HEDGE PERFORMANCE OF SPX INDEX OPTIONS AND S&P 500 FUTURES

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INTRODUCTION

Options and futures exchanges in the United States have introduced a number of new trading instruments in the past two decades, particularly in the financial futures and options areas. For example, the Chicago Board of Trade (CBT) has introduced the revised GNMA, Treasury Bond and Note futures contracts, among others; the Chicago Board Options Exchange (CBOE) has introduced the OEX (S&P 100) contract, and also the SPX (S&P 500) options. The Chicago Mercantile Exchange (CME) has introduced trading in foreign currency futures and the IMM introduced T-Bill and Eurodollar futures in addition to its S&P 500 and other stock index futures contracts. This rapid growth in options and futures provides traders with a greater number of hedging instruments; however, it makes the choice as to the correct, or most effective, hedging vehicle more complicated. A central question, which the exchanges appear to leave to individual preferences, is whether options, futures, or futures options contracts best hedge unanticipated spot price movements. Is trading necessary in both options and futures contracts for the same underlying instrument, or is one or the other redundant?

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Do hedging characteristics differ substantially between options and futures so that each hedging instrument offers specific advantages to its own clientele?

Brenner et al. (1985), Cox and Rubinstein (1985), and Hull (1985) demonstrate how the simultaneous purchase and sale of put and call options with the same exercise price and maturity, combined with simple borrowing or lending strategies, can exactly replicate payoffs of either long or short futures contracts. Giddy (1983) finds the same result, and notes that the reverse is not true, i.e., asymmetric payout and risk characteristics underlying options prevent them from being exactly replicated by a combination of futures contracts. Chang and Shanker (1986) compare ex post hedging effectiveness of currency options and currency futures contracts. Using daily data, they employ a variation of the Howard and D'Antonio (1984) measure of hedging performance and test the effectiveness of five currency futures contracts traded on the IMM of the Chicago Mercantile Exchange against comparable options traded on the Montreal Exchange. Chang and Shanker (C-S) address problems of negative excess rates of return inherent in the Howard and D'Antonio hedging performance measure, and incorporate transactions costs and margin requirements into their comparisons. Their findings suggest that currency futures outperform options as hedging instruments, providing higher excess returns (over the risk-free rate) per unit of risk. Although currency futures appear redundant to options in a simple payout sense, C-S demonstrate that their relative hedging effectiveness distinguishes them as unique and important derivative securities.

Can such findings be generalized or extended to other financial futures and options contracts? The C-S study compares securities traded on two distant exchanges. Nonsynchronous trading hours (differing time zones) or unequal information flows may have caused differences in daily closing or settlement prices. Direct hedge costs differ between options and futures, while transactions costs and margin requirements are not identical across exchanges. In a comparison of derivative hedging effectiveness, these seemingly minor differences ultimately may tip the balance between otherwise similar instruments. Perhaps more importantly, previous studies have not emphasized performance of dynamic strategies frequently used by real-world hedgers, nor have they calculated hedging effectiveness in a more realistic out-of-sample framework.[1]

[1]For example, nondelta neutral option strategies which use low gamma options, but which rebalance hedge positions for a predetermined change in delta, are commonplace among market practitioners. Such approaches may increase hedging effectiveness.

This study extends the Chang and Shanker study by investigating relative hedging performance in stock index derivatives securities markets. SPX (cash S&P 500 index) option contracts traded on the CBOE are compared to the CME's S&P 500 futures contract in terms of hedging effectiveness. Tick-to-tick or transaction data for the two competing contracts are used in an attempt to minimize nonsynchronous pricing problems and hedge cost differences which might otherwise obscure such a comparison. Although the data are somewhat limited, data from the period surrounding the October 1987 stock market crash, when portfolio insurance and other related hedging strategies were believed to be strong market forces, are included. Using three differing performance measures, the relative ex post hedging effectiveness of S&P 500 futures is compared to purchased put, written call, and synthetic short (similar to short collar) options hedge strategies. In-sample comparisons provide several economic insights into the relative hedge performance of the two derivatives. The delta-neutral (unconditional) hedge ratio assumptions underlying these strategies are, however, oversimplified and unrealistic. Therefore, dynamic strategies that estimate performance ex ante while using information available at the beginning of the hedge period are investigated also. Results from this latter approach more realistically approximate risk reduction or risk-return benefits. In an out-of-sample hedging context intertemporal stability of hedge ratios plays an important role.

OPTION VERSUS FUTURES HEDGING EFFECTIVENESS

Traditional hedging theory and portfolio theory [e.g., Johnson (1960) and Markowitz (1952)], as well as conventional wisdom among hedging practitioners, regards options contracts as superior loss-minimization instruments, while futures are considered better risk-minimization vehicles. The option exercise feature creates asymmetric payouts which provides additional flexibility to hedgers.[2] Should spot price move in an unanticipated (but favorable) direction, options hedgers simply allow contracts to expire unexercised and thereby capture spot market gains. However, option prices are lower bounded, i.e., eventually insensitive to spot price moves. This pushes the option deeply out-of-the-money. Additionally, option prices (and consequent hedge ratios) are sensitive

[2]The establishment of futures options pits on floors of futures exchanges is considered by many as a concession and response to the options flexibility advantage.

to changes in volatility of the underlying instrument.[3] Futures contracts provide offsetting spot-futures gains and losses (and essentially a constant hedged value) regardless of the degree or direction of spot price changes. It has been demonstrated [e.g., Brenner et al. (1985), Cox and Rubinstein (1985), Hull (1985), and Giddy (1983)] that option contracts can be combined with simple borrowing or lending strategies to replicate futures payoffs. However, the asymmetric nature of options payoffs precludes futures from exactly mimicking options payoffs.[4] From a strict payoff perspective, futures are redundant securities to options; yet the success of futures contracts and daily open interest numbers attest that real-world traders and hedgers regard them as distinct and important instruments.[5] This point is illustrated with a comparison of the hedging effectiveness of S&P 500 futures contracts and SPX put and call options. The comparison is shown in panel A of Table I. For simplicity, the widely-accepted Ederington (1979) OLS risk-minimization

TABLE I

Derivative Instrument Hedging Effectiveness Direct Comparisons
(Liquidity-Unadjusted, Price Nonmatched Comparisons Using Entire Available Dataset)

Panel A: Ederington Hedge Ratio Estimates and Risk-Reduction Performance of S&P 500 Fututes and SPX Options Tracking Stock Index, Ignoring Margin and Direct Costs

Hedging Instrument:	*S&P 500 Futures*	*SPX Put Options*	*SPX Call Options*	*Synthetic Futures*	*Observations (No.)*
April–December 1986	$B^* = -0.9840$	$B^* = 1.1857$	$B^* = -1.0745$	$B^* = -1.1103$	41,647 (F)
	(6.454)	(3.892)	(4.047)	(3.718)	19,932 (P)
	HE1 = 0.9803	HE1 = 0.7847	HE1 = 0.8349	HE1 = 0.7248	27,905 (C)
					2,047 (SF)
January–December 1987	$B^* = -1.0753$	$B^* = 1.2574$	$B^* = -1.1913$	$B^* = -1.2277$	53,712 (F)
	(4.652)	(2.337)	(3.217)	(2.385)	29,544 (P)
	HE1 = 0.8725	HE1 = 0.6163	HE1 = 0.7847	HE1 = 0.6319	34,813 (C)
					3,016 (SF)
January–September 1988	$B^* = -1.0055$	$B^* = 1.1145$	$B^* = -1.1376$	$B^* = -1.1320$	37,331 (F)
	(5.013)	(3.036)	(3.1077)	(2.737)	16,904 (P)
	HE1 = 0.9424	HE1 = 0.6806	HE1 = 0.8450	HE1 = 0.5996	25,149 (C)
					2,109 (SF)

continued

[3] Many real-world option hedgers consider gamma and vega while rebalancing. Gamma measures option price sensitivity with respect to delta (hedge ratio) changes.

[4] Dynamic hedging strategies using futures contracts can approximate the payoff structure of put options, but do so with associated high transactions costs.

[5] Heavy volume in and of itself may contribute to futures hedge success since volume tends to attract more users; or, put another way, reduces the fee of illiquidity.

TABLE I (Continued)

Panel B: Howard-D'Antonio Hedge Ratio and Risk-Return-Based Effectiveness Estimates Measuring Improvements in (One Plus) "Excess" Return per Unit of Risk, Also Ignoring Margin and Direct Costs

Hedging Instrument:	*S&P 500 Futures*	*SPX Put Options*	*SPX Call Options*	*Synthetic Futures*	*Observations (No.)*
April–December 1986	$b^* = -1.0239$	$b^* = 1.1533$	$b^* = -1.1273$	$b^* = -1.0821$	41,647 (F)
	(4.286)	(2.962)	(3.404)	(2.670)	19,932 (P)
	HE2 = 1.0264	HE2 = 1.0147	HE2 = 1.0201	HE2 = 1.0118	27,905 (C)
					2,047 (SF)
January–December 1987	$b^* = -1.0667$	$b^* = 1.1945$	$b^* = -1.2235$	$b^* = -1.1034$	53,712 (F)
	(3.870)	(3.037)	(3.146)	(2.779)	29,544 (P)
	HE2 = 1.0207	HE2 = 1.0164	HE2 = 1.0178	HE2 = 1.0123	34,813 (C)
					3,016 (SF)
January–September 1988	$b^* = -1.0317$	$b^* = 1.1327$	$b^* = -1.1676$	$b^* = -1.0881$	37,331 (F)
	(3.998)	(3.148)	(3.230)	(2.802)	16,904 (P)
	HE2 = 1.0233	HE2 = 1.0169	HE2 = 1.0184	HE2 = 1.0139	25,149 (C)
					2,109 (SF)

Panel C: Gjerde Hedge Ratio and Risk-Payoff-Based Effectiveness Estimates Measuring Improvements in (One Plus) Absolute Dollar Hedge Payoff per Unit of Risk, While Incorporating Margin and Direct Costs

Hedging Instrument:	*S&P 500 Futures*	*SPX Put Options*	*SPX Call Options*	*Synthetic Futures*	*Observations (No.)*
April–December 1986	$X^* = -1.0307$	$X^* = 1.2238$	$X^* = -1.1013$	$X^* = -1.0110$	41,647 (F)
	(3.892)	(2.731)	(3.296)	(2.437)	19,932 (P)
	HE3 = 1.0192	HE3 = 1.0121	HE3 = 1.0178	HE3 = 1.0089	27,905 (C)
					2,047 (SF)
January–December 1987	$X^* = -1.0985$	$X^* = 1.2118$	$X^* = -1.1900$	$X^* = -1.1088$	53,712 (F)
	(3.466)	(2.953)	(2.993)	(2.573)	29,544 (P)
	HE3 = 1.0158	HE3 = 1.0142	HE3 = 1.0137	HE3 = 1.0111	34,813 (C)
					3,016 (SF)
January–September 1988	$X^* = -1.0654$	$X^* = 1.1502$	$X^* = -1.1446$	$X^* = -1.0532$	37,331 (F)
	(3.710)	(2.848)	(3.003)	(2.806)	16,904 (P)
	HE3 = 1.0185	HE3 = 1.0153	HE3 = 1.0141	HE3 = 1.0120	25,149 (C)
					2,109 (SF)

Note: Hedging effectiveness estimates HE1 (HE2, HE3) measured in (one plus) percentage terms; B^*, b^*, X^* = optimal in-sample hedge ratios (t-statistics in parentheses below estimates).

methodology is used to measure relative performance. These effectiveness estimates compare (one minus) the variance of a hedged versus unhedged position. Note that direct or indirect hedge costs, margin requirements, or risk-return preference differences are not incorporated into the Ederington measure. Panel A of Table I results simply demonstrate how well each instrument reduced spot price risk as measured by variance.

The lower bound problem associated with option contract price changes hinders total variance reduction. Results (shown in Table I) suggest that a stock index futures contract is the hedging instrument which best tracks positive and negative spot price movements, and thereby better locks in a specific hedged portfolio value. Of course, the option exercise feature provides SPX hedges with added flexibility (and potentially higher returns) not measured by the strict risk-reduction estimates reported in Table I. The put option total (including spot) hedge performance may be particularly understated in this aspect during this "up" market sample period, 1986–1988, because many out-of-the-money purchased put hedges would have been allowed to expire unexercised. Similarly, written call performance may be overstated in the sample period using the OLS performance measure.

The added flexibility of option hedges is available only at an added cost, however. Option premia are direct hedging costs paid up front by call or put buyers to writers. For example, a common portfolio insurance strategy, purchasing OEX or SPX puts, incurs substantial costs which directly lower overall portfolio performance.[6] Although an alternative strategy, writing calls, initially increases portfolio return performance by providing premia, the theoretical hedge payout performance of this approach is inferior to those of both put options and futures. Call hedges (exercised against the writer) lose profits from unanticipated positive spot price changes, and provide no absolute floor for portfolio value in the event of a spot market price collapse. It is necessary also to establish margin on written call hedges. These option costs can be contrasted with temporary futures initial margin outlays. Basis changes are the only direct costs associated with futures hedging, and these may be favorable. Lost interest on margin[7] and inflexibility (foregone unanticipated spot profits) are indirect opportunity costs to futures hedgers.

The lower overall risk-reduction potential of individual option contracts (shown in Table I, panel A) and their relatively high direct cost may be improved and offset using combined options positions. In the currency derivatives markets, for example, options collars are a popular hedge strategy designed to minimize foreign exchange exposure at

[6] Many real-world option traders consider premia costs to be partially or wholly "sunk," depending on spot price movements, and the degree of time premia decay during the hedge period. These costs are often reduced by less than fully insuring stock portfolios, or by purchasing out-of-the-money puts. Although some premia paid may be regained eventually via offsetting order, lost interest still results.

[7] Futures hedgers often provide marketable securities such as U.S. T-bills to meet margin. Interest accrued is not lost in this case. In a comparison of options vs. futures hedging effectiveness, differences between margin requirements is a relevant concern.

minimal cost. Chang and Shanker (1986) investigated the effectiveness of such strategies as compared to currency futures. They examined performance of synthetic currency futures contracts, which are option collars combined with simple borrowing or lending strategies. C-S found these option combinations to be inferior hedges to futures. Implicitly, C-S justified the importance and relevance of currency futures trading from a hedging standpoint, irrespective of their basic payoff redundancy to options. This study provides similar evidence of the usefulness of S&P 500 futures hedges in stock index derivatives markets. The C-S study findings are extended by comparing more realistic and representative out-of-sample hedge strategies. In this ex ante framework, relative hedge ratio stability and transaction cost differences between markets play a crucial role. Once these real-world problems and all (direct and indirect) hedge costs are considered and incorporated into out-of-sample effectiveness estimates, S&P 500 futures are shown to outperform SPX index options.

The remainder of this article seeks to refine the results from Table I, panel A to better compare and consider rate of return differences (favorable to options) and hedge cost differences (favorable to futures) between the two alternatives. The third section of the article describes the three measures used to evaluate hedging effectiveness. The fourth section describes the data and the price matching process used to test contemporaneous stock index option and futures prices to obtain comparable performance estimates. The following section presents empirical tests and discusses in-sample static and out-of-sample dynamic relative hedge performance results.

METHODOLOGY

Suppose an index fund manager, fearing a market downturn, decides to hedge against decreases in portfolio value. Both CME S&P 500 futures and CBOE SPX option contracts could be used to construct a variety of portfolio insurance hedges. The manager may choose to purchase SPX put options with underlying contract value comparable in size to spot exposure. Such a hedge would be a trade-off between the desirability of the price floor and additional flexibility provided by the exercise feature, versus the option's higher direct costs, relatively lower liquidity and poorer spot price tracking. Alternatively, SPX net direct hedge costs could be reduced by use of a collar, or synthetic short futures position. A combined option position such as a synthetic short is quite comparable to an actual short futures hedge in terms of payoff at expiration/delivery and initial costs. Following Hull (1985), and Brenner et al. (1985), a synthetic short futures position is constructed via the simultaneous sale of a European call option and purchase of a European put option, both with identical expiration dates and exercise prices. In the example above, the manager would purchase SPX puts and write an equal number of SPX calls with the same exercise price to construct a synthetic short futures hedge. The direct hedge cost for the options combination hedge would be a small sum either borrowed or loaned (depending on market conditions) to exactly replicate actual futures payoffs at delivery.[8] The relative hedging effectiveness of actual short futures, purchased put options, written call options, and synthetic short futures strategies is investigated.

Three alternative effectiveness methodologies are used in this study to evaluate stock index derivatives hedges. Each approach focuses upon an important aspect of options and futures hedging performance. The first measure is generally credited to Ederington (1979) and is widely used in the empirical futures hedging literature. This comparatively simple minimum-variance performance estimate is obtained from an OLS regression of spot price percentage changes onto hedge instrument price percentage changes. The coefficient of determination resulting from this regression is a measure of hedging performance, i.e., the degree of reduction in variance for the hedged position relative to that of the unhedged spot position. The Ederington measure (which is designated HE1):

$$\mathrm{HE1} = \frac{\operatorname{cov}(C_{st}, C_{hit})^2}{\operatorname{Var}(C_{st})\operatorname{Var}(C_{hit})} = r^2 \tag{1}$$

where C_{st} and C_{hit} represent percentage changes in spot and hedge prices, respectively. Although the Ederington approach is tractable and easily understood, a principle criticism of HE1 is that is implicitly considers only one risk/return possibility from a hedger's objective function. Such an assumption may be particularly unsuitable when applied to individual options hedges, where the exercise feature permits consideration of numerous risk-return outcomes. More general risk-return assumptions are examined using the Howard and D'Antonio (1984) (H-D) methodology. This measure of hedging performance examines improvement in excess return

[8]The amount of funds borrowed or loaned would be effectively equal to differences in put and call premia. Also, one may consider this small cash flow to be related to the basis. The Appendix more completely describes the construction of synthetic futures hedges.

(above a risk-free rate i) per unit of risk for a hedged futures or options position relative to an unhedged (spot) position. The H-D measure (which is designated HE2) is conceptually similar to the Sharpe index common to the investments community; however, H-D also incorporates correlation between spot and hedge price changes, which the futures and options literature emphasizes as a principle determinant of effectiveness. HE2 is appropriate as a performance comparison measure between options and futures due to its generality; however, it does not incorporate direct and indirect hedge costs.

The H-D effectiveness measure is:

$$\mathrm{HE2} = \sqrt{\frac{1 - 2\lambda\rho + \lambda^2}{1 - \rho^2}} \tag{2}$$

where

$$\lambda = \frac{(r_h/\sigma_h)}{(r_s - i)/\sigma_s}$$

and r_h, r_s are the one-period percentage change returns for the hedge and spot, i is the risk-free rate of interest, σ_h, σ_s are the standard deviation of one-period percentage returns for the hedge and spot, respectively, and ρ is the correlation between hedge and spot returns.

Chang and Shanker (1986) construct an improved[9] measure similar to the H-D measure by decomposing the positions into separate long and short hedging categories. Transactions costs are brought into the original model by subtracting round trip commissions from payoffs. Margin requirements are incorporated by taking into account a contract size/margin fraction, S_f/M_f. A variation of the C-S measure, developed by Gjerde (1987) is examined also as the third measure of hedging effectiveness. The Gjerde model sidesteps some of the problems associated with the original H-D methodology by adopting an absolute dollar framework. The direct cost of the option premia is added. This adjusted measure is designated HE3.

$$\mathrm{HE3} = \pm\sqrt{\frac{1 - 2\lambda\rho + \rho^2}{1 - \rho^2}}\left(1 - \frac{ip_0}{\mu_y}\right) + \frac{ip_0}{\mu_y} \qquad \begin{array}{c}(+\text{ if } ip_0 < \mu_y)\\ (\text{otherwise } -)\end{array} \tag{3}$$

[9]For example, Chang and Shanker demonstrate that the H-D effectiveness measure actually *decreases* in size, although hedging performance is improving, whenever the percentage excess return is negative.

where

$$\lambda = \left(\frac{\sigma_y}{\mu_y - ip_{y0}}\right) \Big/ \left(\frac{\sigma_x}{\mu_x \pm ip_{x0} \pm (1+i)C \pm im}\right)$$

and μ_x, μ_y are hedger's payoff per unit of hedge and cash positions, respectively, σ_x, σ_y are standard deviation of payoff per unit of hedge and cash positions, respectively, i is the risk-free rate of interest, p_{y0}, p_{x0} are cash price and option premia at beginning of hedge period, ρ is the correlation between hedge and spot prices, C is the transactions cost per unit of hedge position, and m is the margin payment per unit of hedge position, determined by the exchange.

The HE1 performance measure is included in this study because its tractability has made it widely accepted and reported among hedging practitioners and in numerous futures hedging studies. HE1 results are, however, less appropriate as a means of comparison between futures and options hedges because risk (as measured by total variance) minimization is the implicit objective of the hedger. Risk-return relationships are incorporated into the HE2 and HE3 performance measures. The HE2 measure reports excess return per unit of risk offered by options and futures hedges. HE2 estimates compare risk incurred with hedge returns used to offset spot stock market losses. A drawback of the HE2 measure (other than empirical quirks) is that it reports hedge benefits without including costs associated with each hedge vehicle. The HE3 performance estimate is more realistic in that it can include option premia paid or received, transactions costs, and margin requirements. None of the measured is designated the most effective. In-sample results for all three are reported. Each measure provides an economically important perspective on the hedge performance question.

To more realistically estimate hedging performance, two ex ante strategies are tested and compared. For these dynamic approaches, hedged are permitted to be rebalanced following substantial changes in hedge ratio betas of deltas. Such strategies are widely employed by fund managers using stock index derivatives hedges and are generally believed to increase hedge effectiveness out-of-sample.[10] In this study, one-week, two-week, and four-week rebalancing intervals are examined using the entire dataset. Secondly, for the matched data, 5%, 10%, and 15% triggers are tested, where rebalancing occurs following these prespecified changes in optimal hedge ratios via additional contract purchases or

[10]Recent heavily publicized losses by many hedge funds call into question the out-of-sample effectiveness of certain dynamic/rebalancing strategies.

sales. Resulting ex ante effectiveness measures are therefore an average of hedge performance across (a varying number of) rebalancing periods. In this out-of-sample framework, hedge ratio stability plays a key role, as do transactions costs and other market frictions. Therefore, the HE3 is decreased the most appropriate performance measure for the out-of-sample tests.

DATA

Tick-to-tick or transaction data are used to examine the relative hedging effectiveness of stock index options versus futures. This type of data permits sidestepping of the problem of stock index options and futures short trading histories, and increases the sample size. Perhaps more significantly, using tick data permits a comparison of nearly synchronous prices and an evaluation of relative hedge performance on a minute-by-minute basis.[11] The CME and CBOE provided two separate datasets which are combined for use in this study. For the 30-month (April 1986 to September 1988) study period, 132,690 corresponding, independent, S&P 500 futures price observations are used.[12] CBOE data tapes provide 66,380 independent put option transaction prices and 87,867 call prices. Relative performance of individual and combined futures and option strategies for the entire dataset are reported in Table I. These results, however, ignore transaction timing and market activity differences between the CBOE and CME,[13] as well as very substantial SPX versus S&P 500 market liquidity differences. To partially correct for these problems, additional analysis using a price matching approach is performed. This approach permits estimation of effectiveness measures using identical and equal spot index changes as benchmarks for options and futures hedges. While large liquidity differences between hedges are equalized by this process, non-matched price information is sacrificed. Matching is necessary also in the construction of the synthetic short futures hedges. Using the CME and CBOE time stamps as guides,

[11]Some tick prices reported on the CME tape may not be transaction prices. However, tick prices approximate market conditions at which hedgers *could* have established positions. These data are subject to a bid–ask bounce criticism, but bid–ask data are not available. The CBOE tape does not provide any market-maker information.

[12]Open interest, number of contracts bought or sold, or other volume-related market information is not available on tapes used in this study. Therefore, a transaction price is included only once within an interval, even if multiple identical transactions occur.

[13]For example, trading generally tends to cluster around open and close in both markets ("U-shaped" volume). S&P 500 futures trading hours are 8:30 AM to 3:15 PM; while the SPX opened at 9:30, 9:00, and 8:30 AM during the sample period, and closes at 3:10 PM central time.

SPX option contract prices, S&P 500 futures prices, and the S&P 500 index prices are temporally matched.[14] Futures and option returns are approximated by price percentage changes. Excess returns used in HE2 require a risk-free rate proxy. Daily U.S. T-bill rates for (nearest to maturity) 90-day and 360-day bills are from the Federal Reserve Bank of New York.[15] Combining put and call options to construct SPX synthetic futures provides 7172 options observations. Once these options are matched to S&P 500 futures and S&P 500 cash prices, the resulting merged dataset contains 2288 observations. Despite the restrictions placed upon the sample by the temporal matching methodology, the sample size still represents a three to fourfold improvement (more price information) compared to daily data for this time period.

A disadvantage of using transaction data to evaluate hedges is its impact upon rate of return calculations. The haphazard nature of transaction-type data (often worsened by the temporal matching process) causes time intervals between price changes to be unequal. A weighted return/weighted least squares (WLS) approach is adopted, where price changes are divided by the elapsed time (in minutes) from the last price quote. WLS returns effectively are reduced to a common per minute denominator.[16] Estimates of margin requirements and transactions costs for typical CME and CBOE institutional customers are from interviews with market participants from each exchange. Prior to the October 19, 1987 crash, CME margin requirements for the S&P 500 futures contract were 3–4% ($4000); however post-crash margins were raised to nearly 13% ($20,000). CBOE margin requirements for written options are estimated using the formula:

$$\begin{aligned}\text{Margin}(\$) = {} & [\text{option premium (on deposit)} \times \$500] \\ & + [0.3 \times (\text{index value}) \times \$500] \\ & - [0.5 \times (\text{out of the money amount}) \times \$500] \quad (4)\end{aligned}$$

Resulting typical CBOE margins are larger than those for the CME futures contracts, particularly during the pre-crash period. Interviewed

[14]A temporal match is achieved between futures and options with an allowance of one minute. The resulting dataset seemed to be a fair balance between obtaining nearly identical instrument prices and obtaining adequate sample size.

[15]According to actual CME and CBOE participants, it is typical for traders to plug beginning-of-day interest rate quotes and use one interest rate quote throughout the day.

[16]OLS-type (nonweighted) returns are also examined for comparison purposes. The results are very similar, with instrument relative performance rankings remaining unchanged in all sub-periods. Daily data provide identical rankings, although the power of the tests (correlations, t-statistics, and F-statistics) are lower due to smaller sample size.

market participants from both exchanges placed contract transactions costs for institutional investors around \$8–\$10 per round trip. Direct hedge cost and market frictions for options and futures hedges are inputs to the HE3 measure. HE1 and HE2 use only percentage price change data. Static (non-rebalanced) strategy ex post effectiveness estimates of HE3 deduct one round-trip commission, while adding or subtracting, depending on cash flows appropriate to the particular hedge, lost interest on margin and option premia. For the more realistic dynamic option and futures ex ante hedging strategies, transactions costs and other frictions impact upon HE3 at each rebalancing point during the overall hedging period.

EMPIRICAL RESULTS

In-Sample Hedge Ratio Estimates and Hedge Strategy Performance Comparisons

Hedging effectiveness for CME S&P 500 futures contracts, CBOE SPX puts and calls, as well as synthetic short futures contracts constructed from options combinations are each estimated. HE1, HE2, and HE3 measures are calculated for each instrument. HE1 is a risk-reduction (theoretically risk-minimization) measure. HE2 indicates relative improvement in excess return (above the risk-free rate) per unit of risk. HE3 is a measure similar to HE2, except that the relative improvement is in terms of absolute dollar payoffs. Transactions costs, (lost interest on) margin requirement, and option premia cash flows are incorporated into HE3.

Optimal in-sample hedge ratio estimates and relative hedge performance among the four competing strategies are reported for each of the three effectiveness measures in Table I, panels A, B, and C. Estimates are obtained here using the entire dataset, with all available price information used for each instrument. Results are for static ex post strategies, where implicitly (and unrealistically) optimal hedge ratios are known at the beginning of the hedge period, and no rebalancing occurs. Table I results are broken down on a calendar basis and presented separately for 1986, 1987, and 1988 to provide some insight as to the stability of a strategy's relative effectiveness across the sample period.

Optimal hedge ratio estimates are statistically significantly different from unity for 33 of the 36 trials, and clearly different across measures/methodologies. Relative effectiveness results favor futures hedges over any options strategy in all sub-periods, regardless of the measure chosen (HE1, HE2, or HE3). As mentioned previously, however, such performance comparisons do not suitably account for transactions timing or market activity differences between the CBOE and CME, as well as substantial liquidity differences across contracts. This latter point is particularly troublesome, since empirical findings presented in Table I provide a relative performance ranking across instruments which *in every sub-period and for every effectiveness measure* mirrors relative contract/strategy liquidities. Futures performance (41,647 independent observations) is greater than that of short call option (27,905 observations) effectiveness, which is followed by long put (19,932) and synthetic short (2047) performance. Although practitioners may well favor high hedge instrument liquidity, it is unlikely that such a perfect correspondence between hedging effectiveness and contract liquidity would prevail in actual markets over a sustained period of time.

To further compare relative hedging performance, therefore, futures and option price changes are temporally matched and compared to identical spot index benchmark changes. Static ex post hedging effectiveness estimates using the matched dataset are presented in Table II. Three sets of results are reported. In panel #1, the entire 30-month sample period data are included in the effectiveness measure calculations. Panel #2

TABLE II

Hedging Effectiveness of S&P 500 Futures versus SPX Options and Synthetic Futures (In-Sample Hedge Ratios and Effectiveness Measures for Ederington, Howard-D'Antonio, and Gjerde Methodologies. Transaction Tick-to-Tick Data for 30-Month Sample Period, April 1, 1986 to September 30, 1988)

Panel #1: Entire 30-Month Period, Including Two-Week October, 1987 Crash Period

	Methodology			
Hedging Instrument	*Ederington*	*Howard-D'Antonio*	*Gjerde*	*Observations (No.)*
Futures (short)	$B^* = -0.9854$ (4.317) HE1 = 0.8740	$b^* = -1.1709$ (3.465) HE2 = 1.0133	$X^* = -1.2069$ (3.177) HE3 = 1.0097	2288
Puts (purchased)	$B^* = 1.2385$ (3.647) HE1 = 0.6381	$b^* = 1.1644$ (3.713) HE2 = 1.0189	$X^* = 1.0544$ (3.274) HE3 = 1.0078	2288
Calls (written)	$B^* = -1.1733$ (3.851) HE1 = 0.7082	$b^* = -1.2212$ (3.371) HE2 = 1.0178	$X^* = -1.0654$ (3.037) HE3 = 1.0083	2288
Options (synthetic short)	$B^* = -1.0184$ (3.998) HE1 = 0.8172	$b^* = -0.9828$ (3.622) HE2 = 1.0180	$X^* = -0.9912$ (3.195) HE3 = 1.0081	2288

TABLE II (Continued)

Panel #2: Entire Sample Period Excluding the Two-Week October, 1987 Crash Data

Hedging Instrument	Methodology: Ederington	Methodology: Howard-D'Antonio	Methodology: Gjerde	Observations (No.)
Futures (short)	$B^* = -0.9711$ (3.884) HE1 = 0.9150	$b^* = -1.1055$ (3.508) HE2 = 1.0147	$X^* = -1.3431$ (3.236) HE3 = 1.0115	2151
Puts (purchased)	$B^* = 1.1934$ (3.513) HE1 = 0.6120	$b^* = 1.0765$ (3.601) HE2 = 1.0202	$X^* = 1.0827$ (3.388) HE3 = 1.0097	2151
Calls (written)	$B^* = -1.1161$ (3.747) HE1 = 0.7831	$b^* = -1.1910$ (3.845) HE2 = 1.0164	$X^* = -1.1082$ (3.129) HE3 = 1.0077	2151
Options (synthetic short)	$B^* = -1.0207$ (3.827) HE1 = 0.8220	$b^* = -0.9656$ (3.703) HE2 = 1.0187	$X^* = -1.0183$ (3.009) HE3 = 1.0085	2151

Panel #3: October Crash Period (10/12/87–10/23/87)

Hedging Instrument	Methodology: Ederington	Methodology: Howard-D'Antonio	Methodology: Gjerde	Observations (No.)
Futures (short)	$B^* = -0.8889$ (2.251) HE1 = 0.8042	$b^* = -1.2871$ (2.099) HE2 = 0.9780	$X^* = -0.9573$ (2.074) HE3 = 0.9681	137
Puts (purchased)	$B^* = 1.3277$ (2.788) HE1 = 0.7813	$b^* = 1.4412$ (2.831) HE2 = 1.0208	$X^* = 0.8967$ (2.362) HE3 = 0.9873	137
Calls (written)	$B^* = -2.6448$ (1.797) HE1 = 0.3997	$b^* = -1.3016$ (2.220) HE2 = 0.9584	$X^* = -1.0037$ (2.191) HE3 = 0.9539	137
Options (synthetic short)	$B^* = -0.9135$ (2.173) HE1 = 0.6930	$b^* = -0.9555$ (2.341) HE2 = 0.9823	$X^* = -0.9535$ (1.989) HE3 = 0.9710	137

Note: HE1 = relative risk reduction (%). B^*, b^*, X^* = optimal hedge ratios (t-statistics in parentheses). HE2 (HE3) = 1 + relative increase in return (payoff) per unit of risk (%).

results are obtained when data for the two-week period surrounding the October 19, 1987 crash (137 matched observations) are deleted. Panel #3 focuses specifically upon the crash period.

Stock index futures outperform the three options hedge strategies in terms of strict risk-reduction. This type of hedging performance, as represented by the HE1 measure, ranges from a 39.97% reduction in variance for the written call options during the crash period to a 91.50%

variance reduction (relative to an unhedged stock position) for S&P 500 futures (see Table II, panel #2). Futures performance, as measured by HE1, is a least 2.93% to 11.31% higher than the most successful options strategy in each panel period. The synthetic short options combination hedges better track underlying stock price index movements than individual put and call hedges, except during the crash sub-period (see Table II, panel #3). During this highly volatile down market period, put options outperform the other two options strategies and track nearly as well as futures contracts. Weighted least squares (WLS) hedge ratio estimates (B^*s) are statistically significant, and different from the theoretically-expected value index portfolio beta of 1.0.

In contrast to the Ederington performance estimates, hedging effectiveness as measured by the HE2 methodology favors stock index option contracts. The first two panels of Table II show all three options hedge strategies offer higher excess return per unit of risk than S&P 500 futures contracts during the overall sample period (with and without crash data). HE2 estimates range from a 1.33% excess return improvement for S&P 500 futures to 2.02% increase for purchased put options. Negative excess returns (losses) are reported for all hedge instruments during the crash period except for put options.[17] This suggests put options are most successful in establishing a portfolio floor value for hedgers. Relative HE2 results reported here for stock index derivatives are contradictory to those found by Chang and Shanker in foreign currency futures and options markets. However, the C-S study modified the H-D HE2 measure and also incorporated futures and options market frictions into their measure of hedging effectiveness.

The Gjerde methodology used here is comparable to the C-S study. Option premia, transactions costs and initial margin requirements are included in HE3 estimates reported in Table II. HE3 results suggest (CBOE versus CME) market friction differences and option premia have a measurable impact on ex post hedging performance. Once these real-world costs are considered, S&P 500 futures offer a higher dollar payoff (at the same risk level as an unhedged position) than any of the three options strategies during the overall sample period (Table II, panels #1 and #2). As reported in the first two panels of Table II (which include and exclude the crash sub-period, respectively) increases in payoff per unit of risk range from 0.77% for written calls to 1.15% for S&P 500 futures. Futures hedges improve excess dollar payoff per unit

[17]This may be an anomalous result for synthetic put options caused by the glitch in the H-D methodology discussed earlier. See Chang and Shanker (1986) for elaboration.

of risk compared to options by at least 16.87% (panel #1) and 18.56% (panel #2). Panel #3 results show payoff decreases for all securities in the period surrounding the crash. Put option hedges experience the smallest downturn in hedging effectiveness.

Since the Howard-D'Antonio and Gjerde measures are comparable, the reversal in relative hedging effectiveness results from HE2 to HE3 must be caused either by the inclusion of option premia direct hedge costs, or by differences in margin requirements and transactions costs between exchanges. As noted earlier, transactions costs for typical institutional customers in options and futures markets are small (roughly 0.1% to 0.5% of contract value) and similar in size. However, margin requirements are higher (and lost interest greater, thus lowering HE3) for CBOE SPX options are compared to CME S&P 500 futures, particularly prior to late 1987. Performance differences solely attributable to market friction differences are best illustrated in a comparison of actual and synthetic futures hedges, since option premia costs are netted out (or nearly so) in the construction of the synthetic futures position. As expected, given the differences in CME and CBOE market frictions during the sample period, the drop in hedging effectiveness from HE2 to HE3 is greater for synthetic futures than actual S&P 500 futures. Although put (call) premia paid (received) slightly worsens (improves) hedge performance, results reported in the first two panels of Table II support the conclusion that futures contracts generally outperform options as stock market hedges when all hedge costs are considered by the effectiveness measure. Overall, sample relative hedging effectiveness results as measured by HE3, which favor stock index futures, are consistent with the Chang and Shanker (1986) foreign currency derivatives study.

Yet crash sub-period HE3 results, reported in panel #3 of Table II, suggest that put options and synthetic short option combinations may provide the best portfolio floor value during extremely volatile down-market periods. Decreases in payoffs for puts (−1.27%) and synthetic futures (−2.90%) are smaller than for actual futures (−3.19%). Panel #3 results are consistent with the market view that options are better loss-minimizing hedge instruments.

Refining the Realism of Tested Strategies: 90-Day Hedging Horizons

While results in Table II describe ex post hedging performance across the entire sample period, these estimates implicitly assume a 30-month hedging horizon. Such a strategy would be complex to implement, since it would involve repeated rollovers and rebalancing of hedges into subsequent contracts. Therefore, more typical and realistic 90-day hedging strategies are examined. Results for 90-day hedges are reported in Table III. Using the 1987 transaction data, four sub-periods are created, with each sub-period including approximately 13 weeks (about 65 trading days and 90 calendar days). The three hedging effectiveness measures are then recalculated for each instrument within sub-periods.

TABLE III

90-Day Hedges—S&P 500 Futures versus SPX Options

Panel #1: First Quarter 1987 (1/2/87–3/31/87)

	Methodology			
Hedging Instrument	*Ederington*	*Howard-D'Antonio*	*Gjerde*	*Observations (No.)*
Futures (short)	$B^* = -0.9413$ (2.744) HE1 = 0.8308	$b^* = -1.1137$ (2.401) HE2 = 1.0097	$X^* = -1.3351$ (2.381) HE3 = 1.0093	341
Puts (purchased)	$B^* = 1.2761$ (2.179) HE1 = 0.5719	$b^* = 1.2137$ (2.122) HE2 = 1.0113	$X^* = 1.1633$ (2.090) HE3 = 1.0084	341
Calls (written)	$B^* = -1.1749$ (2.207) HE1 = 0.6270	$b^* = -1.0932$ (2.503) HE2 = 1.0154	$X^* = -1.2938$ (2.236) HE3 = 1.0069	341
Options (synthetic short)	$B^* = -1.0755$ (2.451) HE1 = 0.7024	$b^* = -1.1145$ (2.237) HE2 = 1.0139	$X^* = -1.2938$ (2.297) HE3 = 1.0077	341

Panel #2: Second Quarter 1987 (4/1/87–6/30/87)

	Methodology			
Hedging Instrument	*Ederington*	*Howard-D'Antonio*	*Gjerde*	*Observations (No.)*
Futures (short)	$B^* = -0.8934$ (2.665) HE1 = 0.8116	$b^* = -1.0364$ (2.326) HE2 = 1.0198	$X^* = -1.1745$ (2.297) HE3 = 1.0148	319
Puts (purchased)	$B^* = 1.1456$ (2.127) HE1 = 0.6011	$b^* = 0.9897$ (2.077) HE2 = 1.0171	$X^* = 1.0036$ (2.174) HE3 = 1.0098	319
Calls (written)	$B^* = -1.0937$ (2.211) HE1 = 0.6311	$b^* = -0.9973$ (2.201) HE2 = 1.0204	$X^* = -1.1374$ (1.973) HE3 = 1.0072	319
Options (synthetic short)	$B^* = -1.0455$ (2.388) HE1 = 0.6791	$b^* = -1.0945$ (2.216) HE2 = 1.0183	$X^* = -1.0758$ (2.193) HE3 = 1.0088	319

TABLE III (Continued)

Panel #3: Third Quarter 1987 (7/1/87–9/30/87)				
	Methodology			
Hedging Instrument	*Ederington*	*Howard-D'Antonio*	*Gjerde*	*Observations (No.)*
Futures (short)	$B^* = -1.0433$ (3.075) HE1 = 0.9256	$b^* = -1.0487$ (2.653) HE2 = 1.0116	$X^* = -1.0377$ (2.406) HE3 = 1.0101	372
Puts (purchased)	$B^* = 1.1726$ (2.318) HE1 = 0.6381	$b^* = 1.1745$ (2.290) HE2 = 1.0122	$X^* = 1.1983$ (2.079) HE3 = 1.0096	372
Calls (written)	$B^* = -1.1247$ (2.364) HE1 = 0.6141	$b^* = -1.0376$ (2.455) HE2 = 1.0147	$X^* = -1.1009$ (2.128) HE3 = 1.0083	372
Options (synthetic short)	$B^* = -1.0278$ (2.409) HE1 = 0.8004	$b^* = -1.2168$ (2.314) HE2 = 1.0137	$X^* = -1.1375$ (2.286) HE3 = 1.0091	372

Panel #4: Fourth Quarter 1987 (10/1/87–12/31/87)				
	Methodology			
Hedging Instrument	*Ederington*	*Howard-D'Antonio*	*Gjerde*	*Observations (No.)*
Futures (short)	$B^* = -0.7916$ (2.219) HE1 = 0.6783	$b^* = -0.8238$ (2.084) HE2 = 0.9814	$X^* = -0.8937$ (2.197) HE3 = 0.9708	353
Puts (purchased)	$B^* = 0.8781$ (2.264) HE1 = 0.4702	$b^* = 0.8682$ (2.169) HE2 = 0.9889	$X^* = 0.8761$ (2.004) HE3 = 0.9763	353
Calls (written)	$B^* = -0.9887$ (2.089) HE1 = 0.5432	$b^* = -0.7293$ (2.092) HE2 = 0.9789	$X^* = -0.7900$ (1.897) HE3 = 0.9731	353
Options (synthetic short)	$B^* = -0.8855$ (2.124) HE1 = 0.7020	$b^* = -0.9246$ (1.848) HE2 = 0.9842	$X^* = -0.9590$ (1.993) HE3 = 0.9758	353

Note: HE1 = relative risk reduction (%). B^*, b^*, X^* = optimal hedge ratios (t-statistics in parentheses). HE2 (HE3) = 1 + relative increase in return (payoff) per unit of risk (%).

Results in Table III parallel those obtained for the entire 30-month sample. Futures outperform options in terms of strict risk-minimization (HE1) in three of the four hedge sub-periods. Mean HE1 effectiveness across sub-periods is highest for S&P 500 futures contracts at 0.8116. Substantial hedge ratio (B^*) variability is observed across sub-periods for all four strategies, although option hedges seem less susceptible to this problem (e.g., call B^* standard deviation of 0.0844 compared to

0.1046 for futures). Lower HE1 estimates are observed for the 90-day sub-periods than for the overall sample (Table II).

Stock index option 90-day hedges outperform futures contracts according to the HE2 risk-return measure. At least one option strategy has a higher excess rate of return per unit of risk than S&P 500 futures in each sub-period; however, futures effectiveness is higher than put and synthetic short hedges in sub-period two, and greater (less negative) than call hedges in sub-period four. Mean HE2 effectiveness across sub-periods is highest for synthetic short option hedges at 0.0075, and lowest for S&P 500 futures at 0.0056. HE2 90-day performance means are also lower than those for the entire 30-month sample. H-D hedge ratio (b^*) instability appears substantial for all four strategies, and the problem is greater in degree than for the Ederington methodology.

As with overall sample results reported in Table II, a reversal of relative hedging performance is observed when 90-day hedge performance measures are changed from HE2 to HE3. The Gjerde measure shows futures to be the most successful hedging instrument during the first three 1987 sub-periods. Mean HE3 effectiveness across sub-periods for S&P 500 futures is higher (0.0013) than the next best hedge—purchased puts (0.0010). Mean increases in payoff (relative to the risk of an unhedged position) are significantly lower for the other two strategies, and were negative in the case of written calls. Hedge ratio instability is most pronounced for the Gjerde methodology, with hedge ratio (X^*) standard deviations of 0.1887 (futures), 0.1492 (purchased puts), 0.2110 (written calls), and 0.1395 (synthetic shorts) across sub-periods. As for the HE1 and HE2 methodologies, HE3 results for the 90-day hedges are generally lower than for the entire 30-month sample. This positive relationship between hedge period length and ex post effectiveness is consistent with findings from other studies which have used long interval data.

Out-of-Sample Performance of Dynamic Hedging Strategies

To further increase realism and improve applicability of the findings to actual markets the four competing strategies are tested and evaluated in an ex ante out-of-sample framework. For the overall data set, calendar time-based rebalancing intervals (the same as those investigated in the options hedging literature) of one, two, and four weeks are employed. For the price-matched data subset, the extremely haphazard and nonequal time interval problem inherent in transaction data is addressed by testing a rebalancing strategy which focuses on changes in hedge ratios. This empirical approach is consistent with the actual market hedge practice of calculating and following option gammas as a basis for rebalancing.[18] Specifically, options and futures hedge positions are adjusted to an updated new optimal delta or beta once a preestablished percentage change in the hedge ratio occurs.[19] Ratio change triggers of 5, 10, and 15% are examined in this study. Hedge ratio, ratio variability, and ex ante hedge performance estimates for the trigger-rebalancing strategies are reported in panel B of Table IV. Interval rebalancing results are presented in panel A of Table IV.

Out-of-sample hedge performance rankings and comparisons are consistent both with the theoretical discussions in the second section of the article, as well as with the in-sample results reported above. A critical determinant of ex ante hedging effectiveness is intertemporal stability of hedge ratios. Variability estimates presented in Table IV, panel A provide empirical support to the theoretical argument that SPX option prices and delta ratios are more sensitive to a larger number of economic variables (e.g., volatility of the underlying index) than futures betas, and, therefore, are more unstable across the fixed hedging intervals examined here. Higher ratio instability means out-of-sample optimal options positions will diverge more significantly from positions constructed at the beginning of the hedge period (and subsequent rebalancing points). Relatively lower put and call option mean ex ante effectiveness is a consequence of higher ratio instability. Average dynamic futures hedge ratio variability (0.1392) is −38.6% lower than puts, −35.1% below calls, and −21.6% smaller than that of the synthetic short strategy. These differences translate into improved futures ex ante mean HE3 effectiveness (1.0115) which is +26.4% above that of synthetic shorts, +38.6% higher when compared to long puts, and +51.3% over written calls. Ratio instability appears to increase for longer rebalancing intervals, as evidenced by both higher interval variability and lower mean effectiveness estimates.

Differences in futures and options market frictions, which (as noted earlier) generally favor the more liquid S&P 500 futures contracts also influence HE3 estimates reported in Table IV. The specific impact of lost interest on margin, option premia, and round-trip transactions

[18]This second tested dynamic strategy is effectively a gamma-neutral rebalancing approach.

[19]Although dynamic strategies commonly employed in futures markets may approach the hedge adjustment problem from a slightly different perspective, often the net result of real-world futures approaches is to nearly replicate the payoff of put options. It is felt, therefore, that this options-versus-futures dynamic strategy comparison is appropriate.

TABLE IV

Dynamic Strategy Out-of-Sample Hedge Performance Comparisons (Rebalancing Intervals for Nonmatched Price Data; Ratio Change Triggers for Matched Data)

Panel A: Mean Ratio Estimates across Rebalance Intervals, Hedge Ratio Variability and Mean Performance Estimates Using Gjerde Hedge Ratio and Risk-Payoff-Based Effectiveness Measures. Liquidity-Unadjusted, Nonmatched Prices for All Instruments and Strategies for the Entire Dataset

	Hedging Instrument				
	S&P 500 Futures	*SPX Put Options*	*SPX Call Options*	*Synthetic Futures*	*Observations (No.)*
Rebalancing interval equals one week	$X^* = -1.0513$ $\hat{o} = 0.0829$ HE3 = 1.0137	$X^* = 1.1864$ $\hat{o} = 0.1116$ HE3 = 1.0092	$X^* = -1.2012$ $\hat{o} = 0.1350$ HE3 = 1.0078	$X^* = -1.1130$ $\hat{o} = 0.1087$ HE3 = 1.0097	132,693 (F) 66,380 (P) 87,867 (C) 7,172 (SF)
Rebalancing interval equals two weeks	$X^* = -1.0875$ $\hat{o} = 0.1262$ HE3 = 1.0112	$X^* = 1.2109$ $\hat{o} = 0.1790$ HE3 = 1.0086	$X^* = -1.1893$ $\hat{o} = 0.1804$ HE3 = 1.0084	$X^* = -1.1520$ $\hat{o} = 0.1576$ HE3 = 1.0103	
Rebalancing interval equals four weeks	$X^* = -1.0654$ $\hat{o} = 0.2086$ HE3 = 0.0085	$X^* = 1.1611$ $\hat{o} = 0.2733$ HE3 = 1.0071	$X^* = -1.0946$ $\hat{o} = 0.2589$ HE3 = 1.0066	$X^* = -1.0886$ $\hat{o} = 0.2414$ HE3 = 1.0072	
Overall results (means across intervals)	$X^* = -1.0681$ $\hat{o} = 0.1392$ HE3 = 1.0115	$X^* = 1.1861$ $\hat{o} = 0.1880$ HE3 = 1.0083	$X^* = -1.1617$ $\hat{o} = 0.1914$ HE3 = 1.0076	$X^* = -1.1179$ $\hat{o} = 0.1692$ HE3 = 1.0991	

Panel B: Mean Ratio Estimates across Rebalance Triggers, Hedge Ratio Variability and Mean Performance Estimates Using Gjerde Hedge Ratio and Risk-Payoff-Based Effectiveness Measures. Liquidity-Adjusted, Matched Prices for All Hedge Instruments and Strategies

	Hedging Instrument				
	S&P 500 Futures	*SPX Put Options*	*SPX Call Options*	*Synthetic Futures*	*Observations (No.)*
Ratio change trigger equals 5%	$X^* = -1.0419$ $\hat{o} = 0.0500$ HE3 = 1.0155	$X^* = 1.1711$ $\hat{o} = 0.0500$ HE3 = 1.0113	$X^* = -1.1754$ $\hat{o} = 0.0500$ HE3 = 1.0107	$X^* = -1.0813$ $\hat{o} = 0.0500$ HE3 = 1.0162	2,288 (F) 2,288 (P) 2,288 (C) 2,288 (SF)
Ratio change trigger equals 10%	$X^* = -1.0792$ $\hat{o} = 0.1000$ HE3 = 1.0129	$X^* = 1.1490$ $\hat{o} = 0.1000$ HE3 = 1.0103	$X^* = -1.1608$ $\hat{o} = 0.1000$ HE3 = 1.0096	$X^* = -1.0701$ $\hat{o} = 0.1000$ HE3 = 1.0099	
Ratio change trigger equals 15%	$X^* = -1.0368$ $\hat{o} = 0.1500$ HE3 = 1.0102	$X^* = 1.1037$ $\hat{o} = 0.1500$ HE3 = 1.0084	$X^* = -1.1368$ $\hat{o} = 0.1500$ HE3 = 1.0071	$X^* = -1.0215$ $\hat{o} = 0.1500$ HE3 = 1.0087	
Overall results (means across triggers)	$X^* = -1.0526$ $\hat{o} = 0.1000$ HE3 = 1.0129	$X^* = 1.1413$ $\hat{o} = 0.1000$ HE3 = 1.0101	$X^* = -1.1580$ $\hat{o} = 0.1000$ HE3 = 1.0091	$X^* = -1.0576$ $\hat{o} = 0.1000$ HE3 = 1.0116	

Note: Hedging effectiveness (HE3), hedge ratio (X^*), and variability ($\hat{o}$) estimated using the Gjerde risk-payoff-based methodology, measuring (in %) improvement in (one plus) absolute dollar payoff per unit of risk, while incorporating margin and direct costs.

costs is best illustrated in panel B, where hedge ratio instability is held constant within each ratio change trigger (row). In this panel, rebalancing takes place more frequently for the smaller hedge ratio change trigger of 5%, and less often for 10 and 15%. Note that, as with results in panel A, futures and synthetic futures outperform options hedges. Overall, out-of-sample mean effectiveness for futures averages 1.0129, and improvements against the other tested strategies are smaller (since ratio variability is held constant). Yet divergence in performance between futures and the other hedges is greatest for the 5% ratio change trigger, where, due to frequent rebalancing, differences in total transactions costs and other frictions would be largest.

SUMMARY AND CONCLUSIONS

This study examines the hedging effectiveness of stock index options versus stock index futures. Performance of three hedge strategies using CBOE SPX option contracts is compared to that of CME S&P 500 futures. Tick-to-tick or transaction data from the two exchanges for a 30-month (April 1986 to September 1988) period are used. An overall comparison using all available transaction data for the two instruments is first performed (see Table I). S&P 500 futures are shown to track underlying index movements better than either SPX puts or calls. Relative performance rankings using the entire price dataset exactly parallel hedge instrument liquidity. Analysis using temporally matched options, futures, and index prices are performed also. Option premia and other real-world market costs and frictions are incorporated into relative hedging performance estimates, generally following the methodologies of Giddy (1983), Hull (1985), Chang and Shanker (1986), and others. The matched data subset contains 2288 index, put, call, and futures prices all within one minute (or less) of each other. The matching process also facilitated construction of a synthetic short (similar to a real-world options collar) hedge strategy, which combines SPX put and call options. Thus, it is possible to test four competing derivative hedge strategies (short futures, long put, written call, and synthetic short) using the *same* methodologies for all instruments to evaluate performance. Three measures of effectiveness are employed: a risk-reduction (minimization) approach following Ederington (1979), and risk-return and risk-payoff measures based upon earlier work by Howard and D'Antonio (1984) and Gjerde (1987). In this manner it is possible to compare option and futures performance under various investor risk-preference assumptions, and to consider the effects of direct and indirect hedge cost differences, margin requirements, market activity, and liquidity differences in analysis.

Empirical results (Table II) suggest that stock index futures outperform options when a strict risk-reduction measure (HE1) is used to evaluate hedging effectiveness. This finding suggests that futures tick-to-tick price changes are the more highly correlated with movements in the underlying S&P 500 index. Yet when more general hedger risk-return preferences are assumed using the Howard-D'Antonio framework (HE2), options provide a higher excess (i.e., above the risk-free rate) return per unit of risk than futures. However, when option premia, transactions costs, and initial margin requirements are incorporated into the performance measure, futures contracts outperform options. Dollar payoffs (at risk levels equal to an unhedged position) estimated by the HE3 measure are greater for S&P 500 futures than purchased SPX puts, written calls, or synthetic short options combinations. This result is consistent with the Chang and Shanker (1986) study of foreign currency derivatives. It is believed that the direct hedge cost of the option premium, and differences between CBOE and CME initial margin requirements (particularly prior to late 1987) cause the reversal in relative hedging performance from HE2 to HE3. SPX options experience smaller decreases in (i.e., higher) effectiveness using both HE2 and HE3 during the highly volatile two-week sub-period surrounding the October 1987 stock market crash.

Empirical results from Table IV suggest that dynamic strategy out-of-sample performance is affected by (at least) two factors. As with ex post performance findings reported in Tables I–III, differences in market frictions play a role when ex ante effectiveness is estimated by the HE3 measure. What may seem to be small differences in transactions costs or lost interest on margin (or premia) between instruments compound quickly to cause a significant divergence in options and futures performance, particularly when rebalancing occurs frequently. SPX options, being more expensive to trade than S&P 500 futures, experience a deterioration in relative performance due to this effect. Secondly, options are more susceptible to hedge ratios instability across the rebalancing intervals tested in this study. Such empirical findings are consistent with the theoretical comparison arguments presented in the second section of this article. Ratio instability contributes directly to lower out-of-sample effectiveness, especially for longer rebalancing intervals. In contrast to the in-sample results of Tables I–III, ex ante effectiveness appears to be negatively related to hedge period (rebalancing) length.

An important finding of this study is that S&P 500 futures do not appear to be redundant hedging vehicles to options. Futures provide distinct, and in many cases superior, hedging effectiveness relative to stock index options once real-world direct hedge costs and market frictions are considered. Actual derivatives market participants facing these costs should weigh effectiveness differences according to their hedging objectives and other factors.[20] Further research on the relative effectiveness question, perhaps involving tests of more sophisticated hedge strategies or other contract types, is strongly encouraged.

APPENDIX

Giddy (1983), Bookstaber and Clarke (1981), and Bookstaber (1987) have demonstrated that the value of synthetic futures contracts can be derived from no-arbitrage arguments for identical options and futures payoffs at contract expiration (delivery). Following Black (1976), Ramaswamy and Sundaresan (1985), and others, a futures contract (F) is considered on spot instrument (S), which also underlies European call (C) and put (P) option contracts, each with exercise price (X). All three contracts have time ($T - t$) until expiration (delivery). Borrowing and/or lending is possible at the prevailing risk-free rate of interest (r). (PV) signifies present value.

For the synthetic long futures contract, the initial values and terminal payoffs are compared to those of a futures contract:

Position	*Initial Value*	*Terminal Payoff*	
Long futures:	0	$S_T - F$	
"Synthetic" long		$S_T \geq X$	$S_T < X$
Buy a call	$-C$	$S_T - X$	0
Write a put	$+P$	0	$-(X - S_T)$
Borrow (or lend) PV of $(F - X)$[a]	$(F - X)e^{-r(T-t)}$	$-(F - X)$	$-(F - X)$
		$S_T - F$	$S_T - F$

[a]Note: if $F > X$ then borrow; otherwise lend.

[20]For example, the hedger's subjective probability estimates as to the likelihood of a favorable versus unfavorable stock market movement should influence instrument choice.

Since the payoffs of the two strategies are identical in all potential outcome states, no-arbitrage requires that the initial values of the two positions also be equal. This leads to:

$$0 = -C + P + (F - X)e^{-r(T-t)}$$

$$F = (P - C)e^{r(T-t)} + X \tag{A1}$$

Similarly, synthetic short futures replicate payoffs of actual futures contracts regardless of outcome; therefore, the two must be priced identically. Corresponding no-arbitrage conditions to those presented above for synthetic short futures are:

$$0 = -P + C - (F - X)e^{-r(T-t)}$$

$$-F = (C - P)e^{r(T-t)} - X \tag{A2}$$

One may interpret eqs. (A1) and (A2) to show constructed synthetic futures require borrowing or lending the equivalent of the put–call premia difference during period $T - t$; while implicit synthetic futures contract price is equal to X.

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