Ratio Spreads

J. Scott Chaput and Louis H. Ederington

J. Scott Chaput
is a senior lecturer in finance at the University of Otago in Dunedin, New Zealand.
scott.chaput@otago.ac.nz

Louis H. Ederington
is Michael F. Price professor of finance at the University of Oklahoma in Norman, OK.
lederington@ou.edu

Ratio spreads, in which a trader buys calls (or puts) at one strike and sells an unequal number of calls (puts) at a different strike, are among the most actively traded option combinations. They are, however, only briefly mentioned in most derivatives texts and have received no attention in the research literature. In texts and other discussions of option spreads and combinations, there is no agreement on when ratio spreads should be used, little guidance on how they should be designed, and no data on how they are actually used and designed. Seeking to fill this gap, we discuss the properties of ratio spreads and document their design and use in the Eurodollar options market.

Exploring what the chosen designs reveal about the motives of the traders, we find that most ratio spreads are designed to be low cost and roughly, not completely, delta neutral. Frontspread designs, in which profits are bounded and losses unbounded, considerably exceed backspread designs in which losses are bounded and profits unbounded. Results are mixed on whether ratio spreads are primarily used to exploit expected changes in volatility, because while designed so that vega has the hypothesized sign, vega values are generally smaller than could have been achieved with a slightly different design.

Option spreads and combinations, such as straddles, bull and bear spreads, and ratio spreads, are actively traded. Chaput and Ederington [2003] report that they represent about 55% of large trades and about 75% of the trading volume in Eurodollar options. According to Fahlenbrach and Sandas [2006], they represent about 37% of all trades and about 75% of the trading volume in FTSE-100 options.[1]

Ratio spreads in which a trader buys X calls (or puts) at one strike and sells Y calls (puts) at a different strike where $X \neq Y$ are one of the most popular option trading strategies. According to Chaput and Ederington [2003], they account for over 13% of trading volume in the Eurodollar options market and rank fourth in volume behind puts, calls, and straddles.[2] At least in this market, ratio spreads are traded considerably more often than more well-known spreads and combinations such as butterflies, condors, calendar spreads, covered calls, and box spreads. Indeed on the Eurodollar options market which we examine, the trading volume attributable to ratio spreads exceeds that attributable to the latter six strategies combined.

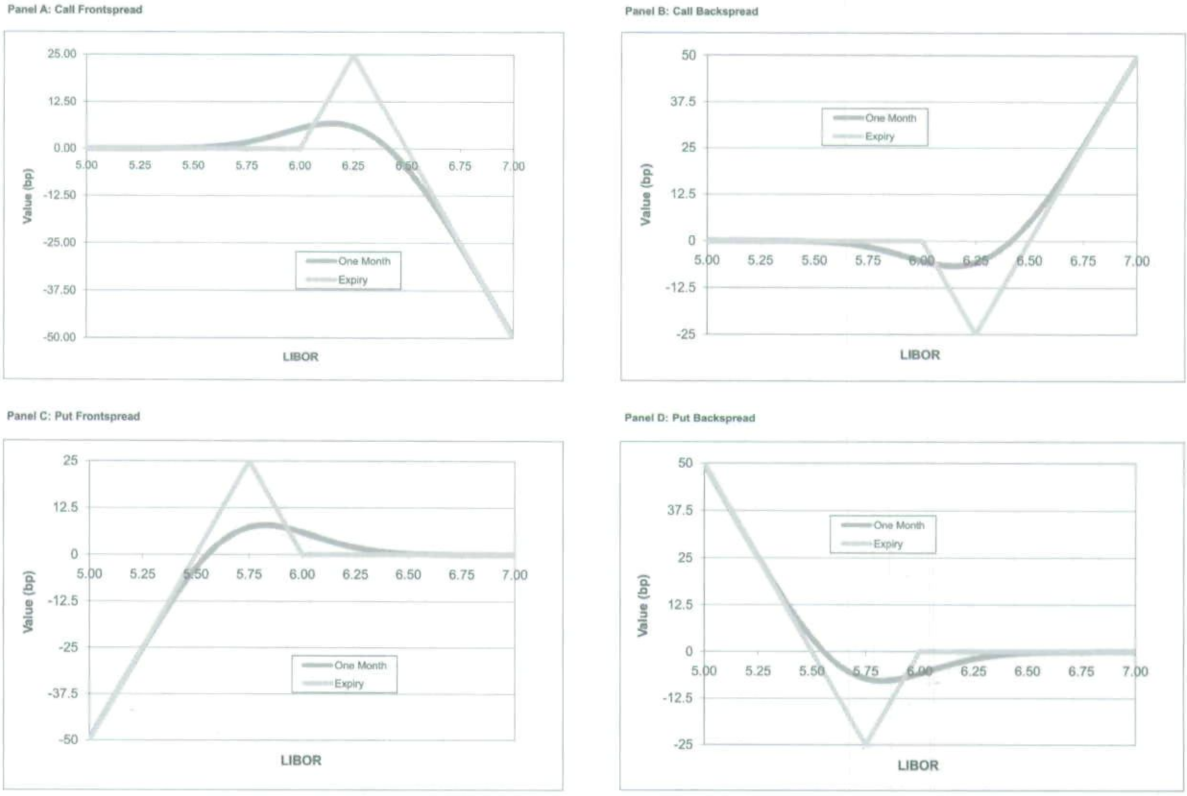
Despite their popularity with traders, we have not found any serious research on ratio spreads and many derivative texts ignore them entirely. The texts which do discuss ratio spreads generally pay much less attention to them than to strangles, butterflies, condors, covered calls, and box spreads which are lightly or rarely traded. While ratio spreads are more widely discussed in the practitioner literature, these sources offer widely differing advice on when to use ratio spreads and little advice on how to design them. We seek to fill this gap in our understanding by documenting the construction of ratio spread trades on the Eurodollar (or LIBOR) options market and exploring what the chosen designs reveal about the traders' objectives.

There are four basic types of ratio spreads: call frontspreads, call backspreads, put frontspreads, and put backspreads.[3] In a call frontspread (backspread), the trader buys (sells) calls at one strike and sells (buys) a greater number of calls at a higher strike. The resulting spread value, a function of LIBOR at expiration and one month before expiration, is illustrated for a typical 1 × 2 Eurodollar call frontspread in Panel A of Exhibit 1 and for a 1 × 2 call backspread in Panel B.[4] In a 1 × 2 call ratio spread, which is the most common ratio, the number of options sold or bought at the higher strike is double the number bought or sold at the lower strike. In a put frontspread (backspread), one buys (sells) puts at one strike and sells (buys) a larger number of puts at a lower strike. The resulting profit pattern is illustrated in Panel C of Exhibit 1 for 1 × 2 put frontspreads and in Panel D for 1 × 2 put backspreads.

Because in frontspreads the number of options sold exceeds the number purchased, possible losses are unbounded while gains are bounded as in Panels A and C of Exhibit 1. In a backspread, more options are purchased than sold, so potential profits are unbounded as in Panels B and D of Exhibit 1. Ratio spread trading is one of the more flexible option trading strategies. Depending on whether one chooses a frontspread or backspread, either losses or profits may be unbounded, and depending on whether one uses calls or puts, they are unbounded in either bull or bear markets. Moreover, for a given type, such as the call frontspread in Panel A of Exhibit 1, delta, gamma, vega, theta, and the net price can be positive, zero, or negative depending on the strike price choices and the ratio of shorts to longs.

EXHIBIT 1
Ratio Spread Values

The values of Eurodollar 1 × 2 ratio spreads are graphed as a function of the underlying LIBOR (underlying asset) at expiration and one month prior to expiration. The strike prices for the calls (Panels A and B) are 6.00% and 6.25%. The strike prices for the puts (Panels C and D) are 5.75% and 6.00%. For the values one month before expiration, the volatility is assumed to be 15% and the riskless rate is 6.00%.



A number of uses of ratio spreads have been proposed in the trader literature. One commonly cited goal is to speculate on a change in volatility. Other proposed objectives include: 1) to speculate on the direction of a future price change in the underlying asset at lower cost than a vertical spread, 2) to exploit perceived mispricings, and 3) to form pay-later hedges. Since these generally imply different designs, we explore what the chosen designs reveal concerning the traders' objectives.

Our findings include the following. One, most ratio spreads are designed so that the net price is positive but small. Two, most are designed so that they have fairly low absolute deltas, but even lower deltas could normally have been achieved with different strike price choices. Three, frontspreads, in which possible losses are unbounded while potential profits are bounded, are considerably more common than backspreads in which losses are bounded and profits unbounded. Four, whether ratio spreads are used as volatility spreads is unclear. Their vegas generally have the signs implied by assertions in the trader literature that ratio spreads are used as volatility plays. However, at the chosen strikes, vega values are generally smaller than at other possible strikes. Five, although examples and illustrations in the literature suggest that one leg of the spread is invariably in the money (ITM) and one is out of the money (OTM), in practice, both legs are usually OTM. Thus, while it is often claimed that frontspreads are designed to have maximum profit if the underlying asset price is unchanged, in fact, most are unprofitable if this occurs. Six, most traders seem to be seeking a balance between spreads with large vegas and low prices and deltas. Seven, ratio traders stick to a few standard ratios with over 90% of traders using a 1×2 ratio even though they could achieve exact delta neutrality or a zero net price by altering the ratio away from integer values. Overall, it appears that most ratio spread traders seek a balance between several objectives, including 1) approximate delta neutrality, 2) low net cost, and 3) relatively high sensitivity to changes in volatility.

ANALYSIS

Descriptions of Ratio Spreads in the Literature

Our primary interest is how ratio spreads are designed and what this reveals about the objectives of ratio traders. Ratio spreads receive little attention in most derivatives texts and, to our knowledge, there is no research on the topic. In trader materials (and when discussed in textbooks), ratio spreads are generally described as volatility trades with frontspreads (see Panels A and C of Exhibit 1) designed to profit from low market volatility, and/or declines in implied volatility, and backspreads (see Panels B and D of Exhibit 1) intended to profit from high volatility and/or increases in implied volatility.

Opinions differ, however, as to whether ratio spreads are designed to be delta neutral or are purposefully directional. Based on expiration profit patterns like those in Exhibit 1, the simpler descriptions of ratio spreads state that they are appropriate for a speculator who anticipates a small movement in the direction of the smaller leg, but not a large movement. In contrast, McMillan [1980]; Natenberg [1994], and Tompkins [1994] describe ratio spreads as delta neutral (at least initially). While not using the term *delta neutral*, the CBOT [2002] describes ratio spreads as indifferent to the direction of any future price change. However, both Natenberg and Tompkins argue that, while ratio spreads may be delta neutral initially, call (put) frontspreads are utilized when the trader thinks volatility will be low but is more concerned about being wrong on the down-(up-)side, and that call (put) backspreads are utilized when high volatility is foreseen, particularly on the up-(down-)side. Tompkins refers to them as "leaning volatility trades."

As explained by McDonald [2006], ratio spreads can also be used to construct *pay-later hedges*. Suppose a trader wishes to protect a long position in an asset against a fall in its price below X. While one possibility is to buy a put with strike = X, this entails an up-front cost. An alternative is to sell a put with a higher strike, Y > X, and buy two puts with strike = X. If the price of the Y put is double the price of the X put, the hedge costs nothing up front. The "cost" is that if the price falls below Y, but not X, the hedger loses on both his original position and the ratio hedge.

Low net cost is an oft-mentioned advantage of ratio spreads (e.g., McMillan [1980, 1996]), most often in descriptions of ratio spreads as instruments for directional speculation. Buying a call to speculate on an anticipated future price increase entails some cost. The cost can be reduced, but not eliminated, with a bull spread in which one buys a low-strike call and sells a high-strike call. The cost can be further reduced or eliminated with a call frontspread in which one buys a low-strike call and sells more than one high-strike call. Of course, this cost minimization argument ignores the fact that the bull spread could be changed from a debit spread to a credit spread by constructing it with puts instead of calls.

Finally, ratio spreads are sometimes described as trades designed to profit from perceived relative mispricings. For instance, Chance [2003], and McMillan [1996] describe a ratio spread as a trade in which the trader buys options regarded as underpriced and sells those regarded as overpriced.

The Spread Type

We now turn our attention to a consideration of what these and other possible trader objectives imply about ratio spread design. The first design choice we consider is the choice among the four possible types illustrated in Exhibit 1: call frontspread, call backspread, put frontspread, and put backspread.[5] We hypothesize that the frontspread/backspread choice depends primarily on whether the trader wishes to long or short volatility and/or to bound profits or losses. As illustrated in Exhibit 1, losses are unbounded and profits bounded on frontspreads, while profits are unbounded and losses bounded on backspreads. As is also illustrated by the expiration payoff patterns in Exhibit 1, frontspreads are generally short volatility (i.e., benefiting from low volatility) while backspreads are long. As we shall see, depending on the ratio of shorts to longs and the chosen strikes, it is not necessarily true in terms of gamma and vega that frontspreads are short volatility while backspreads are long—though they are always described this way—and sizable negative (positive) vegas and gammas are only possible on frontspreads (backspreads). Thus, while one would expect most traders to prefer bounded losses and unbounded profits, this preference for backspreads could be reversed if most wish to short volatility, as has been observed for traders of straddles and strangles in the Eurodollar market (Chaput and Ederington [2003]). The choice of call or put spreads would then appear to depend on the expected direction of any price change.

Volatility and the Strike Price Choice

If, as is often asserted in the literature, frontspreads are used to bet on a decline in volatility and backspreads to bet on a volatility increase, we would expect ratio spreads to be designed so that frontspreads have relatively large negative vegas and backspreads relatively large positive vegas. Consider what this implies about the design of ratio spreads and, in particular, the strike price choices. Since ratio spreads involve longing some options and shorting others, vega maximization implies choosing strikes with high vegas for the larger leg (larger in terms of number of options) and with low vegas for the smaller leg.[6] Since vega is highest on approximately at-the-money options,[7] this in turn implies that the strike of the larger leg should be closer to the money than the strike of the smaller.[8] Finally, because (as illustrated in Exhibit 1) the larger leg is always at a higher strike for calls and lower strike for puts, this would imply that the smaller leg should be in the money (ITM). Thus, vega maximization implies that at least one strike should be ITM.

Consideration of the expiration payoff patterns in Exhibit 1 implies basically the same strike price choices as vega maximization. Note that for frontspreads, expiration profits are maximized if at expiration the asset price (LIBOR in our case) equals the strike of the larger leg. Hence, if a frontspread trader is betting on low volatility in the sense of little change in prices, she should choose ATM strikes for the larger leg and ITM for the smaller. Therefore, both types of short volatility bets (i.e., a bet that volatility will decline and a bet that the future price will differ little from the current price) imply constructing the ratio with the larger leg approximately ATM and the smaller leg ITM. Similarly, a backspread trader betting on either a rise in implied volatility or that the future price will differ considerably from the current price would want to choose ATM strikes for the larger leg and ITM for the smaller.

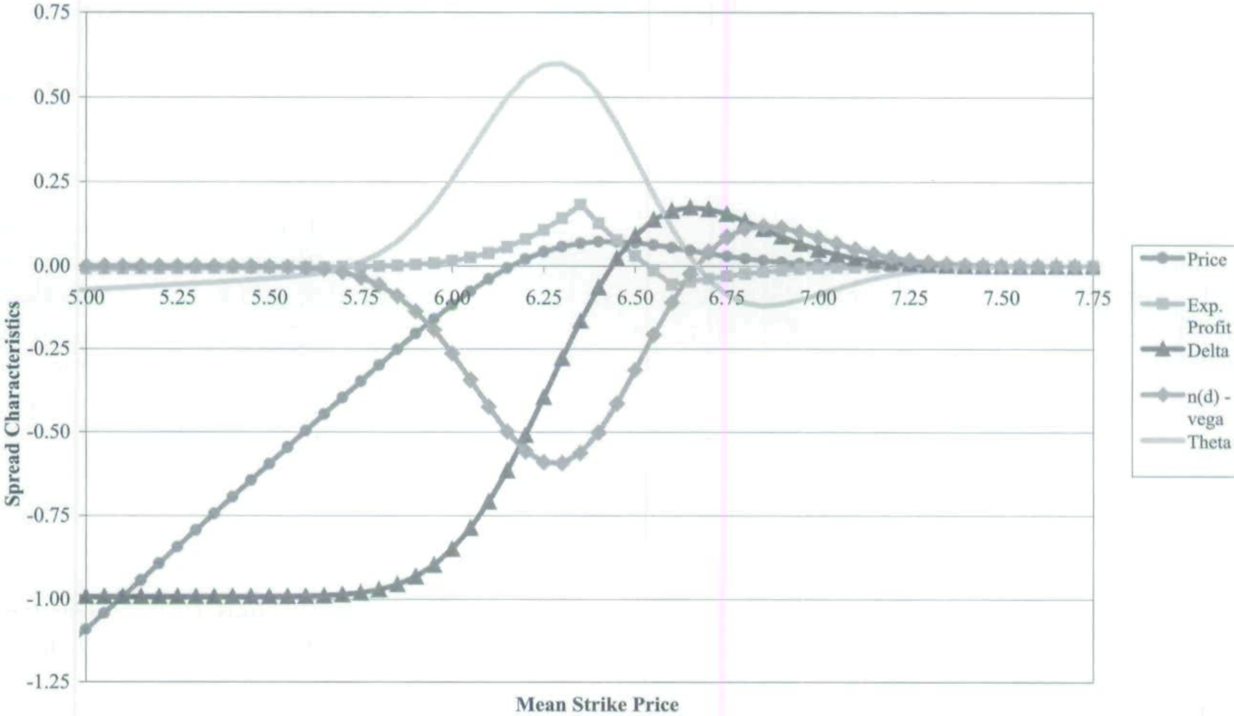
In contrast, use of ratio spreads to construct pay-later hedges (as described in the previous section) implies that at least one strike—and as normally described, both—should be out of the money (OTM). In every ratio spread illustration that we have seen in the practitioner literature, one leg is ITM and one is OTM, but as we shall see later in the article this is not the normal structure in practice.

The impact of the strike choice on vega (and gamma) for typical call frontspreads in our data set (in which the underlying asset is LIBOR) is illustrated in Exhibits 2–4. In our dataset, the vast majority of ratio spreads are in a 1×2 ratio and in most the difference between the two strikes is 25 basis points (bps). The median implied volatility is approximately 11% and median LIBOR is approximately 6.5%. How characteristics of a spread with these properties vary with the mean strike is illustrated in Exhibits 2, 3, and 4 for times to expiration of 1.5 months, 3 months (the approximate

EXHIBIT 2

Call Frontspread Characteristics as a Function of the Strike Price

For spreads with expiry = 1.5 months when σ = 11%, LIBOR = 6.5%, and the strike differential = 25 bps.



median in our sample), and 6 months, respectively.[9] The mean strike shown on the x-axis is the simple unweighted mean of the two strikes (e.g., if one call is longed at a strike of 6% and two shorted at a 6.25% strike, the mean strike shown on the x-axis is 6.125%).

For a given expiry, both vega and gamma are proportional to $n(d) = n(d_l) - Mn(d_h)$ where n is the normal density, $d_i = [\ln(F/X_i)+(0.5\sigma^2 t)]/\sigma\sqrt{t}$, X_l is the low strike, X_h is the high strike, and M is the ratio of the larger leg to the smaller. It is often simpler to explore the impact of trader choices on n(d) than directly on vega; however, the results are the same. Also, n(d) has the advantage that its values are on the same scale as the other characteristics in Exhibits 2–4. So, in Exhibits 2–4, we plot values of n(d) instead of vega itself.

As illustrated in Exhibits 2–4, for call frontspreads with these characteristics, the largest negative n(d) or vega value occurs when the higher strike is slightly ITM and the lower strike is further ITM (e.g., longing one call at a strike of 6.15% and shorting two at 6.40% when LIBOR is 6.50%). We also show the profit if the spread is held to expiration and LIBOR remains unchanged at 6.5%.

Delta and the Strike Price Choice

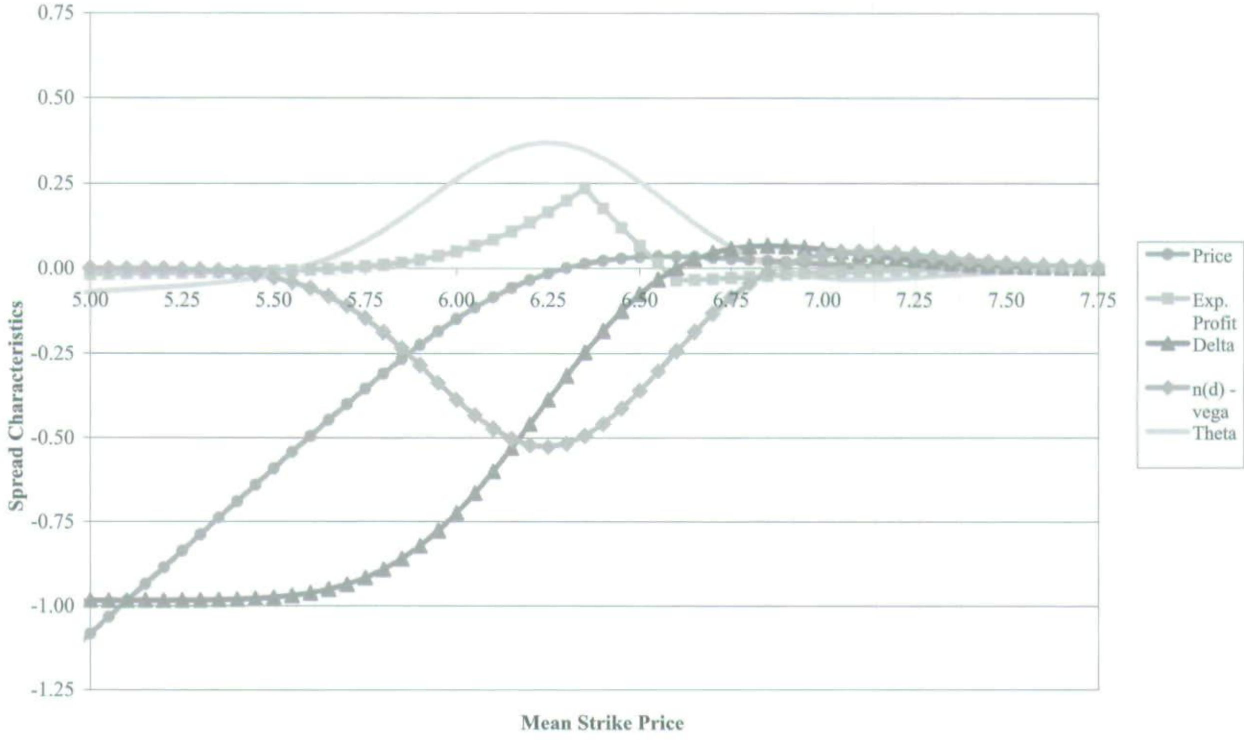
As noted earlier, ratio spreads are sometimes described as spreads designed to bet on the direction of future asset price movements (as well as their magnitude) and at other times as delta neutral. In ratio spreads, the smaller leg is always more ITM than the larger leg so it has a higher absolute delta. Hence, the spread can be made delta neutral by choosing strikes or ratios so that the delta of the smaller leg is approximately equal to M times the (smaller) delta of the options in the larger leg, where M is the ratio of the number of options in the larger leg to that in the smaller.

Generalization appears dangerous here. However, as illustrated in Exhibits 2–4, if we restrict the ratio to 1-to-2 and the strike differential to 25 bps—the most popular structure—then for typical spreads in our sample, delta neutrality implies choosing somewhat higher (lower)

EXHIBIT 3

Call Frontspread Characteristics as a Function of the Strike Price

For spreads with expiry = 3 months when σ = 11%, LIBOR = 6.5%, and the strike differential = 25 bps.



strikes for call (put) ratio spreads than those at which the absolute vega is maximized; that is, further out-of-the money (OTM) strikes.

The Net Price

As described previously, the ability to construct spreads which are approximately costless is an oft-cited advantage of ratio spreads. In ratio spreads, the smaller leg is always further in the money than the larger leg, so its price is higher. Hence, the spread's net price will be zero if the price of the smaller leg is equal to M times the lower price of the options in the larger leg, where M is the spread ratio. If price minimization is an objective, we would expect it to only apply to debit spreads, that is spreads where the net price is positive. For credit spreads in which the trader receives a net payment up front, we see little reason to attempt to reduce the price.

If indeed ratio spreads are used as volatility trades, the price minimization hypothesis has a further implication. Straddles are by far the most popular volatility trade in this market and strangles are also popular. Suppose a trader wishes to long volatility; that is, to construct a position with large positive vegas or one which benefits if the underlying asset price changes considerably. Because long straddles and strangles entail buying both a call and a put, they are expensive. As an alternative, the long volatility trader who wishes to minimize the up-front cost could construct a backspread with a low or negative net price. Note that the same argument would not apply to short volatility positions, since short straddles and strangles are credit, not debit, spreads. This argument has two implications. One, backspreads should be more prevalent than frontspreads. Two, on backspreads, the price should either be negative (a credit spread) or close to zero.

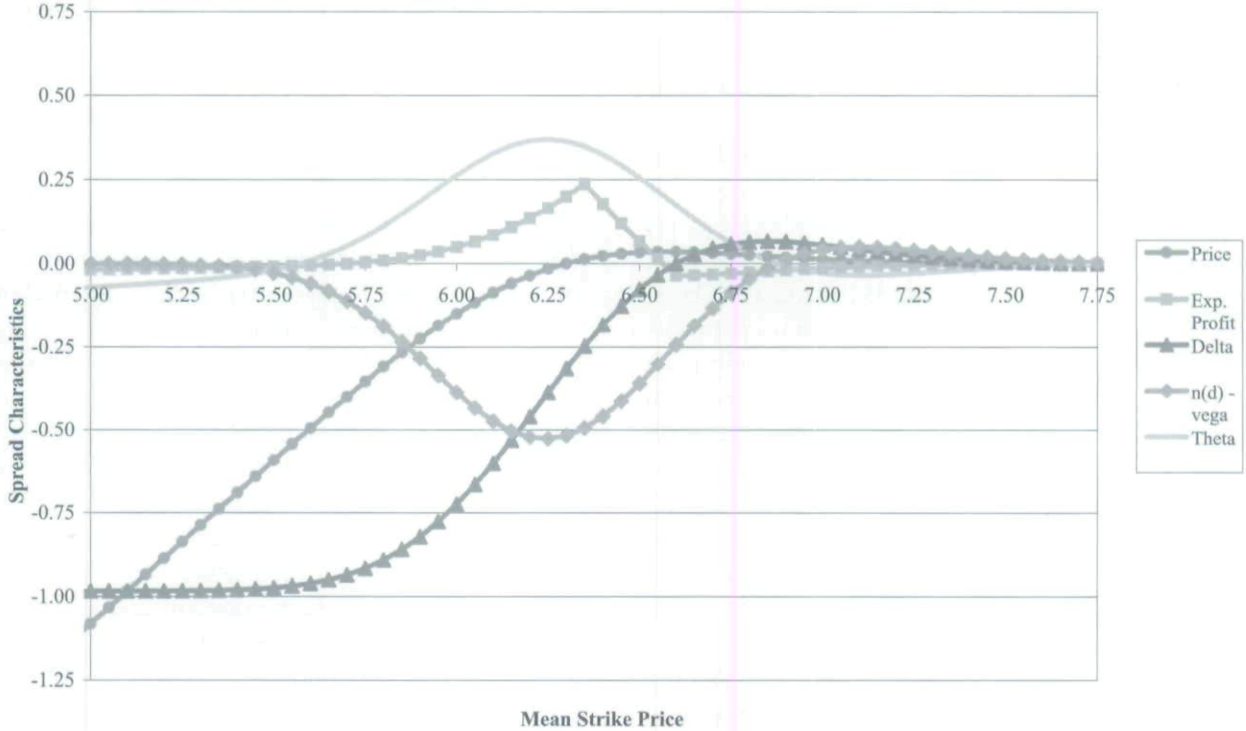
Option Mispricings

Chance [2003], and McMillan [1996] argue that ratio spreads are used to trade on perceived mispricings. Assuming the pricing model is correct, this would imply

EXHIBIT 4

Call Frontspread Characteristics as a Function of the Strike Price

For spreads with expiry = 6 months when $\sigma = 11\%$, LIBOR = 6.5%, and the strike differential = 25 bps.



that traders should buy options with low implied volatilities and sell those with high implied volatilities.

The Spread Ratio

To this point, our discussion of the implications of various objectives has focused on implications for the strike price decision. Obviously the chosen ratio also impacts the greeks and the price. Note that due to the discreteness of the traded strikes, ratio spreads cannot normally be made exactly delta neutral with the standard integer ratios of 1×2, 1×3, 2×3, and so forth. Likewise, the net price cannot be made exactly zero and vega cannot be maximized or minimized. However, any of these objectives could be met with the appropriate non-integer ratio (e.g., 1 to 1.23). A disadvantage of non-integer ratios is that they are likely to be less liquid. The standard ratios are traded so that transaction costs may be lower and reversing the trade easier. Hence, one question we are interested in is how often non-integer ratios are observed. We know they are very rare for straddles and strangles (Chaput and Ederington [2003]).

DATA AND MARKET CHARACTERISTICS

The Market for Options on Eurodollar Futures

We examine ratio spread trading in options on Eurodollar futures. Eurodollar futures contracts are cash-settled contracts on 3-month LIBOR traded on the Chicago Mercantile Exchange. Since LIBOR is a frequent benchmark rate for variable rate loans, loan commitments, and swaps, hedging opportunities abound and the Eurodollar futures and options markets are the world's most heavily traded short-term interest rate futures and options markets.

Unfortunately, terminology in Eurodollar options can be confusing. Eurodollar futures and options are officially quoted as 100-LIBOR which converts a LIBOR call (put) into a 100-LIBOR put (call). We find the common practice of treating these as options on LIBOR instead of 100-LIBOR less confusing, so we follow that approach in this study. When we refer to a LIBOR call with a strike of 6.5%, we mean an option which is in the money if the spot rate exceeds 6.5%.

Data

As explained in Chaput and Ederington [2003], major options spreads and combinations are traded as such. That is, instead of separate trades and prices for each leg, there is a single trade at a single combined price. Prices of recent trades are displayed on the exchange floor for the most popular combinations, but these trade prices are not included in existing public datasets. Fortunately, Bear Brokerage generously provided us data on large option trades, including combination trades, in the Chicago Mercantile Exchange's market for Options on Eurodollar Futures. Bear Brokerage regularly stations an observer at the periphery of the Eurodollar pits with instructions to record all option trades of 100 contracts or more. For combination trades, this 100 contract minimum applies to the smallest leg. Thus, for 1 × 2 ratio spreads, the smallest trade in our sample would be for a total of 300 option contracts. This observer records (1) the net price, (2) the clearing member initiating the trade, (3) the trade type (e.g., naked call, straddle, and ratio spread), (4) a buy/sell indicator, (5) the strike price and expiration month of each leg of the trade, and (6) the number of contracts for each leg. The large trades recorded by Bear Brokerage account for approximately 65.8% of the options traded on the observed days—the remainder were unrecorded smaller trades.

Several limitations of the data are worth noting. First, we only observe ratio spreads which are ordered as such. If an off-the-floor trader places one order to buy 100 calls at one strike and a separate order to sell 200 calls at a higher strike with the same expiry, our records show two naked trades, not a call frontspread. Consequently, our data may understate the full extent of ratio spread trading. However, if a trader splits his order he cannot control execution risk. For example, if the trader orders 100 2-to-1 call frontspreads, he can set a net price limit of 5 bps, but he cannot do this if he splits the order. If he sets limits on each leg, one leg may wind up being executed without the other. Consequently, the traders to whom we have talked think the data capture almost all spread trades. Second, in a ratio spread trade, the buyer and seller agree on a net price, not prices for each leg, so only the net price is available to us. Third, unless futures are a part of the order (rarely with ratio spreads), we do not know the underlying futures price at the time of the trade nor the exact time of the trade.

Fourth, we cannot distinguish between trades which open and close a position.[10] This is a significant limitation. For instance, if a frontspread position is first opened and then closed, we would initially observe a frontspread trade and later a backspread trade. Also, while a trade may have initially been designed with a particular delta, vega, or net price, since the underlying asset price will likely change, these will normally be different when the position is closed. Fortunately, both characteristics of our data here and in previous studies indicate that our data is dominated by position-opening trades (i.e., that traders hold many positions at expiration or close to it).

Bear Brokerage provided us with data for large orders on 385 of 459 trading days during three periods: (1) May 12, 1994, through May 18, 1995; (2) April 19 through September 21, 1999, and (3) March 17 through July 31, 2000.[11] Data for the other 74 days during these periods was either not collected due to vacation, illness, or reassignment, or the records were not kept at all. We applied several screens to the raw data and removed trades solely between floor traders (since it is unclear who initiated the trade), obvious recording errors, and incomplete observations.

The resulting dataset consists of 13,597 large trades (e.g., 100 or more contracts in each leg) on 385 days. Of these, 5,750 (42.3%) are straightforward trades of calls or puts, and 7,847 represent trades of combinations or spreads. Ratio spreads total 968 which represents 7.12% of all trades and 12.3% of spread and combination trades. However, because ratio spreads tend to be larger, they account for 13.4% of the trading volume attributable to large trades and 18.1% of the volume accounted for by spreads and combinations. Among spreads and combinations, only straddles are more heavily traded. Moreover, during the sample period, ratio spread trading increased. Ratio spread trades accounted for only 8.55% of trading volume in the 1994–95 half of our sample, but 18.23% in the 1999–2000 half. In the latter subsample, the trading volume attributable to ratio spreads exceeded that attributable to any other spread or combination.

RATIO SPREAD ATTRIBUTES

Descriptive statistics for the ratio spreads in our sample are reported in Exhibit 5 after elimination of 1) ratios involving mid-curve options (165 observations), 2) spreads

EXHIBIT 5
Descriptive Statistics

Various descriptive statistics are presented for a sample of 741 large ratio spreads observed in the Eurodollar options market on 385 trading days over three periods: (1) 5/12/1994–5/18/1995, (2) 4/19/1999–9/21/1999, and (3) 3/17/2000–7/31/2000.

Panel A - Descriptive Statistics					
Variable		Mean	Median	Std. Dev.	
Size (in contracts)		2842	1500	3572	
Time to expiration (months)		3.41	2.77	2.48	
Price (absolute and in basis points)		3.61	2.50	4.72	
Panel B - Spread Types and Characteristics					
Spread Type	Call Frontspread	Call Backspread	Put Frontspread	Put Backspread	All
Percentage	34.7%	12.7%	40.00%	12.7%	100%
Mean Price (bps)	2.98	6.58	2.86	4.71	3.61
Median Price	2.00	4.50	2.00	3.00	2.50
Credit Spread	12.45%	82.98%	4.05%	86.17%	27.4%
Panel C - Ratios					
1.5	2	2.5	3	4	5
2.56%	91.77%	0.27%	4.18%	0.94%	0.27%
Panel D - Strike Price Gaps (in basis points)					
12 or 13 bps	25 bps	37 or 38 bps	50 bps	75bps	100bps
18.8%	60.2%	0.4%	18.2%	0.8%	1.6%

accompanied by a simultaneous futures trade (13 observations), and 3) incomplete observations and apparent recording errors (27 observations). We also drop 22 observations for which the time to expiration of the options is less than two weeks. We do this because some of our calculations are likely highly noisy for spreads this short and we would expect most of these to be closing positions opened earlier. This leaves a final sample of 741 ratio spreads.

As reported in Exhibit 5, the ratio spreads in our sample are sizable; the median size is 1,500 contracts and the mean is 2,842. Of course, this is a conditional mean since the observer's instructions are to record all trades in which the smallest leg is 100 contracts or more (implying a minimum of 300 contracts for a 1×2 spread). Nonetheless, the size of these trades is impressive. The mean and median times to expiration are 3.41 months and 2.77 months, respectively, which are roughly in line with averages for most option trades in this market.

Spread Types

As shown in Exhibit 5, frontspreads, that is ratio spreads in which more options are sold than bought so that possible losses are unbounded while possible gains are bounded (as illustrated in Panels A and C of Exhibit 1), are much more common than backspreads (Panels B and D of Exhibit 1); specifically, 74.7% are frontspreads. Although it is possible to construct frontspreads (backspreads) with small positive (negative) vegas, in general, vega is negative for frontspreads and positive for backspreads. Thus, most ratio spread traders are shorting volatility.[12] Recall that we cannot distinguish between trades that open and close a position. If every position-opening trade observation was matched by a position-closing observation, we would observe a 50–50 split between frontspreads and backspreads. The fact that almost three quarters are frontspreads has a couple of implications. One, because the proportion is far from 50–50, our sample is apparently dominated by position-opening trades. Data from our earlier studies of vertical and volatility spreads also indicates this. Two, to the extent that *some* observed trades are position-closing trades, the figure of 74.7% possibly understates the true proportion of frontspreads. However, if many of the observed backspread trades are position-closing trades, we would expect their times to expiration to be shorter than for frontspreads, but there is no significant difference between the two.

If, as suggested by some writers and as we just discussed, minimization of up-front cost is an objective, then volatility traders might tend to substitute backspreads for long straddle/strangle positions, but there would not be the same incentive to substitute frontspreads for short

EXHIBIT 6

Ratio Spread Characteristics—Full Sample

Characteristics of 741 ratio spreads are reported. Greeks and implied standard deviations are based on an average of options and futures settlement prices on the day of the trade and the previous day.

	All	Call Front Spread	Call Back Spread	Put Front Spread	Put Back Spread
Mean delta	-0.0143	0.0004	0.0043	-0.0357	-0.0057
Mean absolute delta	0.1123	0.1062	0.1543	0.0971	0.1348
Mean vega	-0.1832	-0.6753	0.8945	-0.3604	0.6429
Percent positive vega	37.38%	13.23%	93.62%	27.04%	79.79%
Mean vega when <0 for frontspreads and >0 for backspreads		-0.8001	0.9685	-0.5485	0.8455
Mean n(d)	-0.0102	-0.1963	0.5913	-0.1051	0.1962
Mean n(d) when <0 for frontspreads and >0 for backspreads		-0.2526	0.6566	-0.1809	0.2646
Mean gamma	-0.0878	-0.4927	0.8730	-0.2630	0.6082
Percent with both strikes out of money	68.42%	66.15%	39.36%	82.09%	60.64%
Percent with both strikes in the money	4.72%	3.89%	7.45%	2.36%	11.70%
Percent with one strike OTM and one ITM	26.86%	29.96%	53.19%	15.54%	27.66%
Percent profitable if LIBOR is unchanged	32.12%	36.19%	39.36%	17.19%	58.51%
Percent for which ISD(sold)>ISD(bought)	63.72%	90.27%	15.96%	64.19%	53.19%
Observations	741	257	94	296	94

straddles and strangles. Given the preponderance of frontspreads, there is clearly no evidence to support this hypothesis.

Ratios and Strike Differentials

As reported in Panel C of Exhibit 5, the most common ratio is 1 × 2 which accounts for 91.8% of all ratio spreads. It is followed by the ratios 1 × 3 (4.2%) and 2 × 3 (2.6%). We observe no cases in which the trader chose a non-integer ratio (e.g., 1 × 1.65). It is possible to create a non-integer ratio spread by combining an integer ratio spread with a separate purchase or sale of calls and puts with the same expiration and one of the two strikes. However, we only observe one instance in our dataset when there was such a simultaneous trade. Given the lumpiness of traded strikes, usually a ratio spread's delta and net price cannot be set to zero, and vega cannot be fully maximized by restricting the ratio to integer values. The fact that traders do not choose non-integer ratios while over 90% choose 1 × 2 indicates that there is an important advantage to standardizing—likely in the form of lower transaction costs and/or higher liquidity.

As reported in Panel D of Exhibit 5, the most common difference between the two strike prices is 25 bps (60.2%) followed by 12.5 bps (18.8%) and 50 bps (18.2%). For maturities exceeding three months, Eurodollar option strikes are listed in increments of 25 bps. However, in May 1995, the CME began adding strikes in increments of approximately 12.5 bps between strikes within about 50 bps of the underlying futures once the time to expiration falls below three months.[13] Since these strikes are added after open interest has accumulated in the existing strikes, they tend to be less liquid than the existing strikes. In a majority of cases, therefore, it appears that ratio spread traders are choosing the minimum feasible strike differential.

Prices

The observed net prices or premiums are quite small. Prices in the Eurodollar options market are quoted in basis points or occasionally in 0.5 bp increments. Ignoring whether the spread is a credit spread (negative net price) or debit spread (positive net price), the mean ratio spread price in our sample is only 3.61 bps and the median is only 2.5 bps.[14] In this market, each basis point represents $25, so the mean price is $90.25 and the median is $62.50. Since in ratio spreads some options are bought and others sold, small net premiums are expected. Nonetheless, the mean and median net prices for ratio spreads are considerably below those of other spreads in our sample, such as butterflies and vertical spreads, in which options are both bought and sold. On the surface it appears that ratio spreads are designed to have very low prices, but we will consider this issue more carefully by examining whether—compared with possible alternatives—the chosen design had the minimum net price.

Another price issue is whether the spreads are designed so that the net premium is positive (a debit spread) or negative (an up-front cash in-flow or credit spread). As shown in Exhibit 5, 72.6% are debit spreads. However, this may be an artifact of the frontspread/backspread choice since the vast majority of frontspreads (backspreads) are debit (credit spreads). Consistent with our hypothesis that (absolute) price minimization should only be an objective for debit spreads, the mean price is 2.88 basis points for debit spreads and 5.54 for credit spreads. The difference is significant at the 0.0001 level.[15]

Vega and Other Volatility Spread Characteristics

Next, we consider the spreads' characteristics starting with vega. To estimate the greeks requires the price of the underlying LIBOR futures at the time of the spread trade. Unfortunately, our dataset includes neither the LIBOR futures price at the time of the trade nor the exact time of the trade (which would allow us to find the price at that time). Also, we know only the net price of each spread, but prices for each leg are needed to calculate the greeks. Consequently, we approximate these prices using an average of the settlement prices on the day of the trade and the preceding day.[16] The greeks were calculated using both the Black [1976] model for options on futures and, because these are American options, the Barone-Adesi Whaley [1987] model, but since the figures proved virtually identical only the former are reported in Exhibit 6.[17] As noted previously, the vast majority of ratio spreads are in a 1×2 ratio and, in most, the gap between the strikes is 25 bps. In order to focus on a more homogenous sample, statistics for this subset are reported in Exhibit 7.

Frontspreads are often described as spreads designed to short volatility and backspreads are supposedly designed to long volatility. Consistent with this, vega is negative for 79.4% of frontspreads and positive for 86.7% of backspreads. Keeping in mind that some of our observed trades likely close positions which were opened earlier when the underlying asset price was different, the percentages for opening trades are possibly higher.

Our main evidence on whether traders choose frontspread designs which minimize vega or backspreads which maximize it is provided later when we compare the chosen spread's vega with what it would have been for alternative designs. However, Exhibits 6 and 7 provide initial evidence. Since vega varies with the term to maturity of the options, it is helpful to examine a measure which controls for expiry. For the same time to expiration, vega is proportional to $n(d) = n(d_l) - M\, n(d_h)$ where n is the normal density, X_l is the low strike, X_h is the high strike, and M is the ratio of the larger leg to the smaller. For a single option, $n(d_i)$ is maximized at 0.3989 at a strike $X_i = F * \exp(0.5\, \sigma^2 t)$ which, for the normal values of σ and t in our sample, is a strike just slightly above F. Hence, for a 1×2 ratio spread, the maximum n(d) would be 0.7979 for a spread where the larger leg is approximately at the money and the smaller is very deep in the money. So, in Exhibits 6 and 7, we report means of both vega and n(d).

Except for call backspreads (which are not numerous in our sample), values of vega and n(d) appear relatively low. While maximum values of n(d) are 0.3989 for an individual option and 0.7979 for a 1×2 ratio spread (albeit not a very plausible one), except for call backspreads for which n(d) = 0.5913, n(d) values range from only –0.1963 for call frontspreads to 0.1962 for put backspreads. If vega >0 for frontspreads or <0 for backspreads, it seems clear that either the spreads were not intended as volatility spreads or that we are observing position-closing spreads after LIBOR and vega have changed. Consequently, in Exhibits 6 and 7 we also report means of vega and n(d) when vega <0 for frontspreads and >0 for backspreads. Again vega and n(d) values appear low for all except call backspreads as values of n(d) range from –0.2526 to 0.2646.

If ratio spread traders are designing backspreads to maximize vega (or gamma) and frontspreads to minimize vega, at least one leg (the smaller) would be ITM. Except for call backspreads, this is clearly not the case. In 68.4% of the full sample and 66.8% of the 1×2 ratio sample, *both* legs are OTM. Since some of our observations are likely position-closing trades after the position has drifted in or out of the money, this percentage is likely higher for the initial designs. Clearly, most frontspreads (backspreads) are not designed to minimize (maximize) vega or gamma. In every ratio spread illustration we have seen in the literature, one strike is OTM and one is ITM so that they straddle the price of the underlying asset, but clearly most are not designed this way in practice.

The fact that in most spreads both legs are OTM means that if the underlying LIBOR does not change,

EXHIBIT 7

Ratio Spread Characteristics—Restricted Sample

Characteristics are reported for 413 1-to-2 ratio spreads with a 25 bp differential between the two strikes. Greeks and implied standard deviations are based on an average of options and futures settlement prices on the day of the trade and the previous day.

	All	Call Front Spread	Call Back Spread	Put Front Spread	Put Back Spread
Mean delta	-0.0189	-0.0132	0.0292	-0.0377	-0.0107
Mean absolute delta	0.1174	0.1188	0.1722	0.0972	0.1338
Mean vega	-0.1713	-0.6874	0.8977	-0.3347	0.6001
Percent positive vega	40.44%	16.39%	89.77%	29.40%	86.27%
Mean vega when <0 for frontspreads and >0 for backspreads		-0.8464	0.9618	-0.5199	0.7108
Mean n(d)	-0.0073	-0.2132	0.6149	-0.1001	0.2066
Mean n(d) when <0 for frontspreads and >0 for backspreads		-0.2689	0.6594	-0.1728	0.2451
Mean gamma	-0.0014	-0.4844	1.0784	-0.1870	0.7623
Percent with both strikes out of money	66.83%	61.48%	23.53%	83.60%	60.78%
Percent with both strikes in the money	5.33%	4.92%	9.80%	2.12%	13.73%
Percent with one strike OTM and one ITM	27.85%	33.61%	66.67%	14.29%	25.49%
Percent profitable if LIBOR is unchanged	30.99%	43.44%	21.57%	16.93%	62.75%
Percent for which ISD(sold)>ISD(bought)	63.20%	89.34%	19.61%	59.79%	56.86%
Observations	413	122	51	189	51

the spread expires worthless. Consider frontspreads (roughly 75% of our sample). According to many assertions in the literature, frontspreads are designed to profit if there is little change in the underlying asset price. Of these, however, 92.0% are debit spreads and on 74.7% both legs are OTM. Hence, if the underlying asset price (LIBOR) does not change, most (74.0%) lose money at expiration—hardly the design one would expect from traders betting on low volatility. Moreover, while backspreads are described as designed to bet on high volatility, 48.9% are profitable *at expiration* if LIBOR is unchanged.

In summary, vega's signs are generally consistent with the assertion in the practitioner literature that frontspreads are designed to bet on low volatility and backspreads to bet on high volatility. However, little else seems consistent with this characterization. The strike price choices on most spreads are such that (1) vega is fairly small in absolute terms and (2) most frontspreads lose money at expiration if the underlying LIBOR is unchanged. This apparent preference for OTM strikes is consistent with what we have observed previously for vertical spreads (Chaput and Ederington [2005b]). It is also consistent with the use of ratio spreads to construct pay-later hedges. The preference for OTM strikes might also be due to other objectives such as delta neutrality, because, as illustrated in Exhibits 2–4, for the median spreads in our sample, delta neutrality is achieved at somewhat higher (lower) strikes for calls (puts) than those at which vega is minimized (maximized). This will be explored further later in the article.

Delta

Many discussions of ratio spreads describe them as "delta neutral" while others describe them as designed to bet on the direction of any price change as well as volatility. As reported in Exhibit 6, the average absolute delta is 0.1123. The median is below 0.10. Whether this is low enough to warrant the characterization delta neutral is in the eye of the beholder, but it indicates to us that most are not designed to bet on the direction of a future change in interest rates.[18] Given these results, the question arises whether the observed vega levels are fairly low because the trader could not raise them without increasing delta. This question will be explored later in the article.

At given strikes, a ratio spread can be made exactly delta neutral by adjusting the ratio of bought to sold options. Indeed, in his example Chance [2003] constructs a ratio spread with a ratio of 1 to 0.903 so that the spread is exactly delta neutral. Clearly, that rarely happens. As documented in Exhibit 5, virtually all spreads are in a few ratios and we observe almost no non-integer ratios (e.g., 1 to 0.903). As argued earlier, we think this strong preference for even ratios is probably due to liquidity and/or transaction costs.

Implied Volatilities

Some observers, such as Chance [2003], point out that ratio spreads could be used to speculate on apparent mispricings. That is, the ratio spread trader longs options regarded as underpriced and shorts those regarded as overpriced, probably in a ratio which is approximately delta neutral. If so, and if the pricing model is correct so that such relative mispricings are reflected in their implied volatilities, then we should observe traders buying options with low implied volatilities and selling options with higher implied volatilities.

In Exhibits 6 and 7, we report whether the implied standard deviation (ISD) is lower on the bought options than on those sold.[19] In 63.7% it is, which would seem to confirm this hypothesis. However, this high percentage could also be an artifact of the observed preference for OTM strikes—or could explain it. In this market, the smile tends to be U-shaped with its nadir at the money (Chaput and Ederington [2005a]). If traders regard the smile as due to hedging pressures as argued by Ederington and Guan [2002] and Bollen and Whaley [2004], they would tend to buy at-the-money (ATM) options and sell ITM and OTM options. Thus for frontspreads, a strategy of longing options with low ISDs and shorting those with high ISDs could explain the observed preference for OTM options. But if OTM strikes are preferred for other reasons, we would observe that frontspread traders seem to be longing high ISD options and shorting low ISD options when the relative ISDs are actually irrelevant to them.

Backspreads are potentially more informative here since for these implied volatility trading would imply selling ATM and buying ITM options. As reported in Exhibits 6 and 7, this is rarely the case. Moreover, on call backspreads traders generally buy high ISD options and sell low ISD options. We conclude that there is little evidence to support the hypothesis that traders are using ratio spreads to profit from perceived mispricings as reflected in implied volatilities.

THE STRIKE PRICE DECISION

Next, we examine more closely what the traders' strike price choices reveal about their objectives. For this we compare characteristics of the spreads at the chosen strikes with estimates of what these characteristics would have been if the traders had instead chosen slightly higher or lower strikes. We have noted that in most ratio spreads both strikes are OTM and that minimization of vega on frontspreads and maximization on backspreads implies that at least one strike should be ITM. One possible explanation is that OTM strikes are chosen because to switch to less OTM strikes would raise either the spread's delta or price.

Consider again how the spread greeks and net price depend on the strike price choice. For this, consider a typical 1×2 call frontspread with a 25 bp difference between the two strikes as illustrated in Exhibit 3. Let us start with both strikes very low (deep ITM). At this point, the prices of both options will be close to their intrinsic value so that the spread is a credit spread with a sizable cash inflow which means that the net price or cost is a large negative figure. Since both options are deep in the money, their deltas are close to 1 and the spread's delta is approximately -1. Consequently, as both strikes are raised, holding the differential constant, the net price rises so that the credit spread shrinks.[20] When deep ITM, the spread's gamma and vega are close to zero. As the strikes increase, gamma and vega fall (rise in absolute terms) since they are higher for the closer-to-the money option which is sold. Since gamma is negative, the spread's delta rises (falls in absolute terms). As the two strikes continue to rise, the net price may become negative (a net outflow or debit spread) and delta may become positive. When both legs are ITM, gamma and vega are higher on the sold options, but once both are sufficiently OTM, gamma and vega are higher on the bought options and fall in absolute terms. It is therefore possible for vega to switch signs and become positive.

We have presented statistics on attributes of the observed spreads. Next, we will compare the attributes of the chosen spreads with those of other possible designs that the trader could have chosen. In this section, we will focus on the strike price decision, leaving questions of the ratio for later. As noted, virtually all ratio spreads are in the 1×2 ratio and, in most, the differential between the two strikes is the minimum possible, generally 25 bps. So we restrict this analysis to the 413 spreads in Exhibit 7 with these characteristics. To simplify the analysis, we further restrict the sample to the 328 cases in which, at the chosen strikes, vega is negative for frontspreads and positive for backspreads. For these, we compare the characteristics of the chosen strike pair with those of the strike pair 25 bps lower and the pair 25 bps higher.[21] This should give us insight into the traders' objectives. For instance, if we observe that most frontspread traders chose the strikes at which delta is minimized but not the strikes at which vega is minimized (maximized in absolute terms), then we would conclude delta neutrality appears more important.

Results of this experiment are shown in Exhibit 8. Assuming that vega, delta, and the net price are among the

EXHIBIT 8

Impact of the Strike Choice on Spread Characteristics

For the 328 spreads with 1) a 1×2 ratio, 2) a 25 bp strike difference, and 3) vega <0 for frontspreads and >0 for backspreads, characteristics of the ratio spreads at the chosen strike pair are compared with estimated characteristics if the trader had chosen strikes 25 bps lower or 25 bps higher.

	All	Call Front Spreads	Call Back Spreads	Put Front Spreads	Put Back Spread
Panel A - Chosen Strike Pair					
Absolute vega maximized	9.76%	8.82%	18.75%	2.99%	22.73%
Absolute delta minimized	32.93%	25.49%	35.42%	35.07%	40.91%
Absolute net price minimized	3.35%	5.88%	0.00%	2.99%	2.27%
% Credit spreads	30.79%	18.63%	72.92%	8.21%	81.82%
Panel B - More In-the-Money Strike Pair					
Absolute vega raised (same sign)	90.24%	91.18%	81.25%	97.01%	77.27%
Absolute delta reduced	14.02%	8.82%	0.00%	23.13%	13.62%
Absolute net price reduced (same sign)	43.90%	57.84%	60.42%	32.09%	29.55%
All three	5.18%	8.82%	0.00%	5.97%	0.00%
Panel C - More Out-of-the-Money Strike Pair					
Absolute vega raised (same sign)	0.00%	0.00%	0.00%	0.00%	0.00%
Absolute delta reduced	66.77%	74.51%	64.58%	64.18%	59.09%
Absolute net price reduced (same sign)	64.94%	67.65%	72.92%	63.43%	54.55%
All three	0.00%	0.00%	0.00%	0.00%	0.00%

attributes important to ratio spread traders, it seems clear that none of these represents an overriding objective. Comparing vegas at the chosen strike pair with higher and lower strike pairs, vega is minimized for frontspreads and maximized for backspreads at the chosen pair in only 9.76% of the 328 spreads. The case is slightly stronger for delta neutrality in that in 32.93% the spread is closest to delta neutral at the chosen strikes, but still over two-thirds could have moved closer to delta neutrality by choosing slightly different strikes. In only 3.35% of the spreads is the absolute net price minimized. In summary, it seems clear none of these are over-arching objectives for most traders.

In most ratio spreads, both strikes are OTM. Absolute vega maximization implies, however, that at least one strike should be ITM. And maximization of profits on frontspreads, if the underlying price does not change, implies that one should be ATM and the other ITM. Consistent with this, in 90.24% of the cases (and 94.4% of frontspreads), vega could have been raised in absolute terms (without changing its sign), but choosing the next most ITM strike pair as reported in Panel B of Exhibit 8. Also reported in Panel B, in 85.98% of the spreads this would move the spread further away from delta neutrality and in 56.1% it would mean a larger net price without changing its sign. In only 5.18% does it appear that the trader could have simultaneously raised the absolute vega and lowered delta and the net price by choosing more ITM strikes. Likewise, as shown in Panel C of Exhibit 8, in about two-thirds of the observations, delta and/or the net price could be lowered by choosing more OTM strikes, but in every case this would lower the absolute vega.

In summary, in the vast majority of cases, ratio spread traders cannot choose strikes which simultaneously maximize (absolute) vega, minimize (absolute) delta, and minimize the (absolute) net price. In particular, there appears to be a conflict between vega maximization and delta minimization. Faced with this trade-off, most traders seem to seek a middle ground. They appear to choose strikes at which delta is low (but not usually minimized) and vega is reasonably large in absolute terms.

THE SPREAD RATIO

Finally, we consider the spread ratio decision. As noted earlier, in over 90% of the spreads the chosen ratio is 1×2. We examine how the spread characteristics would have differed if the trader had instead chosen ratios of 1×1, which would be a vertical spread instead of a ratio spread, or 1×3 holding the strikes constant.

In frontspreads (backspreads) more (fewer) options are sold than bought. So for frontspreads, increasing the ratio reduces the net cash inflow and vega, while these characteristics are increased for backspreads. An increase

Exhibit 9

Impact of the Chosen Ratio on Spread Characteristics

For the 328 spreads with 1) a 1×2 ratio, 2) a 25 bps strike difference, and 3) vega <0 for frontspreads and >0 for backspreads, spread characteristics at the chosen ratio are compared with estimates of what these characteristics would have been if the trader had chosen a ratio of 1-to-1 (a vertical spread) or 3-to-1.

	All	Call Frontspread	Call Backspread	Put Frontspread	Put Backspread
Panel A: 1-to-1 Spreads (i.e., vertical spreads)					
Mean price (basis points)	3.21	8.51	-11.35	7.81	-7.22
Mean absolute price	8.47	8.51	11.35	7.81	-7.22
Mean delta	-0.0214	0.2310	-0.2936	-0.2002	0.2351
Mean absolute delta	0.2282	0.2310	0.2936	0.2002	0.2351
Mean vega	0.1389	0.1222	0.0088	0.2910	-0.1432
Mean absolute vega	0.2814	0.2554	0.2181	0.3179	0.2995
Percent credit spreads	28.05%	0.00%	100.00%	0.00%	100.00%
Panel B: 2-to-1 Spreads (the configuration actually observed)					
Mean price (basis points)	0.53	1.48	-3.23	2.54	-3.70
Mean absolute price	3.22	2.50	4.69	2.90	4.30
Mean delta	-0.0128	-0.0478	0.0497	-0.0026	-0.0310
Mean absolute delta	0.1119	0.1101	0.1643	0.0865	0.1364
Mean vega	-0.2395	-0.8464	0.9618	-0.5199	0.7108
Mean absolute vega	0.7117	0.8464	0.9618	0.5199	0.7108
Percent credit spreads	30.79%	18.63%	72.92%	8.21%	81.82%
Panel C: 3-to-1 Spreads					
Mean price (basis points)	-1.85	-5.44	4.58	-2.94	3.02
Mean absolute price	5.84	6.45	7.24	4.54	6.87
Mean delta	-0.0042	-0.3267	0.3930	-0.1951	0.2971
Mean absolute delta	0.2862	0.3281	0.3968	0.2019	0.3249
Vega	-0.6179	-1.8150	1.9180	-1.3308	1.5649
Mean absolute vega	1.5982	1.8150	1.9180	1.3308	1.5649
Percent credit spreads	63.72%	80.39%	35.42%	70.15%	36.36%
Observations	328	102	48	134	44

in the ratio increases delta for call backspreads and put frontspreads, and decreases delta for put frontspreads and call backspreads. Magnitudes of these changes are reported in Exhibit 9 where we again restrict the sample to those cases where the chosen ratio is 1×2, the strike differential is 25 bps, and vega <0 for frontspreads and >0 for backspreads.

Results are shown in Exhibit 9. In most cases, choosing a ratio other than the 1×2 ratio that was actually chosen would have resulted in a higher absolute delta (i.e., it would have moved the spread further away from delta neutrality). This holds for both calls and puts and frontspreads and backspreads. As shown in Panel C of Exhibit 9, a 1×3 construction would have resulted in substantially larger negative vegas for frontspreads and substantially larger positive vegas for backspreads. However, in many cases a 1×3 ratio turns credit spreads into debit spreads, or the reverse, and absolute prices are higher. As previously noted, a 1×3 ratio also leads to higher absolute deltas.

CONCLUSION

Having looked at how ratio spreads are traded and designed, our major findings are these. One, ratio spreads are actively traded in the Eurodollar options market accounting for over 13% of trading volume. Two, approximately three-quarters are frontspreads which means that potential profits are bounded and potential losses unbounded. Three, most frontspreads are debit spreads (net initial cash outflow) and most backspreads are credit spreads. Four, over 90% use a 1×2 ratio and, in most, the difference between the two strikes is the smallest possible. Five, the net premium is quite low; the lowest among all combinations we have studied. Six, most ratio spreads are approximately, but not completely, delta neutral. Seven, consistent with assertions that frontspreads are used to short volatility and backspreads to long volatility, vega is generally negative for frontspreads and positive for backspreads, but absolute vega values are fairly small compared to other volatility spreads. Eight, in most ratio spreads both strikes are OTM. This tends to result in relatively small net prices and absolute deltas, but smaller absolute vegas. It also means that if the underlying asset price does not change, most frontspreads lose money which conflicts with the portrayal of frontspreads as designed to profit from low volatility. Finally, it is at odds with most descriptions of ratio spreads in which one leg is normally portrayed ITM and one leg OTM.

Ratio spreads have been described as being designed to 1) profit from anticipated changes in volatility, 2) be delta neutral, 3) have low net prices, and/or 4) profit from option mispricings. We find some support for each of the first three, but no one objective explains all our findings. It appears that either the objective varies from trader to trader or that individual traders have multiple objectives. At least when constrained to a 1 × 2 ratio and available strikes, ratio spreads cannot normally be designed to simultaneously be delta neutral, have very low net prices, and be highly sensitive to volatility changes. Instead, ratio spread traders face trade-offs, and most ratio spreads seem designed to balance some combination of these objectives.

ENDNOTES

[1]However, Lakonishok, et al. [2006] report minimal straddle and strangle trading in individual stock options.

[2]In terms of number of trades, vertical (bull and bear) spread trades are slightly more common, but these tend to be smaller in size and, therefore, account for less trading volume.

[3]Definitions of ratio spreads and terminology differ in the options literature. Since we are investigating Eurodollar ratio spreads which are traded on the Chicago Mercantile Exchange (CME), we use the CME's definition.

[4]Of course, the value pattern one month before expiration, specifically the hump, depends on such parameters as volatility, but these are typical for the spreads in our sample.

[5]As shown in Exhibit 1, we define *call* and *put* in terms of LIBOR, not 100-LIBOR as Eurodollar options are officially quoted.

[6]Throughout the article, we will use the terms *larger leg* and *smaller leg* to mean larger or smaller in terms of the number of options traded.

[7]Gamma and vega do not peak at exactly the at-the-money strike, but at a slightly higher strike equal to $S * \exp(0.5\,\sigma^2 t)$ where S is the underlying asset price, t the time to expiration, and σ the volatility. However, the difference is normally slight. For instance, for our sample the median values of t and σ are 0.236 and 0.11, respectively. For these, gamma and vega are maximized at a strike only 0.14% above the underlying asset price.

[8]Like its price, a spread's greeks are simple linear combinations of the derivatives for each of its legs; that is; $G_c = \Sigma_i m_i G_i$ where G_i is the greek (delta, gamma, vega, theta, or rho) for leg i and m_i is the number of options bought (+) or sold (–). In a call (put) frontspread, $m_i = +1$ for the leg with the lower (higher) strike and $m < -1$ (such as –2) for the other leg. In a call (put) backspread, $m_i = -1$ for the leg with the lower (higher) strike and $m > 1$ (such as + 2) for the other leg.

[9]The median expiry in our sample is 2.77 months and the mean is 3.41 months.

[10]We attempted to see if we could match ratio spread trades by size, ratio, strikes, expiries, and clearing firm to see if we could identify position opening and closing trades. However, we found very few matches.

[11]Additional information on the data are in Chaput and Ederington [2003].

[12]Consistent with this over our data period, implied volatilities on ratio spreads tended to exceed actual volatilities, but the difference was small and not statistically significant.

[13]Initially, these in-between strikes were 12 bps from one existing strike and 13 bps from the other—not 12.5 bps from each—but we will treat all as midway between the two.

[14]Per-spread prices and greeks are calculated for a spread in which the smallest leg is one contract. This differs in a few cases from market convention in which prices are quoted for the smallest possible combination in which each leg is an integer value. For instance, for a 2 × 3 ratio spread, the quoted price is generally for five contracts, but for consistency with the other ratios we calculate prices and greeks for a spread with 1 unit of the smaller leg and 1.5 of the larger, or 2.5 contracts. Our prices and greeks for 1 × 2 and 1 × 3 ratios accord with the market convention.

[15]The credit spread subsample contains an outlier with a price of 84 bps. Removing this observation from the sample reduces the mean spread on credit spreads from 5.54 bps to 5.15 bps. The difference between the credit and debit spread means is still significant, however, at the .0001 level.

[16]One check on the appropriateness of these approximations and the accuracy of our dataset is to compare the price for our trades with the prices calculated from the settlement prices for the individual legs. The average absolute difference is approximately one basis point. We eliminated five observations where the difference exceeded four basis points.

[17]In the greek calculations, constant maturity 3-month T-bill rates are used for options expiring in less than 4.5 months, 6-month T-bills for options maturing in 4.5 to 7.5 months, 9-month T-bills for options expiring in 7.5 to 10.5 months, and 1-year T-bill rates for all longer options.

[18]It is noteworthy that it is somewhat below the average delta on straddles (0.156) which are universally viewed as

volatility trades.

[19]Again, we caution that because we only observe the net price of a ratio spread, the ISDs, like the greeks, are estimated using settlement prices for the options and LIBOR futures, and thus contain measurement error.

[20]This makes use of the approximation that the partial derivative of an option's price with respect to its strike is approximately equal to the negative of its partial derivative with respect to the underlying asset price (its delta).

[21]In the vast majority of cases, these are the closest alternative strikes to those actually chosen while maintaining the same strike gap.

REFERENCES

Barone-Adesi, G., and R. Whaley. "Efficient Analytic Approximation to American Options Values." *Journal of Finance*, 42 (1987), pp. 301–320.

Black, F. "The Pricing of Commodity Contracts." *Journal of Financial Economics*, 3 (1976), pp. 167–179.

Bollen, R.P., and R. Whaley. "Does Net Buying Pressure Affect the Shape of Implied Volatility Functions?" *Journal of Finance*, Vol. 59, No. 2 (2004), pp. 711–753.

Chance, D. *An Introduction to Derivatives and Risk Management*, 6th ed. Nashville, TN: Southwestern, 2003.

Chaput, J.S., and L. Ederington. "Option Spread and Combination Trading." *Journal of Derivatives*, 10 (2003), pp. 70–88.

——. "Volatility Spread Design." *Journal of Futures Markets*, Vol. 25, No. 3 (2005a), pp. 243–279.

——. "Vertical Spread Design." *Journal of Derivatives*, Vol. 12, No. 3 (2005b), pp. 28–46.

Chicago Board of Trade. *Agricultural Option Strategies Menu*, 2002.

Ederington, L., and W. Guan. "Why are Those Options Smiling?" *Journal of Derivatives*, Vol. 10, No. 2 (2002), pp. 9–35.

Fahlenbrach, R., and P. Sandas. "Does Information Drive Trading in Option Strategies?" Working paper, 2006.

Lakonishok, J., I. Lee, N. Pearson, and A. Poteshman. "Option Market Activity." *Review of Financial Studies*, Forthcoming.

McDonald, R.L. *Derivatives Markets*, 2nd ed. Addison Wesley Publishers, 2006.

McMillan, L.G. *Options as a Strategic Investment*. New York, NY: Institute of Finance, 1980.

——. *McMillan on Options*. New York, NY: John Wiley and Sons, 1996.

Natenberg, S. *Option Volatility and Pricing: Advanced Trading Strategies and Techniques*, 2nd ed. Chicago, IL: Probus, 1994.

Tompkins, R.G. *Options Analysis*. Chicago, IL: Probus, 1994.