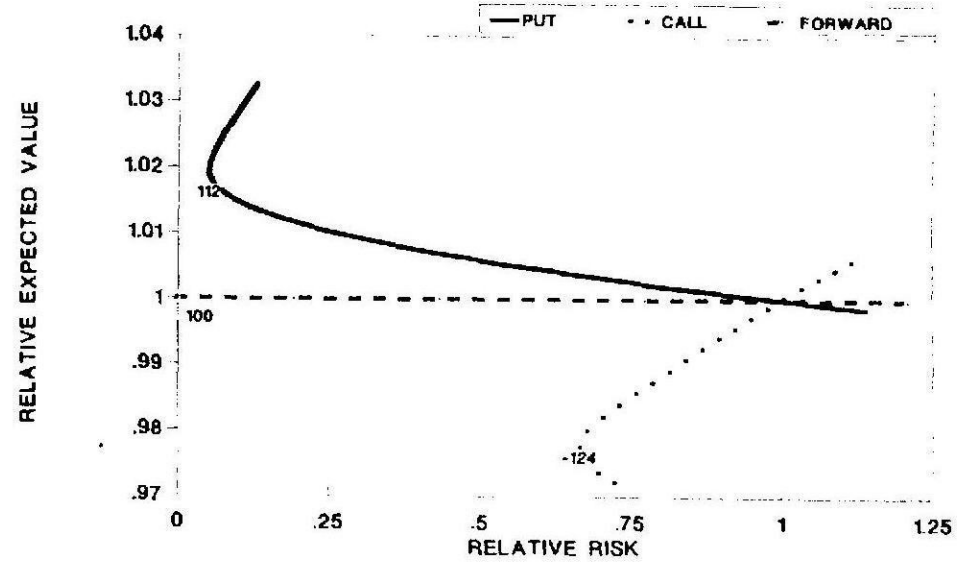


FIGURE 4B: STATE II
 TARGET = 160
 EXERCISE = 1.6, ALPHA = 2

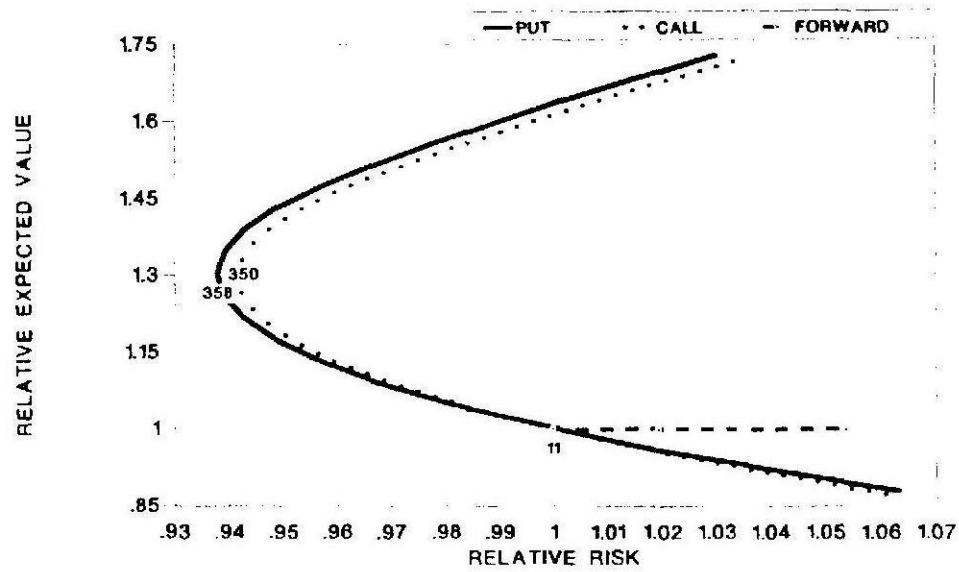


FIGURE 4C: STATE III
 TARGET = 160.96
 EXERCISE = 1.6, ALPHA = 2

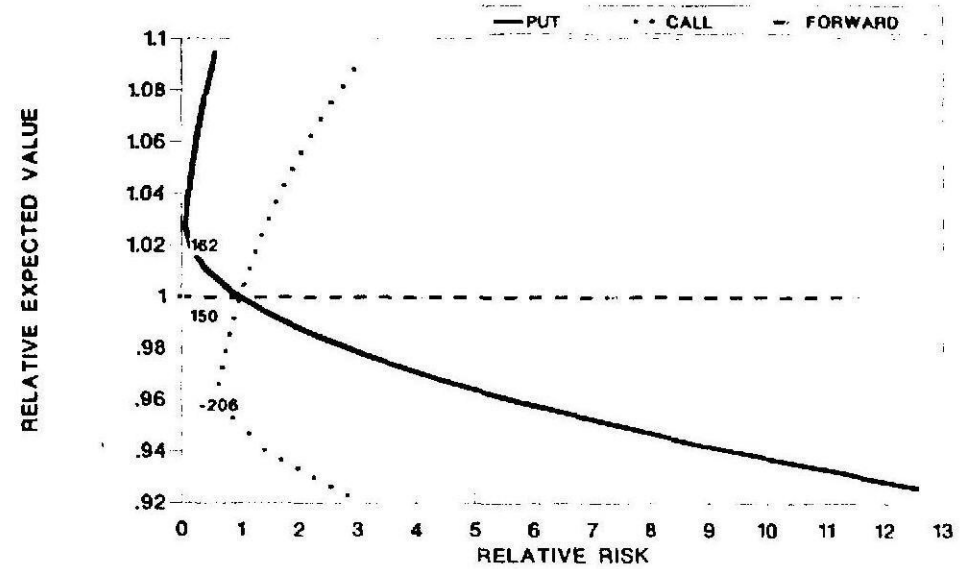


FIGURE 5A: TARGET = 160
STATE IV
EXERCISE = 1.6, ALPHA = 2

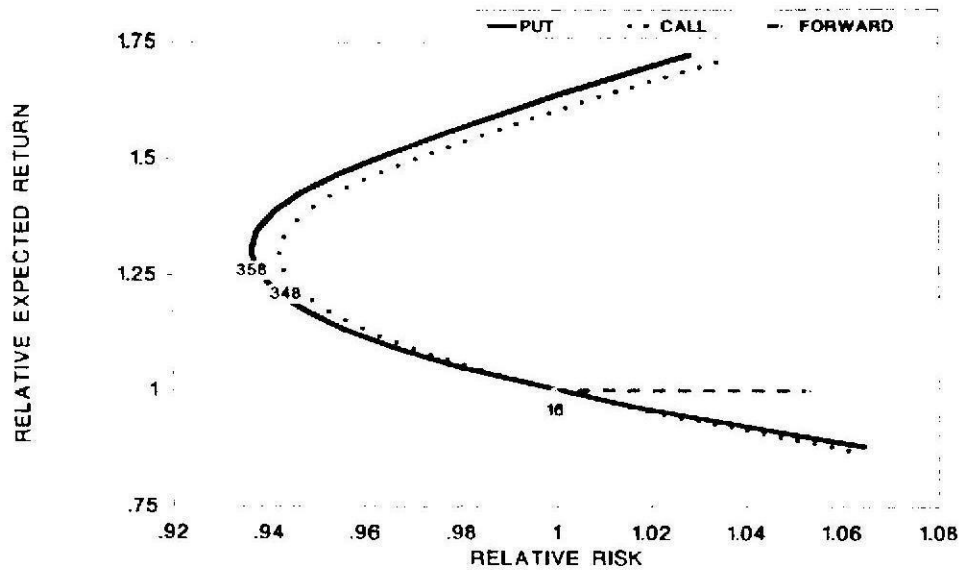


FIGURE 5B: TARGET = 32.192
STATE IV
EXERCISE = 1.6, ALPHA = 2

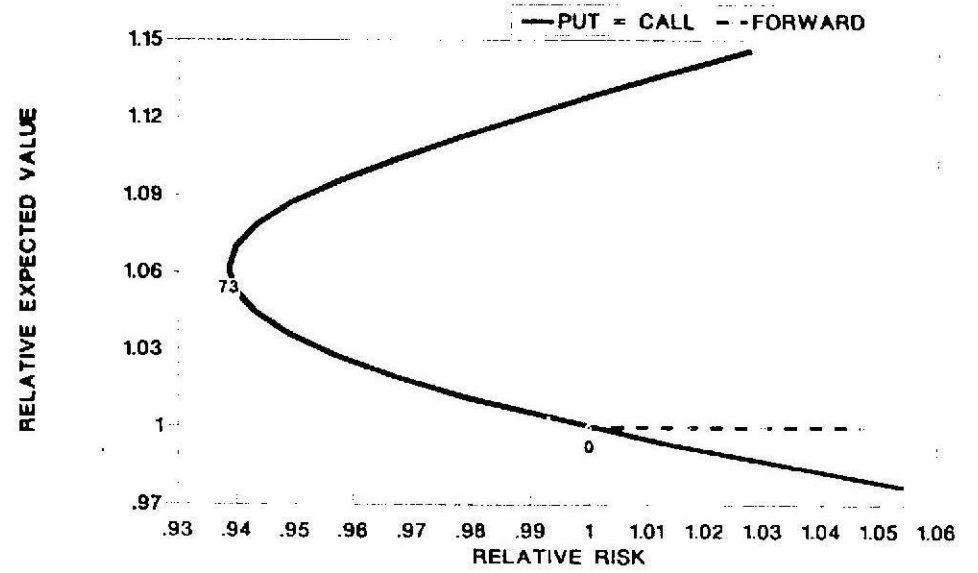


FIGURE 6A: $q = 1.0$
TARGET = 160.96

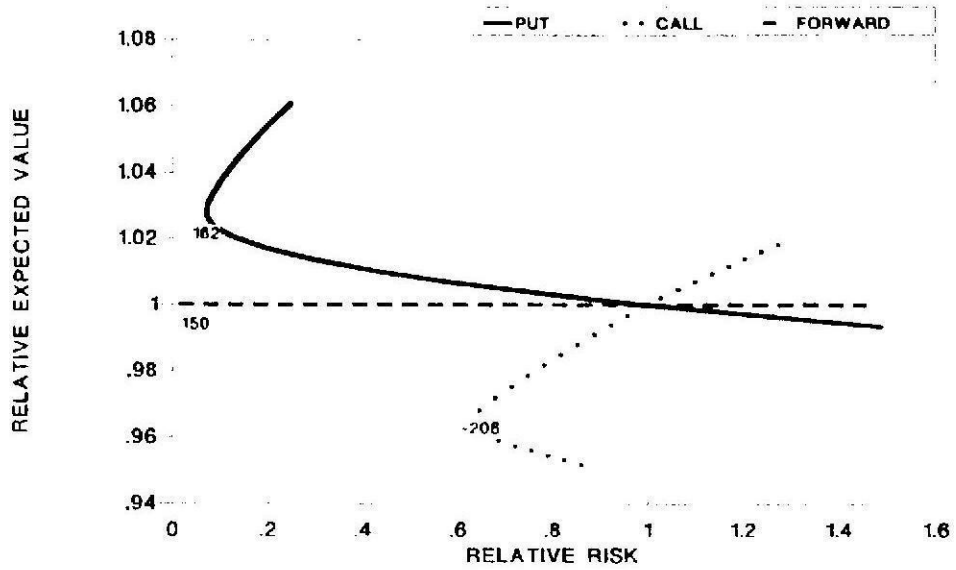


FIGURE 6B: $q = .8$
TARGET = 128.768

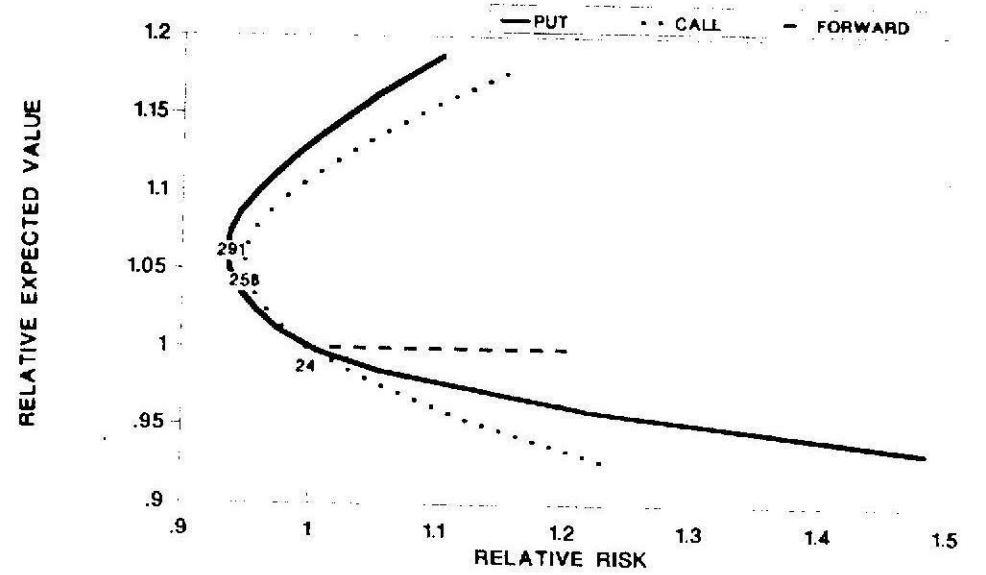


FIGURE 6C: $q = .4$
TARGET = 64.384

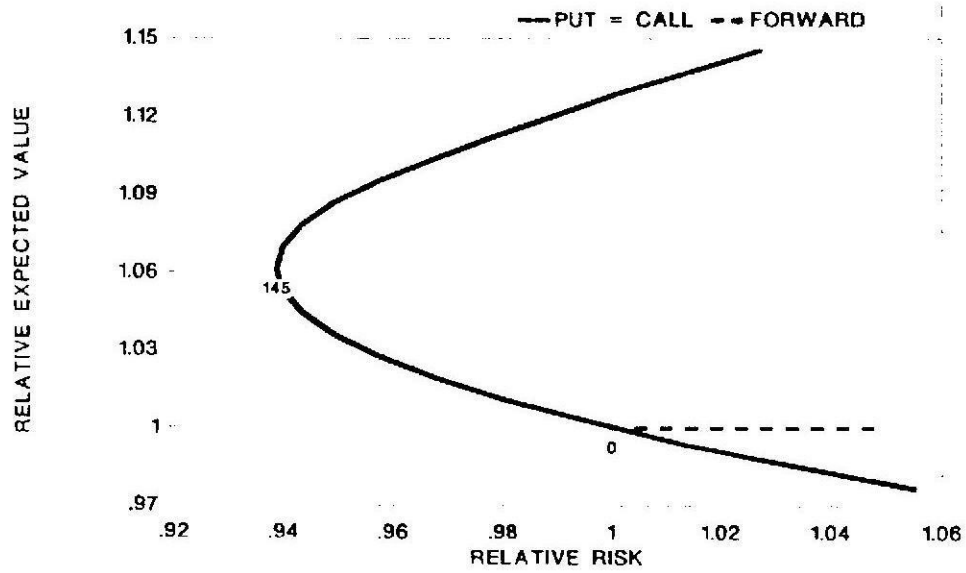


FIGURE 7A: ALPHA = 1.0
TARGET = 128.384

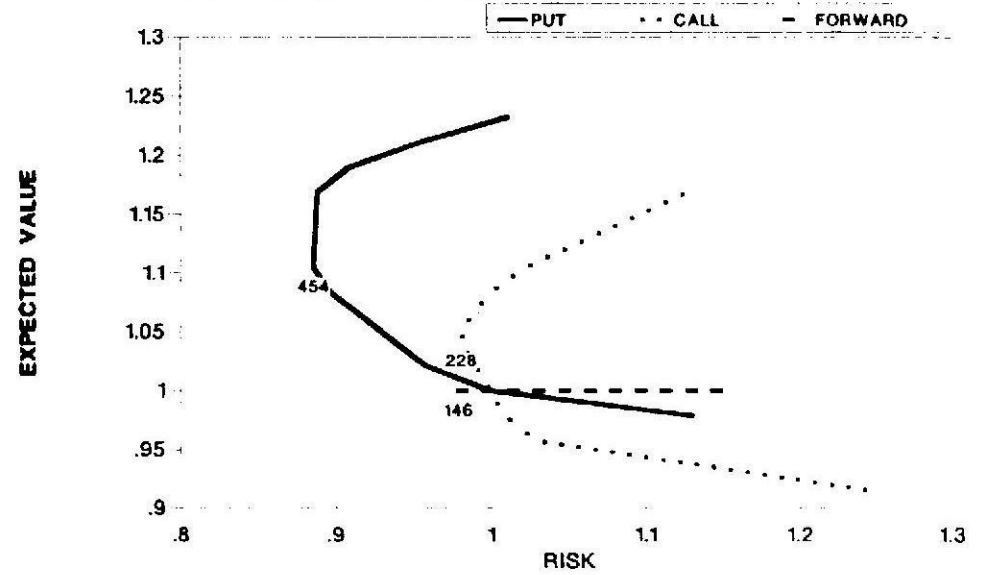


FIGURE 7B: ALPHA = 1.5
TARGET = 128.384

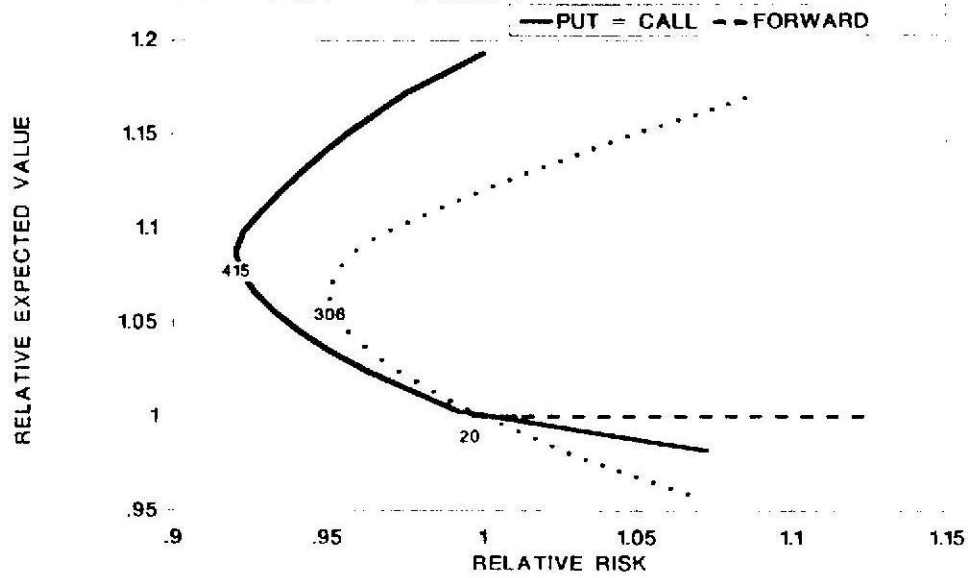


FIGURE 7C: ALPHA = 2.0
TARGET = 128.384

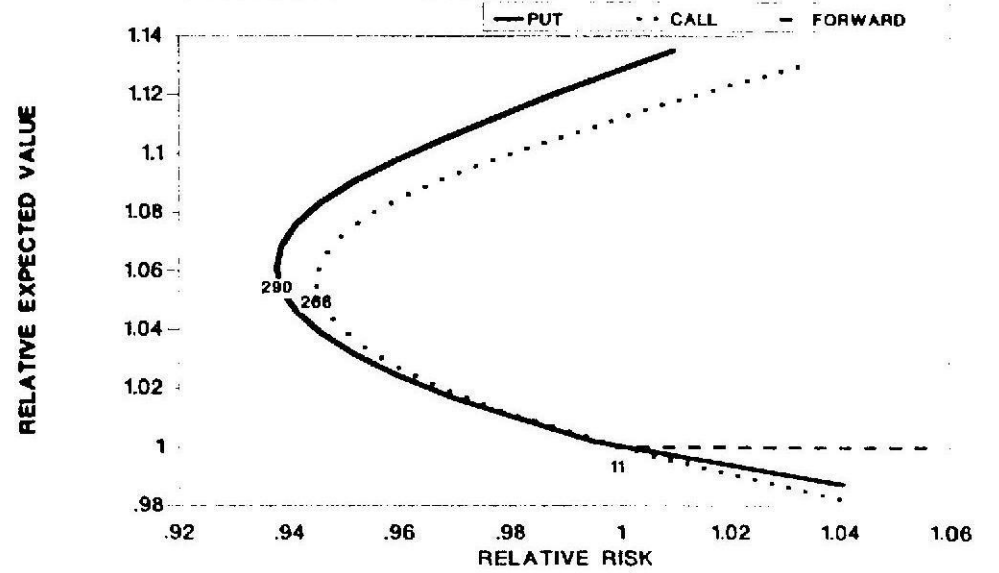


FIGURE 8A: $\text{CORR}(L,s) = 1.0$
 TARGET = 128.768

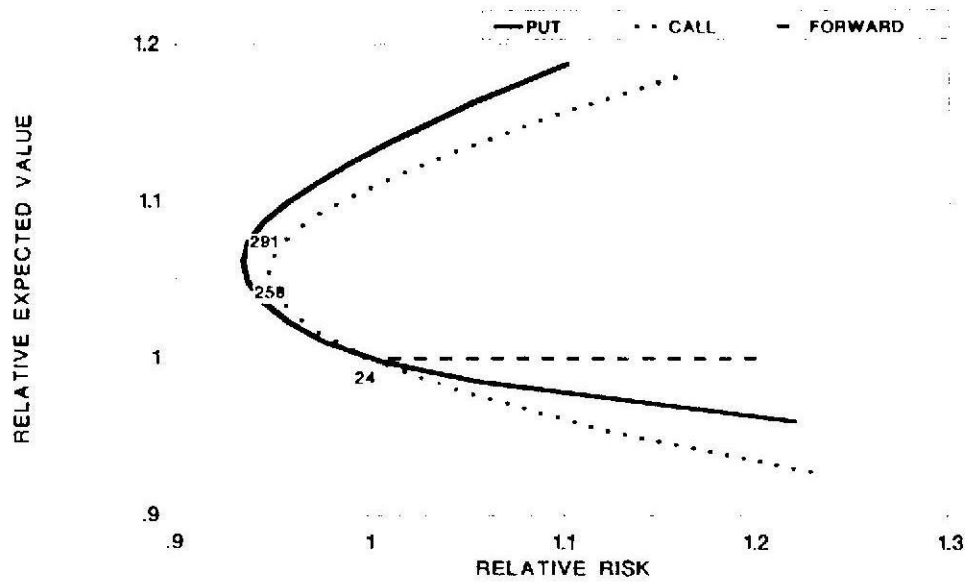


FIGURE 8B: $\text{CORR}(L,s) = .05$
 TARGET = 128.384

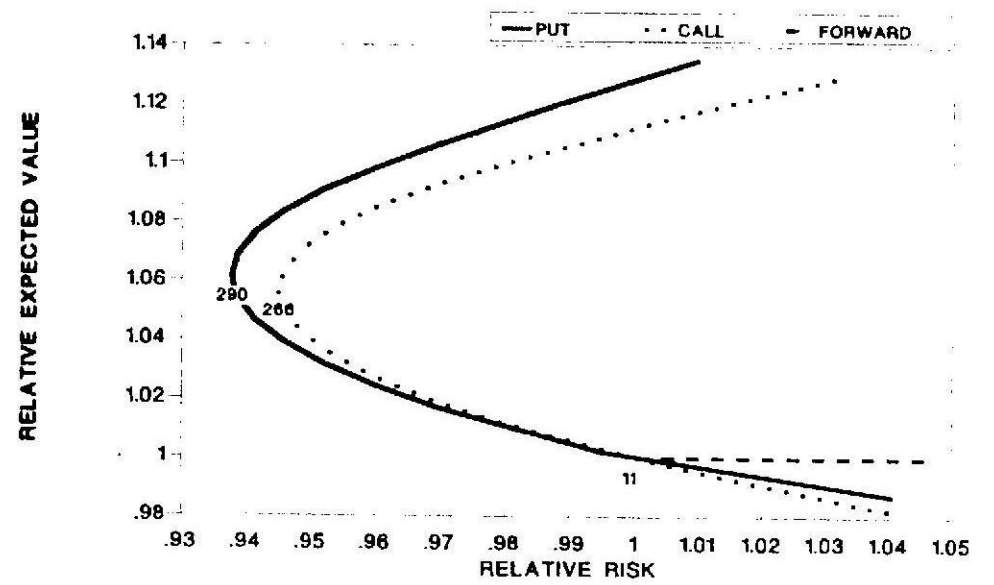


FIGURE 8C: $\text{CORR}(L,s) = -.05$
 TARGET = 127.616

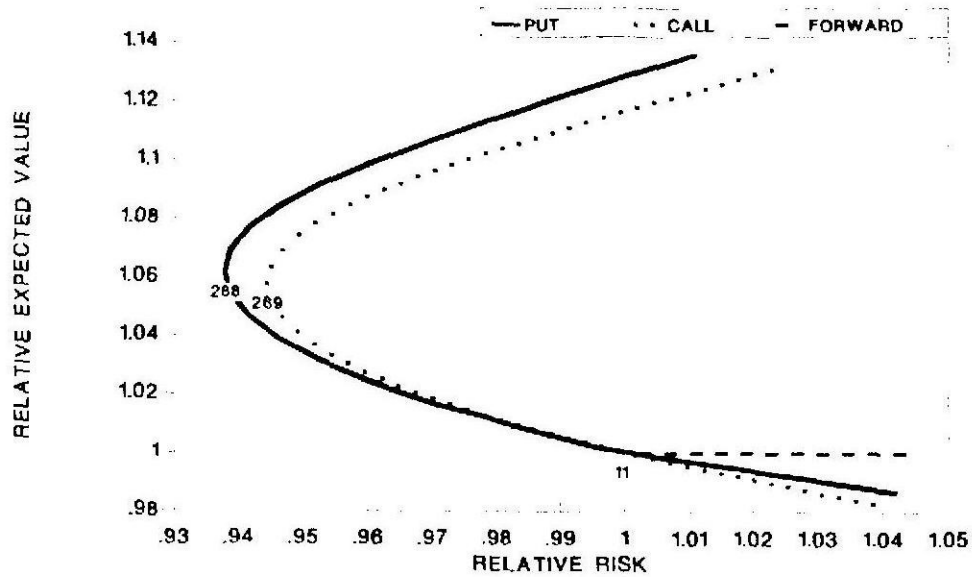


FIGURE 9A: TARGET = 10
 $Q = .2$, $\text{ALPHA} = 2$, $\text{CORR}(L,s) = .5$

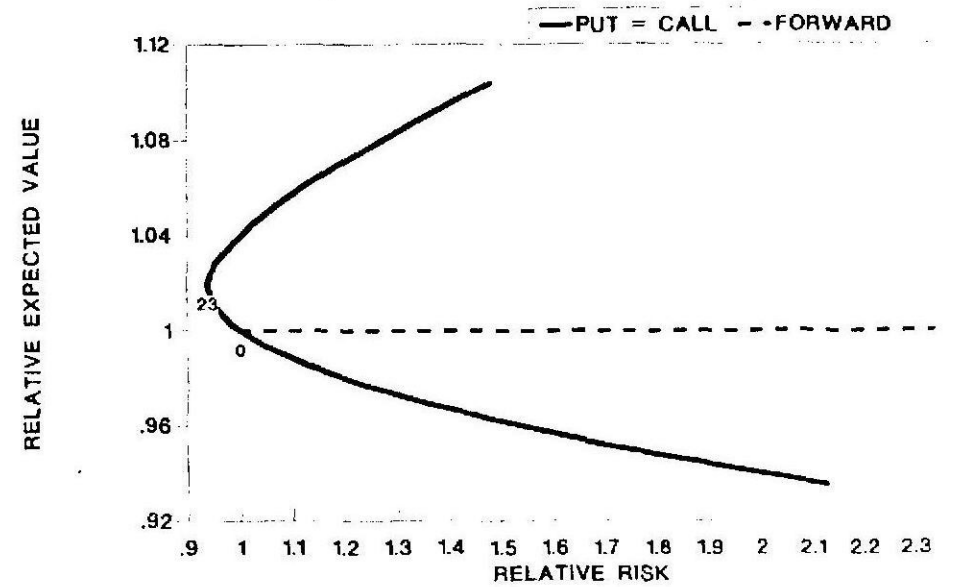


FIGURE 9B: TARGET = 100
 $Q = .2$, $\text{ALPHA} = 2$, $\text{CORR}(L,s) = .5$

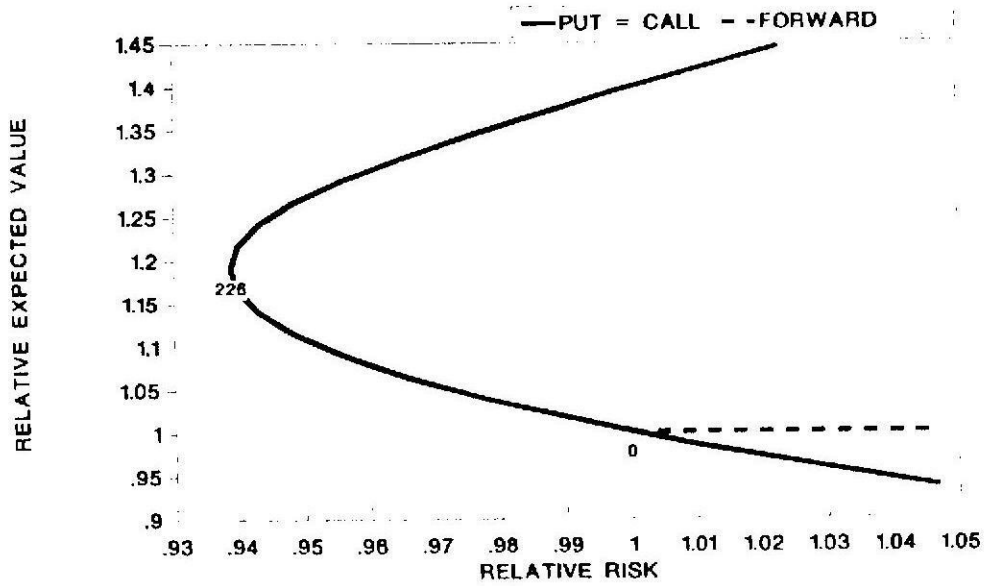
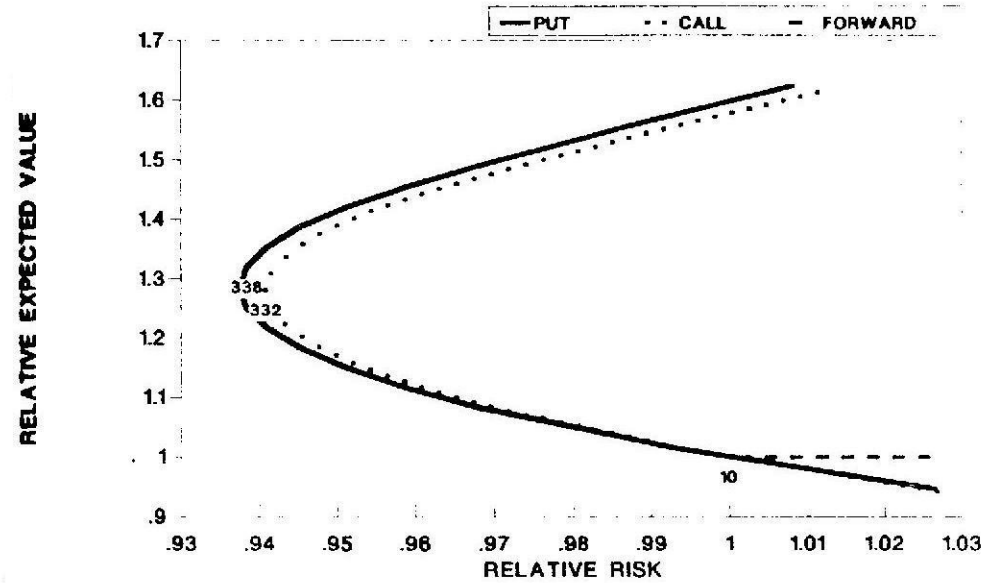


FIGURE 9C: TARGET = 150
 $Q = .2$, $\text{ALPHA} = 2$, $\text{CORR}(L,s) = .5$



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