# Speculating on a Tender Offer Using Options: the Case of RJR Nabisco, Inc.

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Tender offers can create a cash flow for shareholders which is similar to a dividend. Option prices will reflect the probability and magnitude of this "dividend." This paper shows that the value of a box spread is related to the discounted, risk-neutral probabilities of exercising both a call and a put at the same strike price. Thus, the box spread can serve as a state-contingent claim for the payment of a dividend, and it is therefore a natural vehicle for speculating on the success of a tender offer. We show how a box spread could have been used to speculate on the success of the KKR tender offer for RJR Nabisco.

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## Speculating on a Tender Offer Using Options:

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In the absence of cash payouts, option prices convey no information about the expected future stock price. If there is a possibility of cash payouts, however, the price of an unprotected option will reflect the market's estimate of the probability and size of the cash payment. A tender offer for a stock is one example of a transaction which can create the equivalent of a large dividend payment. In this case, options can be used to speculate on the success of the tender offer (i.e. the likelihood of the "dividend" being paid), and option prices may contain information about the probability of the tender offer succeeding.

Using the example of RJR Nabisco, Inc., this paper illustrates the use of a particular option strategy — the box spread[1] — to speculate on the success of a tender offer. RJR was the object of a tender offer for control by the investment banking firm Kohlberg, Kravis, and Roberts in late 1988 and early 1989. The box spread provided a unique opportunity to speculate on the success of this tender offer. During part of this period, the price of the box spread exceeded what would have been the no-arbitrage price in the absence of the tender offer. Thus, the position would have had a predictable price change in the event the tender offer failed, thereby providing a natural vehicle for speculating on the success of the offer. In effect the price of the box spread implied a state price for the tender offer succeeding.

Of course it would also have been possible to speculate on the success of the tender offer simply by buying RJR stock. The advantage of the box spread over the stock is that the value of the spread is relatively insensitive to the post-tender share price if the tender offer succeeds, and behaves predictably if the tender offer fails.

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[1]The box spread is created by buying a call and selling a put at a low strike price, and selling a call and buying a put at a higher strike price, with all of the options expiring at the same time. Ronn and Ronn (1989) discuss the box spread in more detail.

Section I illustrates the behavior of RJR option prices in January, 1989, and discusses the terms of the KKR tender offer. Section II considers various possible strategies for using American and European options to speculate on the takeover. We show that the price of the spread is an estimate of the sum of the discounted risk-neutral probabilities of eventually exercising *both* the call and put at a given strike price. For short-lived American options, both are likely to be exercised only in the event of a dividend, so the sum of the two probabilities reflected the likelihood that the tender offer would succeed.

Section III uses actual RJR option prices to illustrate the behavior of the box spread during the period of the RJR tender offer. We derive a new, dividend-dependent upper bound for the value of a box spread and show that i) the value of the spread exceeded this bound the period December, 1988 through February, 1989, and that ii) changes in the value of the spread were related to news events during this period.

## I. RJR Nabisco Option Prices in January, 1989: An Apparent Anomaly

### A. A Violation of Put-Call Parity

Table 1 contains the January 10, 1989 closing prices of American RJR call and put options with January and February expirations. On the same date, the common stock of RJR closed at 94-7/8. The well-known put-call parity formula relates the price of European-style put options and call options on the same stock, with the same striking price, and with the same time to expiration:

$$\text{Call}(K) = \text{Put}(K) + S - PV(K) \tag{1}$$

where Call(K) and Put(K) represent the prices of call and put options with the same time to expiration and strike price K, S is the current stock price, and PV(K) is the present value of the strike price, computed using the time to expiration of the options.

**Table 1:** Closing prices of RJR call and put options on January 10, 1989.

| Strike | Call | Put | European Call Deviation | American Call Deviation |
|---|---|---|---|---|
| | January expiration | | | |
| 80 | 15.000 | 0.063 | -0.138 | 0.062 |
| 85 | 10.250 | 0.125 | 0.038 | 0.250 |
| 90 | 5.375 | 0.250 | 0.026 | 0.250 |
| 95 | 0.906 | 0.750 | 0.044 | 0.281 |
| 100 | 0.125 | 5.125 | -0.124 | 0.125 |
| | February expiration | | | |
| 80 | 16.500 | 4.000 | -2.375 | -1.830 |
| 85 | 11.875 | 6.625 | -4.625 | -4.080 |
| 90 | 7.250 | 10.250 | -7.875 | -7.330 |
| 95 | 3.000 | 13.750 | -10.625 | -10.080 |
| 100 | 0.531 | 18.125 | -12.469 | -11.924 |

Option prices are closing prices obtained from the Chicago Board Options Exchange. The stock price is the closing price obtained from the CRSP tape. "European Call Deviation" is calculated as Call Price - Put Price - Stock Price + (Strike Price)/(1+r), where $r = .09\times$(days to expiration$\div$365). "American Call Deviation" is calculated as Call Price - Put Price - Stock Price + Strike Price for the January option, and the same formula plus .545 for the February option. The closing stock price was 94-7/8. January options have 10 days to expiration. February options have 38 days to expiration.

The column in Table 1 entitled "European call deviation" is the dollar difference between the observed call price and the call price implied by equation (1). While the January options come close to obeying the put-call parity relationship, the February options, especially those with high strike prices, appear severely mispriced. There are a number of possible explanations for this apparent mispricing. First and foremost, the put-call parity formula in (1) holds exactly only for European options on stocks which pay no dividends. Cox and Rubinstein (1985, p. 152) show that American options on stocks which pay dividends must satisfy the following bound:

$$\text{Call}(K) - S + K + D^{+} \geq \text{Put}(K) \geq \text{Call}(K) - S + PV(K) \quad (2)$$

where $D^{+}$ is the present value of the maximum possible dividends to be paid over the remaining life of the option. The previous quarterly dividend with an ex-date of November 11 had been $0.55. Thus, it might have been reasonable to expect the same dividend sometime in early February.

The columns in Table 1 entitled "American call deviation" are the dollar differences between the observed call price and the *minimum* call price implied by equation (2). This time the January options obey the bounds, but the February options are again severely mispriced. Note that the deviation from parity appears to be primarily due to the prices of the puts; for example, for the 95 strike puts, an extra 28 days until expiration results in a $13 increase in the put price. Since the price of an American put can exceed that of an otherwise identical European put by at most the value of interest on the strike price, it is not surprising that accounting for the options being American does not eliminate the mispricing puzzle.

As a final possible source of error, closing prices will often display apparent arbitrage opportunities because the reported price is that of the last trade in the option. The differences in the table are large, systematic, and too persistent to be explained by this, however.[2]

A better explanation of Table 1 is the fact that RJR, Inc., was the subject of a tender offer by Kohlberg, Kravis, and Roberts (KKR) during this period. To understand the effect of the tender offer, we will see how an arbitrageur attempting to profit from the "mispricing" in Table 1 would have fared. First, however, it is necessary to understand the terms of the tender offer.

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[2]Similar apparent mispricing persisted throughout January. In addition, volume in the options was not trivial. For example, volume for the 95 strike options on January 10 was as follows: Jan call, 3377; Jan put, 1141; Feb call, 4092; Feb put, 614.

## B. The KKR Tender Offer for RJR

KKR's offer to buy RJR Nabisco was accepted on November 30, 1988 by the RJR board. At the time, there were 225,518,355 RJR shares outstanding. The tender offer was an offer to purchase up to 165,509,015 shares (73.39% of outstanding shares) for $109 cash. The tender was conditional upon i) at least half of the outstanding shares being tendered, and ii) the completion of financing arrangements. If more than 73.39% of shares had been tendered, 73.39% would have been purchased pro rata from those who tendered. Shares outstanding after the tender completion were to be converted into convertible preferred stock and debentures at an unstated date following the completion of the tender offer. We will refer to these shares as "residual shares". Although KKR described the residual shares as being worth $109, the market apparently disagreed; at no time before the tender completion did the share price approach $109.[3]

Highlights of the buyout over the period 10/88-2/89 are described more fully in Appendix A. The success of the buy-out was uncertain for at least four reasons: 1) it was the largest buy-out up to that time, and there was uncertainty that the financing could successfully be arranged; 2) Drexel Burnham Lambert was responsible for placing almost $5 billion in junk bonds, and for much of this period there was the possibility of a U.S. criminal indictment against the firm; 3) the Federal Trade Commission had threatened antitrust action against KKR; and 4) a shareholder suit contended that the RJR board had violated its fiduciary duty by accepting the KKR offer rather than a competing managment-led offer. Eventually each of these uncertainties was resolved. Nevertheless, the success of the buy-out appeared uncertain during most of this period.

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[3]In a "Heard on the Street" column entitled "KKR's Plan to Acquire RJR Nabisco Raises a $4 Billion Question Among Some Analysts", (*Wall Street Journal*, Dec 7, 1988), analysts estimated a value of around $85 for the residual shares. Just prior to the completion of the tender offer, the stock price was $100; following the completion of the tender, the value of the residual shares was $81.50.

## II. Speculating on the Success of the Tender Offer

In this section we explore the use of options to speculate on the success of the tender offer. Throughout this section we make the important assumptions that the options expire just after the tender-offer expiration and that the success or failure of the tender offer is also determined at this time. While unrealistic, these assumptions clarify the value of the box spread in this speculation. In the following section we drop these assumptions and show how traded American options could have been used to speculate on the success of the tender offer.[4]

### A. European Options

Although traded options on RJR were American, it is useful to first discuss strategies using European options since this highlights some of the issues in the RJR tender offer. As we saw in Table 1, the February call appears underpriced based on put-call parity. Thus one could buy the call, sell the put, short the stock, and lend the present value of the strike price; this strategy is called a "reverse conversion". Had a trader bought a reverse conversion for the 95 strike February options, Table 1 shows that the cash inflow would have been $11.50.

Suppose this position were maintained until option expiration, February 17, which is after the tender date. If the tender offer had been unsuccessful or had otherwise not been completed by February 17, there would have been a terminal payoff of zero, and the original cash inflow would have constituted

[4]There is one other risk we will ignore: it is conceivable that the terms of the options would be directly affected by the tender offer. For example, the exchange might have decided to "dividend-protect" the options against large cash payouts. The Chicago Board Options Exchange did not do so, however. In some cases there is also the problem that if the tender offer were for 100% of the shares, there would be no market for the stock and hence no option trading following a successful tender; the exchange in this case would have to decide how to settle the options. For example, during the Conoco takeover in 1981, options were cash-settled, since the stock did not exist to settle the options (Ruback, 1982). In the case of RJR, the option continued trading after the tender since there were still shares in existence.

a profit.

Suppose, on the other hand, that the tender offer had been successful. The arbitrageur has a short position in the stock. In order for the proposed arbitrage to be successful, this position must be held open across the tender expiration date. How is such a short position closed?

An investor who loans the stock for a short sale must be made at least as well off as if they had kept possession. Thus, if the tender offer were successful, for every share borrowed the short seller would have to pay $109 × 73.39%, and would have to repurchase on the open market (1 - .7339) of the post-tender shares. Essentially, the short-seller would have to mimick the terms of KKR's stock purchase. Denote the post-tender stock price by P, and the pre-tender stock price by S. Let $\lambda$ be the fraction of shares which received Q in cash. Table 2 depicts the cash flows in the cases of successful and unsuccessful tender offers.

**Table 2:** Cash flows from the strategy of buying a European call, selling a European put, shorting the stock, and lending the present value of the strike price.

| | Tender offer unsuccessful | Tender offer Successful | |
|---|---|---|---|
| | | Post tender stock price > K | Post-tender stock price < K |
| Buy Call | Max[0,S-K] | P - K | 0 |
| Sell Put | -Max[0,K-S] | 0 | - (K - P) |
| Short Stock | -S | $-\lambda Q-(1-\lambda)P$ | $-\lambda Q-(1-\lambda)P$ |
| Lend PV(K) | K | K | K |
| Total | 0 | $\lambda(P-Q)$ | $\lambda(P-Q)$ |

K is an arbitrary strike price, S the price of the stock conditional on the tender offer failing, P the post-tender price of the stock conditional on the tender offer succeeding, and Q the per-share cash payment for the fraction $\lambda$ of shares.

In the event the tender offer is unsuccessful, the strategy pays 0; in this case the put-call parity arbitrage succeeds. The problem is that if the tender offer is successful, the arbitrageur is required to make both a cash payment and return a fraction of the borrowed shares to close the short sale. The net effect is for the arbitrageur to pay 73.39% of the difference between the post purchase price and the cash price per share. From the perspective of the arbitrageur, the tender offer creates a stochastic dividend. Thus, the "arbitrage" position with European options amounts to *both* a bet on the takeover occurring (taking as given the terms) and on the difference P-Q.[5]

In the event of a successful tender offer, the net cash flow does not depend on the strike price of the option. Therefore there is no way to sharpen the arbitrage by using strategies involving multiple strike prices. In addition, any pricing correction implied by Table 2 is independent of the strike price, so Table 2 is no help in explaining Table 1, in which the apparent mispricing rises with the strike price.

## B. Arbitrage with American Options

In this section we will first examine the consequences of undertaking an "arbitrage" based on the reverse conversion. We will then see that by using an appropriately-selected box spread we obtain a payoff which 1) is relatively insensitive to the post-tender stock price, and which 2) pays one amount if the buyout succeeds and a different amount otherwise.

With American options we must consider the effect of early exercise. For the moment, however, we will assume that the options expire immediately after the tender offer expires, so that following the tender offer there is no remaining time premium in the option prices. Furthermore, we will assume that puts are not exercised prior to the tender offer.[6] Since the prospect of a dividend reduces the incentive to exercise a put, this is a plausible assumption. In the next section we deal with early exercise more carefully.

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[5]We ignore the possibility that the tender offer fails and is replaced by another offer with different terms.

[6]In the absence of interim dividends calls would not be early-exercised, but puts might be.

*B.1. The Reverse Conversion*

As before, suppose that we enter a reverse conversion, i.e. we buy a call, sell a put, short the stock and lend the present value of the strike price. In order for stock-holders to willingly tender, the tender price, Q, must be above the expected post-tender stock price, P. Assume this is the case. The result is an expected stock price drop at the moment the tender is executed. If the tender date is close to expiration, in-the-money call options will be exercised just prior to the tender completion, and in-the-money put options will be exercised after the tender completion. This dual exercise is the key difference between using American and European options.

Let S* denote the stock price just prior to the tender execution, assuming that the tender offer is certain to succeed. As before, P denotes the post-tender price, $\lambda$ the percentage of shares purchased, and Q the tender purchase price. If the tender is believed certain to succeed, then at the moment prior to the tender completion, a no-arbitrage condition in the stock market is

$$S^* = \lambda P + (1-\lambda)Q \tag{3}$$

i.e., the stock price just prior to the tender expiration should equal the value of the post-tender portfolio. Since we have assumed $Q > P$ (and hence $S^* > P$), there are three possible sets of pre- and post-tender stock prices for a given strike: $S^*>K$ and $P>K$; $S^*>K$ and $P<K$; $S^*<K$ and $P<K$. Using equation (3), these three regions can be expressed solely in terms of P, K, $\lambda$, and Q. Unlike with European options, there are different payoffs to the strategy depending upon whether either or both of the options are exercised. The general case is analyzed in Appendix B.

Figure 1 depicts the cash flow at expiration from this position as a function of P, conditional upon the completion of the tender offer, using options with a strike price of 90 and 95. Calculations in Appendix B show that both the 90 strike call and put will be exercised as long as the post-tender stock price is between 90 and 37.60; and both of the 95 strike options will be exercised as long as the post-tender stock price is between 95 and 56.39. In the region where both options are exercised the payoff is the strike price less the post-tender stock price. Obviously, even if the tender offer succeeds this strategy is not riskless since the terminal payoff depends upon the post tender stock price, P (see Figure 1).

If the tender offer fails each position is worth 0 because of the assumption that the options expire simultaneously with the resolution of the tender offer.

*B.2. The Box Spread*

Examining Figure 1 suggests that taking offsetting positions in the 90 and 95 strike conversions will — in the event the tender offer succeeds — decrease the sensitivity of the position to the terminal stock price. The cost of this strategy — known as a box spread — is given by

$$B(K_1,K_2) = [\mathrm{Call}(K_1) - \mathrm{Put}(K_1)] - [\mathrm{Call}(K_2) - \mathrm{Put}(K_2)] \tag{4}$$

Figure 2 depicts the result of buying a 90-95 box spread, i.e. buying the 90 strike call and 95 strike put, and selling the 90 strike put and the 95 strike call. (This position is analyzed more fully in Appendix B.[7]) As long as the post-tender stock price is between 56.39 and 90, the position pays $10. For positions above 95 and below 37.60 the position pays $5. If the tender offer fails the position pays $5, independently of the stock price. Thus, for a broad range of post-tender stock prices, the box spread approximates a state contingent claim which pays off only in the event that the tender offer succeeds.

Figure 2 makes clear why an option position may be preferred to a stock position when speculating on the success of the tender offer. With the stock, the payoff depends both upon whether

[7]Ronn and Ronn (1989) discuss the box spread. The lower and upper bounds for the value of a box spread without borrowing or lending are PV(ΔK) and 2(ΔK), where ΔK is the difference in strike prices between the two sets of puts and calls. As we show in the text, it is possible to tighten the upper bound by making an assumption about dividends.

the tender offer is successful and also upon the value of the post-tender shares. With the option strategy, however, the payoff is — over a broad range of stock prices — independent of the post-tender share value. Thus, the option strategy is more of a pure bet on the success or failure of the tender offer.

## C. Interpretation of the Box Spread

In what sense does the box spread approximate a state-contingent claim on the occurence of the successful tender offer? It is well-known that options can provide state prices for future levels of the stock price. For example, Breeden and Litzenberger (1979) show that the value of a butterfly spread approximates both a state price and the second derivative of a European option price. There is a similar interpretation for the box spread.

To interpret the box spread, note that $B(K_1,K_2)$ can be rewritten

$$C(S,K) - C(S,K+\Delta) - [P(S,K) - P(S,K+\Delta)],$$

where K and K+Δ are the two strike prices. Dividing by Δ and taking the limit as Δ approaches zero, we obtain

$$\lim_{\Delta \to 0}\left(\frac{C(S,K) - C(S,K+\Delta)}{\Delta} - \frac{[P(S,K) - P(S,K+\Delta)]}{\Delta}\right) = -\frac{\partial C(S,K)}{\partial K} + \frac{\partial P(S,K)}{\partial K} \tag{5}$$

The interpretation of these partial derivatives is provided by the following lemma:

***Lemma*** *$-\partial C/\partial K$ and $\partial P/\partial K$ are the risk-neutral discounted probabilities of exercising the call and the put, respectively.*

The proof is in Appendix C. This Lemma, together with (5), implies the following:

***Proposition 1*** *$B(K_1,K_2)/(K_2-K_1)$ approximates the sum of the discounted risk-neutral probabilities of exercising both a call and a put with the same strike price (between $K_1$ and $K_2$) and the same time to expiration.*

If both the call and put options are likely to be exercised in the near future, $\partial C/\partial K \approx -1$ and $\partial P/\partial K \approx 1$, and the box spread will be worth twice the difference in the strike prices. This can happen if the tender offer is certain to succeed and the implicit dividend is large enough to assure that both the puts and calls will be early exercised. If, on the other hand, early exercise for both options is unlikely, then the options behave more like European options: for a given strike price, either the call or the put will be exercised, but not both.

## III. Speculating on the RJR Tender Offer

In the previous section we assumed that the options expired just after the tender offer completion and that puts were not exercised prior to that time. In practice, neither is certain. In this section we show how the box spread could have been used even without these assumptions.

### A. Speculation with the Box Spread

Ronn and Ronn (1989) show that the box spread satisfies the bounds

$$PV(K_2-K_1) \leq B(K_1,K_2) \leq 2(K_2-K_1) \tag{6}$$

In some cases, however, there is a smaller upper bound on the value of the box spread.

***Proposition 2.*** *The upper bound on the value of a box spread, $U(K_1,K_2)$, is given by*

$$U(K_1,K_2) = \min[\ 2(K_2-K_1),\ K_2 - PV(K_1) + D^+]. \tag{7}$$

*Proof* Using equation (2), we can substitute the smallest possible value for Put($K_1$) and the largest possible value for Put($K_2$) into B($K_1$, $K_2$) (from equation (4)) . This implies that

$$PV(K_2-K_1) \leq B(K_1,K_2) \leq K_2 - PV(K_1) + D^+ \tag{8}$$

Combining (6) with (8) gives (7).■

This alternative upper bound is useful because, as we have seen, the tender offer effectively creates a dividend. The possibility of this large dividend causes the value of the box spread to exceed the upper bound in the absence of the tender offer. In that case, the value of the spread will predictably decrease if the tender offer fails.

We saw earlier that RJR had paid a November dividend of \$.55. With an interest rate of 9% and one month to expiration, 95 - PV(90) + .55 = 6.21. Thus, if the buyout failed one month prior to expiration and RJR were expected to pay a February dividend, the box spread would have a value no greater than 6.21.[8] From Table 1, however, the box spread on January 10 had a price of 7.75. Note that the upper bound on the value of the position declines as the options approach maturity.

Figures 3, 4, and 5 graph the daily value of the box spread from late November 1988 to February 1989 for the 90 and 95 strike options expiring in January, February, and May. These figures also show the theoretical lower and upper bounds for the box spread in the absence of a tender offer. The upper bound assumes that a \$.55 dividend would have been paid in February and May. Before discussing these Figures, it is important to be aware of measurement problems in the data. First, since

[8]This of course presumes that no subsequent tender offer could be completed in the interim.

the reported option price on the CBOE is that of the last trade rather than a "true" closing price, the prices of the various options may be non-synchronous and may not reflect end of day prices. Second, the reported prices could be either at the bid or ask. To get an idea of the maximum error, suppose that the reported price for the purchased options is at the ask, and the reported price for the written options is at the bid. Suppose further that the stock price dropped $.25 in the last hour, and that the purchased options reflect the lower stock price while the written options do not. If the bid-ask spread for each option is 1/8 and the option deltas are all 1/2, the cumulative effect is to understate the cost of the spread by $.50. This suggests that large persistent changes in the value of the spread are real, but that smaller changes may be noise. At several points there seems to be negative serial correlation in the changes in the spread value; this would be expected from using non-synchronous prices.

For all of the options in Figures 3-5, the upper bound in the absence of a tender offer was violated at least some of the time from early December through February 9, when the tender offer was finally completed. In all cases, the box spreads took large jumps over the period from November 30 to December 2; November 30 was the date on which KKR was selected as the winning bidder; all figures identify this date.[9]

In the KKR Prospectus dated December 7, the stated expiration date for the tender offer was January 11, 1989. A comparison of the figures, however, suggests that the market did not assign a high probability to the completion of the tender offer prior to the January 20 expiration date for the January options. The January spread rarely exceeded the upper bound, and did so for the last time on December 16, when the FTC announced that it required KKR to submit additional information on the proposal, a move which seemed likely to lengthen the approval process.

Throughout January both the prices of both the February and May spreads drifted upwards. The

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[9]The May box spread actually fell in value on December 1, but this may be an artifact arising from low volume. Whereas the relevant January and February options traded several thousand contracts per strike on December 1, none of the May options traded more than 300 contracts.

*Wall Street Journal* on Friday, January 6, and the *New York Times* of Saturday, January 7, reported that large financing agreements had been concluded. On January 9 the February spread jumped in value \$1.50, the May spread by a smaller amount. In late January a Drexel-led junk bond issue was reported oversubscribed, and several days later the FTC ended its antitrust investigation. By early February both spreads were trading at close to their unconditional upper bound of \$10, suggesting that the market placed a high probabilty on successful completion of the tender offer prior to the February 16 expiration of the February options. Finally, on February 9, KKR completed the takeover and both option spreads fell to their lower bound of \$5.

## B. Speculating With the Stock or Single Options

If a stock is the object of a tender offer for a fraction $\lambda$ of outstanding shares, the current stock price, S, reflects $\lambda$, the stock price conditional on the tender offer completion, Q, the price conditional on the tender not being completed (i.e. the offered price), Y, and the probability of the tender offer being completed, $\rho$. Assuming that the completion of the offer is contingent only on non-systematic events,

$$S = \rho[\lambda Q + (1-\lambda)P] + (1-\rho)Y.$$

If we can estimate Q, P, Y, and $\lambda$, and we can observe S, we can compute the market's estimated probability that the tender offer will succeed. The problem, of course, is that while we may know Q, the residual share value, Y, is likely to be hard to estimate. In any case, there is more uncertainty in the stock price than simply whether or not the tender offer succeeds. Speculating with individual options only compounds the difficulties, since the distribution of the stock price may be difficult or impossible to estimate.

To clarify the differences between the box spread arbitrage and simply buying the stock, Figure 6 compares the behavior of the spread with the stock price from November, 1988 to February, 1989. In examining Figure 6 we should keep in mind that small moves in the option spread may not be meaningful (as already noted, transactions costs are a significant fraction of the price) whereas transactions costs are a much smaller percentage of the stock price. Since good news about the tender offer would raise both the stock price and the spread price, and since the tender offer was ultimately successful, we would expect the stock and the spread price to behave similarly over this period. There are at least two significant differences worthy of discussion, however. First, in the period immediately preceding KKR's selection, the option spread fell in value while the stock rose. Betwen November 23 and November 29, the stock rose from 86-7/8 to 90-7/8, while the spread fell from 6 to 5. Following KKR's selection, the spread rose to $7.50 on December 2, whereas the stock on that date was at 90-3/4, essentially the same as several days earlier. Although it is difficult — even *ex post* — to explain stock and option price movements, it is clear that the stock and the spread could behave differently, since the spread was reflecting the possibility of a cash tender offer being completed prior to February, whereas the stock is simply reflecting news about RJR in general and the possibility of an eventual buyout.

Second, on February 9 the tender offer succeeded and the stock price dropped from 100 at the close on February 8 to 81.50 at the close on February 9. At the same time, the 85, 90, and 95 strike February and May puts all dropped between $2 and $3 in price. This decline in the put price at the time of an anticipated event which lowered the stock price suggests that the residual shares on February 9 were worth more than the market had expected on February 8. A stock-holder (or put-holder) speculating on the takeover would have been exposed to this uncertainty even when the takeover succeeded (in this case, of course, the uncertainty resolved to the benefit of unhedged stock-holders). The February box spread, however, was worth the expected price, approximately $5.

## IV. Conclusion

In the case of KKR's buyout of RJR Nabisco, Inc., options provided a unique opportunity to speculate on the success of the tender offer. Option traders could speculate on the timing and success of the buyout, without worrying specifically about what would happen to the stock price if the buyout failed, or, within a broad range, what the residual stock price would be if the tender offer succeeded. The price of the spread did appear to respond to news about the takeover.

**Appendix A: Chronology of RJR Nabisco, Inc. Takeover, October, 1988 — February, 1989.**[10]

The following dates are either i) publication dates of a news item in the *Wall Street Journal* or *New York Times*, or ii) when the date is in italics, the business day preceding the publication day.

| | |
|---|---|
| *Oct. 20*: | First announcement of possible $20 billion LBO led by F. Ross Johnson, RJR President and CEO. Proposed price of $75/share. |
| *Oct. 23*: | Kohlberg, Kravis, Roberts (KKR) proposes tender offer at $90/share. |
| Nov. 30: | Press stories that KKR selected by RJR Nabisco board. |
| *Nov. 30*: | Formal announcement that KKR group has been selected by RJR Nabisco board. |
| *Dec. 5*: | Salomon Bros. and Shearson-Lehmann announce that they will make no further offers for RJR. |
| *Dec. 6*: | S&P puts Drexel Burnham Lambert, a lender in the proposed buyout, on its watch list. |
| *Dec 16*: | KKR receives request from the FTC for additional information relating to the buyout; the *New York Times* reports that this could delay completion of the deal. |
| Dec 22: | The *Wall Street Journal* reports that Drexel, Burnham, Lambert's settlement of criminal charges brought by U.S. has increased the likelihood of successful takeover. |
| Jan. 6: | The *Wall Street Journal* reports that Japanese banks are ready to commit funds to KKR. |
| Jan. 7: | The *New York Times* reports (on a Saturday) that significant financing commitments have been obtained. |
| Jan. 18: | KKR obtains agreements for $14 billion in bank loans. |
| Jan. 25: | KKR postpones closing of RJR deal because FTC has not finished review for antitrust implications. |
| Jan. 26: | *Wall Street Journal* reports that the Drexel-led $3 billion RJR junk bond issue is |

[10]All items here are taken from the *Wall Street Journal* and the *Wall Street Journal Index.*

oversubscribed.

*Jan. 30*: KKR reports resolution of potential antitrust problems with U.S.

*Feb. 1*: Delaware Chancery court rules that RJR directors did not violate fiduciary duty in accepting RJR bid.

*Feb. 3*: FTC formally approves KKR bid for RJR; closing postponed until February 9.

*Feb. 9*: KKR buyout completed.

## Appendix B: The Reverse Conversion with American Options

This appendix presents payoff tables for two strategies using American options: in Table 3, buying a call, selling a put, and shorting the stock (a reverse conversion); and in Table 4, buying a call and selling a put at strike price $K_1$, while selling a call and buying a put at strike price $K_2$. The calculations assume that the tender offer stock purchase is for a fraction $\lambda$ of the shares at price Q, and the post-tender stock price is S. The pre-tender price is therefore $S^* = \lambda Q + (1-\lambda)P$.

**Table 3:** Payoffs in different stock-price regions for reverse conversion (buy call, sell put, short stock). Assumes $Q > K$, which implies that $K > (K-\lambda Q)/(1-\lambda)$

| Strategy | Tender Offer Fails | Tender Offer Succeeds | | |
|---|---|---|---|---|
| | | $P > K$ | $K > P > (K-\lambda Q)/(1-\lambda)$ | $P < (K-\lambda Q)/(1-\lambda)$ |
| Buy Call | Max[0,P-K] | $\lambda Q+(1-\lambda)P-K$ | $\lambda Q+(1-\lambda)P-K$ | 0 |
| Sell Put | -Max[0,K-P] | 0 | P - K | P - K |
| Short Stock | -P | $-\lambda Q - (1-\lambda)P$ | $-\lambda Q - (1-\lambda)P$ | $-\lambda Q - (1-\lambda)P$ |
| Lend PV(K) | K | K | K | K |
| Total | 0 | 0 | P-K | $\lambda(P-Q)$ |

**Table 4:** Payoffs in different stock-price regions for box spread arbitrage (assumes $Q > K_2 > K_1$)

| Strategy | Stock Price after Tender Completion | | | | |
|---|---|---|---|---|---|
| | $P > K_2$ | $K_2 > P > K_1$ | $K_1 > P > (K_2-\lambda Q)/(1-\lambda)$ | $(K_2-\lambda Q)/(1-\lambda) > P > (K_1-\lambda Q)/(1-\lambda)$ | $(K_1-\lambda Q)/(1-\lambda) > P$ |
| Buy Call($K_1$) | $\lambda Q+(1-\lambda)P-K_1$ | $\lambda Q+(1-\lambda)P-K_1$ | $\lambda Q+(1-\lambda)P-K_1$ | $\lambda Q+(1-\lambda)P-K_1$ | 0 |
| Sell Put($K_1$) | 0 | 0 | $P-K_1$ | $P-K_1$ | $P-K_1$ |
| Sell Call($K_2$) | $K_2-\lambda Q-(1-\lambda)P$ | $K_2-\lambda Q-(1-\lambda)P$ | $K_2-\lambda Q-(1-\lambda)P$ | 0 | 0 |
| Buy Put($K_2$) | 0 | $K_2 - P$ | $K_2-P$ | $K_2-P$ | $K_2-P$ |
| Total | $K_2-K_1$ | $2K_2-K_1-P$ | $2(K_2-K_1)$ | $\lambda Q+(1-\lambda)P+K_2-2K_1$ | $K_2-K_1$ |

To understand the tables it is helpful to consider one case in detail. Suppose that the tender offer succeeds, and that we have purchased the 90 strike call, sold the 90 strike put, and shorted the stock. The tender offer is for a fraction .7339 of the shares at \$109/share. We will exercise the 90 strike call if the pre-tender price is greater than 90. This will occur if

$$.7339 \times 109 + .2661 \times P > 90$$

or

$$P > (90 - .7339 \times 109)/.2661 = 37.60.$$

We will exercise the 90 strike put as long as $P < 90$. Thus, both options are exercised if $90 > P > 37.60$. Table 4 considers the possibilities for various subsets of the options in a box spread to be exercised; it is thus basically an extension of Table 3.

## Appendix C: Proof of Lemma

Consider the time t value of an American call option with strike price K, expiring at T. Suppose that option exercise is possible only at the n times T, T-$\Delta$, T-2$\Delta$,...,t+$\Delta$, where $\Delta \equiv (T-t)/n$. Let $S_i$ denote the stock price at time T-i$\Delta$, with $\bar{S}_i$ denoting the stock price at time T-i$\Delta$ above which the call should be exercised. Let $g_i(S_i) \equiv g_i(S_i \mid S_{i+1})$ denote the risk-neutral probability density of stock prices at time T-i$\Delta$ conditional on the stock price at T-(i+1)$\Delta$.

Following Kim (1990), we can use the risk-neutral price process to write the value of a live American call recursively as

$$V_1(S_1) = e^{-r\Delta}\int_K^{\infty}(S_0-K)g_0(S_0)dS_0 \tag{9}$$

$$V_{i+1}(S_{i+1}) = e^{-r\Delta}\left[\int_{\bar{S}_i}^{\infty}(S_i-K)g_i(S_i)dS_i + \int_0^{\bar{S}_i}V_i(S_i)g_i(S_i)dS_i\right] \qquad i = 1,...,n. \tag{10}$$

where r is the risk-free rate. These equations make obvious the well-known result that the optimal exercise boundary, $\{\bar{S}_i\}$, is selected recursively. The early exercise bound $\bar{S}_i$ is chosen to maximize $V_{i+1}(S_{i+1})$.

Now we wish to evaluate the derivative $\partial V_n(S_n)/\partial K$. Note first that by the envelope theorem, induced changes in the optimal exercise schedule $\{\bar{S}_i\}$ may always be ignored since this schedule was optimally chosen. We proceed by induction. Beginning in period T-Δ, we have

$$\frac{\partial V_1}{\partial K} = -\int_K^{\infty} e^{-r\Delta} g_0(S_0)dS_0 \tag{11}$$

Clearly $-\partial V_1/\partial K$ represents the discounted risk-neutral probability of exercising the option at time T, conditional on $S_1$. Now assume that $-\partial V_i/\partial K$ represents the discounted risk-neutral probability of exercising the option after time T-iΔ, conditional on $S_i$. We compute $\partial V_{i+1}/\partial K$ as

$$\frac{\partial V_{i+1}}{\partial K} = -\int_{\underline{S}_i}^{\infty} e^{-r\Delta} g_i(S_i)dS_i + \int_0^{\bar{S}_i} e^{-r\Delta} \frac{\partial V_i}{\partial K} g_i(S_i)dS_i \tag{12}$$

Since $-\partial V_{i+1}/\partial K$ is clearly also the discounted risk-neutral probability of option exercise from period T-(i+1)Δ, conditional on $S_{i+1}$, it follows by induction that the same is true for $-\partial V_n/\partial K$.

We have assumed that the option is alive. If it is in the early-exercise region, $\partial V_n/\partial K = -1$, and $-\partial V_n/\partial K$ trivially equals the probability of early exercise. Since n is arbitrary and can be made large, the proposition is true for a continuously-exercisable option. Finally, an identical proof obtains for puts.■

**References**

Breeden, Douglas and Robert Litzenberger. "Prices of State Contingent Claims Implicit in Option Prices," *Journal of Business*, 51 (4), 1978, pp. 621-652.

Cox, John C. and Mark Rubinstein. *Options Markets.* Prentice-Hall, 1985.

Kim, In Joon. "The Analytic Valuation of American Options," *Review of Financial Studies* 3 (4), 1990, pp. 547-572.

Ronn, Aimee Gerbarg and Ehud Ronn. "The Box Spread Arbitrage Conditions: Theory, Tests, and Investment Strategies," *Review of Financial Studies*, 2 (1), 1989, pp. 91-108.

Ruback, Richard S. "The Conoco Takeover and Stockholder Returns," *Sloan Management Review*, Winter 1982, pp. 13-32.

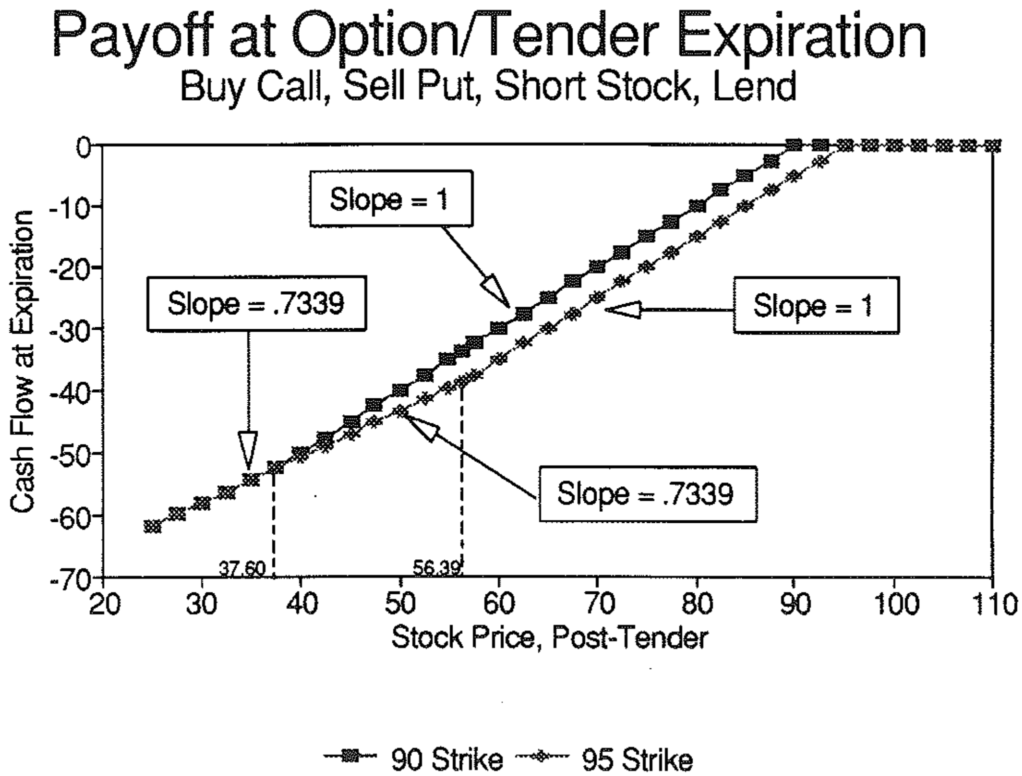


**Figure 1**: Expiration value of reverse conversion (short stock, sell put, buy call, lend PV(strike)) using American options, for 90 and 95 strikes; assumes that due to a dividend prior to expiration, calls and puts are both exercised.

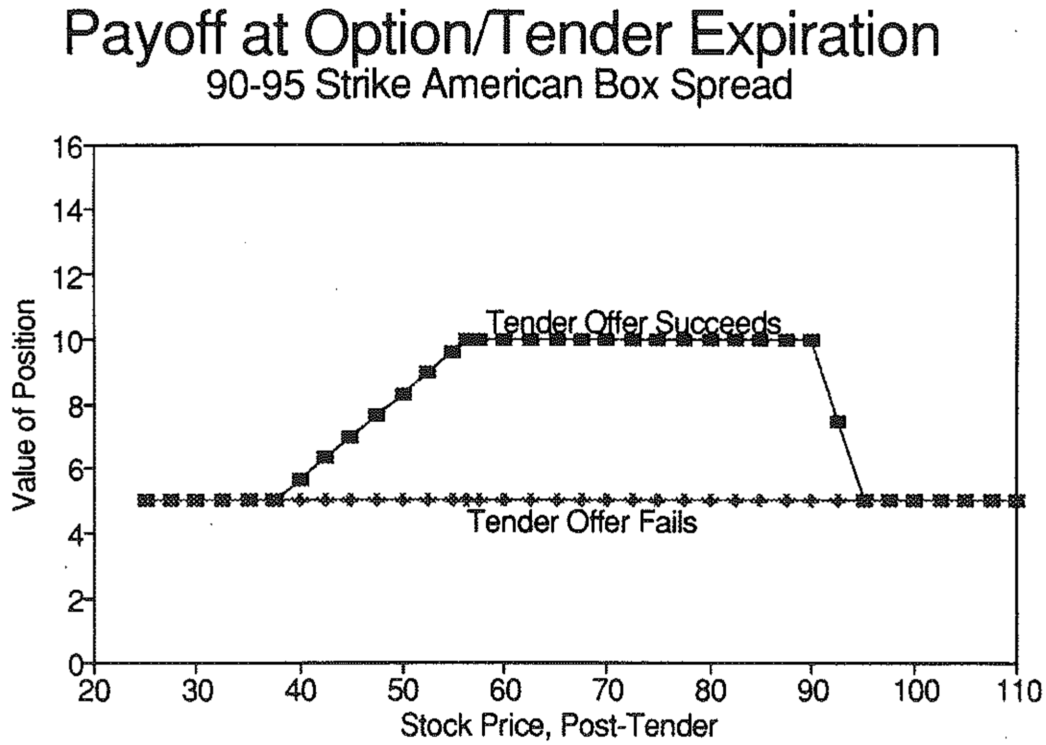


**Figure 2**: Expiration value of box spread with American options (buy 90 strike call, sell 90 strike put, sell 95 strike call, buy 95 strike put) assuming that there is a dividend just prior to expiration and all options are exercised.

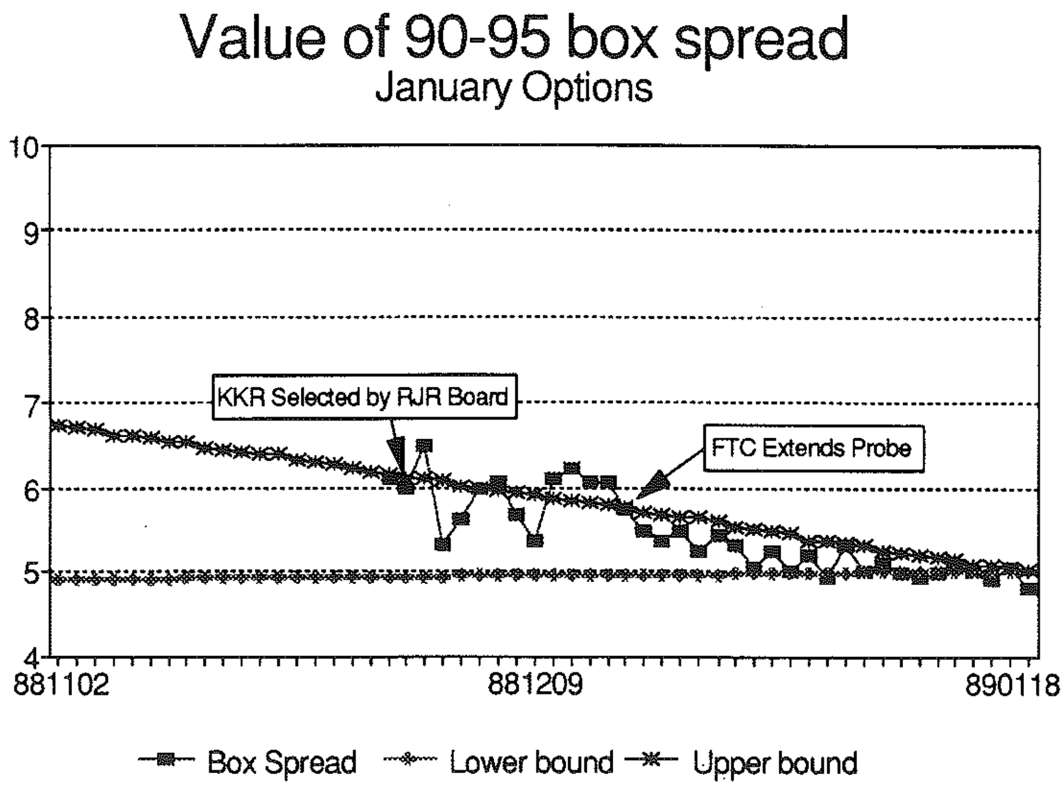


**Figure 3**: Value between November 1988 and February 1989 of a box spread on RJR Nabisco constructed using 90 and 95 strike January options.

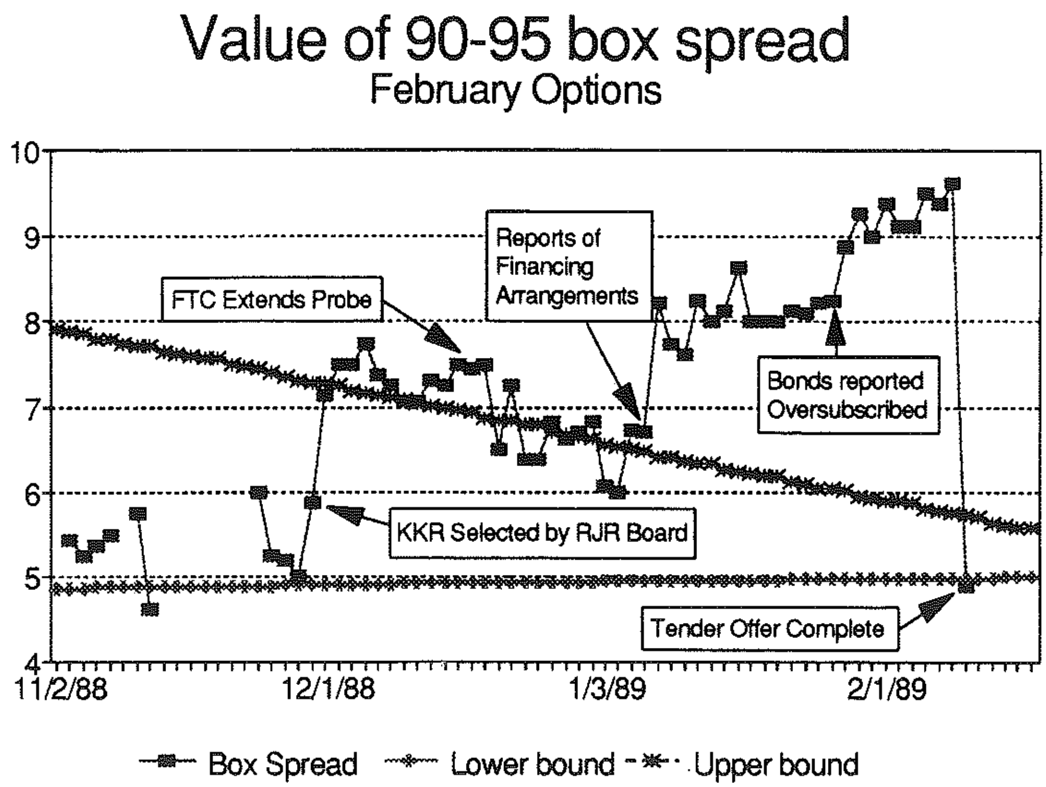


**Figure 4:** Value between November 1988 and February 1989 of a box spread on RJR Nabisco constructed using 90 and 95 strike February options.

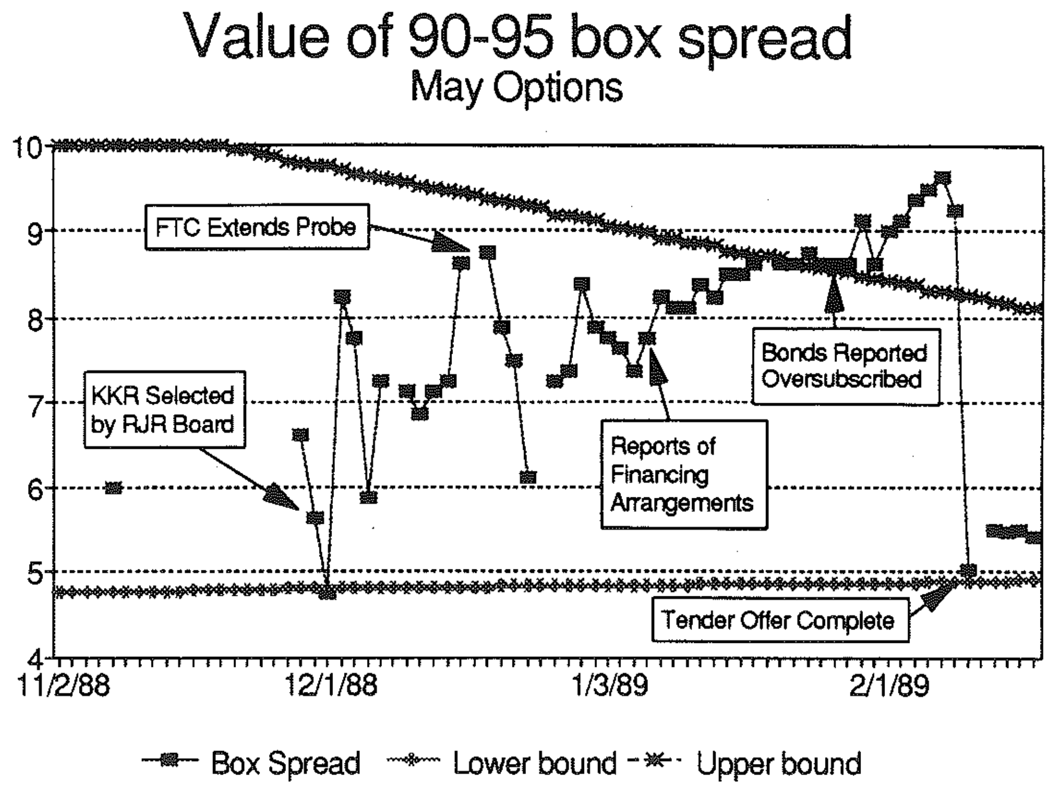


**Figure 5**: Value between November 1988 and February 1989 of a box spread on RJR Nabisco constructed using 90 and 95 strike May options.

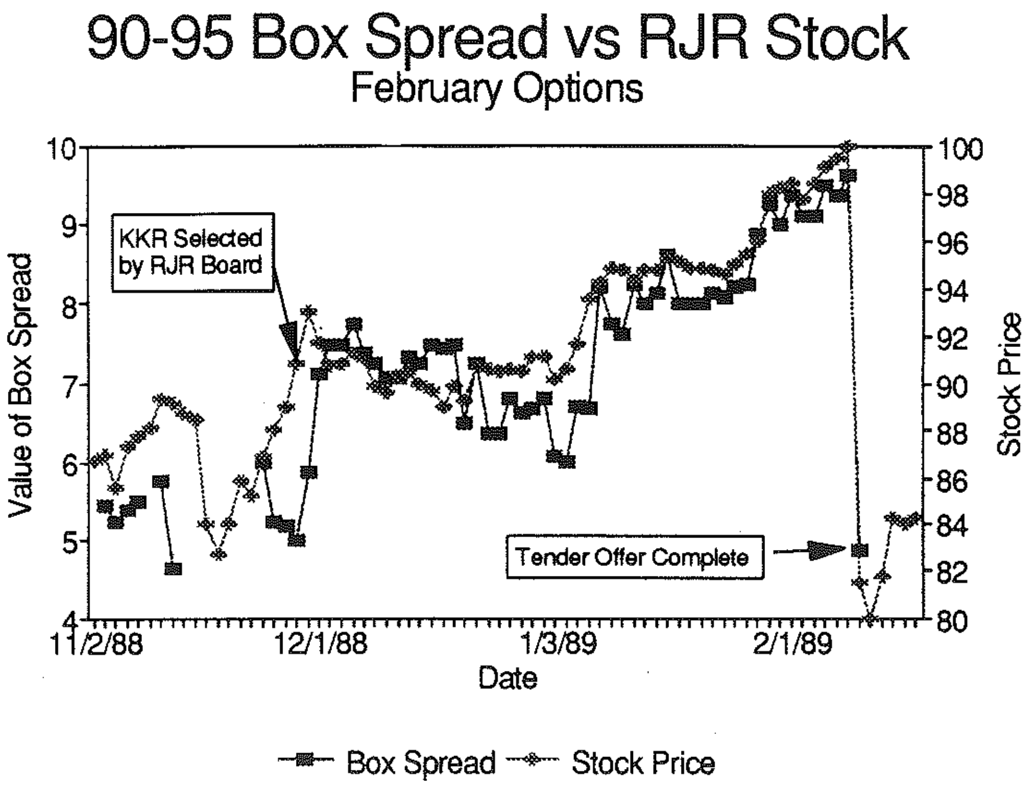


**Figure 6**: Comparison of RJR Nabisco daily closing stock price against the daily closing price of a box spread using 90 and 95 strike February options.