An Examination of the Lead/Lag Relationship Between the Option Market and the Stock Market: Where Do We Stand?

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This paper examines cross-market efficiency as it relates to the lead/lag relationship between the option market and the stock market. Our study shows that neither market leads the other consistently over time. Instead, differences in sample size, event type, time period studied, and methodology employed explain why these two markets do not react instantaneously and simultaneously to an indistinguishable set of relevant information. Specific instructions are provided to direct future research efforts to determine which market first reflects price discovery.

Introduction

When two financial markets, such as the stock market and the options market, react simultaneously to an indistinguishable set of information they are portraying perfect cross-market efficiency. Financial markets rarely react simultaneously to information. That is, some markets react before others, resulting in a lead/lag relationship. If better informed investors are more present in one market or if one market is preferred to another due to greater leverage resulting in higher gain potential and execution speed, that market could create a lead/lag relationship. It is important to learn if one market leads the other because if there exists cross-market inefficiency, then arbitrage profits would exist to the extent that the lead/lag effect outweighs the associated transaction costs (Fleming, Ostdiek, and Whaley, 1996). That is, traders could earn a riskless profit.

Options have increased dramatically in popularity over the last two decades. The most significant reasons for the success of options are the ability to hedge, to speculate, and to make arbitrage profits. Other reasons contribute to the success of options;

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options have the ability to reduce cost for the investor, provide substantial leverage, and can avoid stock market restrictions on short sales. Moreover, the maturity of options make them more risky than stocks. Hence, if a stock's price declines, the investor has the convenience to wait for it to go back up again, but the option has a maturity and may not have time left to go back up again. Finally, there is faster execution in the options market on the trading floor than in the stock market. For all these reasons, it is reasonable that investors may prefer to trade in options instead of stocks. Is that reason enough to conclude there exists a cause and effect relationship between the options market and the stock market?

Price discrepancies are supposed to be instantly arbitraged away, and only very short leads should occur. In the financial markets, however, there are transaction costs, delays in transmissions, and contrasts in interpretation and assessment of new information. The assumption of a perfect market can never hold 100 percent of the time.

Why do some studies show that stocks lead options, while others conclude that options lead stocks? The purpose of this paper is to explain why discrepancies occur in the findings of these lead/lag studies. We demonstrate that conflicts occur due to differences in sample selection, methodology, analytical techniques used, and time period studied. The synthesis of this information will explain contradictory findings and will yield an answer to the question "Does a lead/lag relationship exist between the options market and the stock market?"

The answer to this question is important to all financial market participants. If, for example, the stock market is found to reflect information in a significantly more timely manner than does the option market, then traders could make money simply by watching stock price movements and then trading in the corresponding derivative asset in the option market before the underlying asset movements influence this slower market.

Stock and option market exchanges spend millions of dollars updating the technology of their exchange. The New York Stock Exchange, for example, prides itself as being the most efficient and technologically advanced marketplace in the world. Regulators like the three-dimensional trading floor (3DTF), an interactive virtual view of the entire trading floor, which is used by regulators to monitor the NYSE's business and systems' activities. Brokers have benefited from the new Wireless Data System (WDS), which consists of wireless voice headsets and hand-held data terminals. WDS allows them to receive orders and send reports and other electronic messages from anywhere on the trading floor. Listed firms desire technology because it allows them to gain visibility that they expect from their exchange. This exposure helps them with capital-raising activities. For institutions, advanced technology creates a fair, orderly, and highly liquid market that institutions require in order to allocate the funds they have under management [www.nyse.com]. Whether placing orders for individual stocks or executing programs (a series of up to 500 orders usually related to an index), informed investors desire to trade in the market where their executed trades will be processed

quicker. Even herding investors, who thrive on mimicking the trading behavior of informed investors before the rest of the market reacts, want to know which market is faster. In sum, all financial market participants are interested in knowing which market reflects new information in a more timely fashion.

Literature Review

Many authors agree that option price behavior differs from stock price behavior, but there is no consensus regarding how they differ. The relationship is inconclusive: Manaster and Rendleman (1982), Bhattacharya (1987), Anthony (1988), and Varson and Selby (1997) conclude that the options market leads the stock market. Conversely, Stephen and Whaley (1990) and Chan, Chung, and Johnson (1993) find that the stock market leads the options market. Several other studies also contribute to this topic, although they do not specifically test for a lead/lag relationship.

Stocks Lead Options

Although Stephen and Whaley (1990) state that reduced transaction costs and increased financial leverage may make trading in the options market more attractive than trading in the market for the underlying stock, they find that the stock market leads the options market. In addition, these cheaper and more flexible trading opportunities attract newly and differently informed investors to the marketplace. Their findings show that price changes in the stock market tend to lead those in the options market. They claim that abnormal intraday trading patterns exist in the stock and options market. They suggest more research is needed to explain the cause(s) of the differential trading activity between the two, essentially redundant, markets. Stephen and Whaley also find that the New York Stock Exchange (NYSE) stocks have the familiar U-shaped pattern of trading activity by time of day, whereas the options market begins at a relatively low level of activity, rises to a maximum activity about 45 minutes into the day, declines to a uniform level of activity (above the level of activity in the stock market during the trading day), and then rises again at the close. Stephen and Whaley and Chan, Chung, and Johnson test only a three-month period between the two markets, however, whereas Varson and Selby concentrate on the time period around the arrival of new information. Stephen and Whaley purge price change series of the effects of bid and ask spreads to estimate the lead/lag relationship. Their results verify that price changes in the stock market lead the options market by as much as 15 minutes, and their analysis of trading volume attests that the stock market lead may be even more distant.

Chan, Chung, and Johnson (1993) find no evidence that options, even deep-out-of-the-money options, lead stocks. Furthermore, they find no arbitrage opportunities for the stock leads when the average of the bid and ask prices is used instead of transaction costs. Stocks lead options by 15 minutes, and the lead seems to be spurious because of the way stocks and options are traded.

Options Lead Stocks

Manaster and Rendleman (1982) were the first to study the lead/lag relationship between the options market and the stock market. They use the Black and Scholes option pricing model to compute cooperatively implied stock prices and implied standard deviations. Comparing the two, they find that closing prices include information concerning equilibrium stock prices that is not completely reflected in observed closing prices of the underlying stock. Accordingly, they find evidence that even after a 24-hour time lapse that information is not fully reflected in stock prices.

Anthony (1988) investigates the relationship between the two markets by examining trading volume. The supply of options is not fixed, whereas the supply of stock is limited. Consequently, if a new option is written (even for random reason), then others may trade in the stock to return to their desired hedge positions. Anthony's results indicate that changes in call option trading volume lead trading volume in the underlying stock, with a one-day lag.

Varson and Selby (1997) find that through the five trading days prior to earnings announcements with vital unforeseen and informative significance (when the information is unanticipated), implied stock values lead their parallel observed stock prices by 15 minutes. On the same day as the announcement is made, the lead increases to the point that call option prices generally adjust at least one hour before the public announcement. After the announcement has been made, the lead dissipates almost instantaneously, and prices stay synchronous between the two markets. This observation suggests that their paper is more evidence of leakage of information (trading on private information) than evidence of a lead/lag relationship.

Bhattacharya (1987) finds evidence that option prices contain some information not found in contemporaneous stock prices. Correspondingly, Bhattacharya finds that option prices lead stock prices, but he does not test whether option prices lead stock prices as a result of insider information.

Studies Indicating No Lead/Lag Relationship

Several authors contribute to the topic of no lead/lag relationship, although they do not test for cross-market efficiency between the options and the stock market. Their findings support the idea that earlier studies have failed to prove a significant consistent lead/lag relationship between the options market and the stock market.

Kumar, Sarin, and Shastri (1992) show that the options market exhibits abnormal price behavior starting 30 minutes before a block trade, while the price reaction in the stock market leads the block by 15 minutes for downtick block trades and does not lead the block for upticks. This is consistent with Stephen and Whaley's results. Moreover, Kumar *et al.* also find that the options market takes longer to adjust to the block transaction than does the stock market. The options market, however, begins the adjustment procedure before the stock market, which supports the idea that options lead stocks. They also acknowledge that the returns on options are related to lagged and

simultaneous returns on the underlying stock, so their findings produce mixed results indicating no lead/lag relationship.

Figlewski and Webb (1993) find that trading in options contributes to both the transactional and informational efficiencies of the stock market by reducing the effect of constraints on short sales. They state that options trading creates a channel that effectively allows investors who are constrained from taking direct short positions to short a stock through the options market. The evidence is that optionable stocks exhibit a significantly higher level of short interest than do stocks without options, and additional results confirm that an individual's stock short interest increases after option listing. Therefore, samples from periods around option introduction will differ from other time periods when the option is listed.

Jennings and Starks (1986) investigate if options may be preferred to direct equity investment and find that option premia appear to anticipate stock price changes. Their findings are in line with Manaster and Rendleman in the sense that the common stock of firms with exchange-listed options is associated with a different price adjustment process than that of non-option firms. Jennings and Starks also conclude that the options market makes stock market pricing more efficient, a conclusion also reached by Manaster and Rendleman.

Grossman (1988) observes that traded options reveal information about investors' future trading intentions and, therefore, reveal information about future price volatility in a way that a dynamic option replication scheme does not. Furthermore, Patell and Wolfson (1981) study the effect of investors' anticipation of impending informative disclosures on the behavior of option and stock prices. They analyze pre-announcement option prices in order to derive investors' beliefs about the range of possible stock price reactions expected to accompany a forthcoming disclosure whose actual content is not yet known. Their *ex ante* tests indicate that the average standard deviations to expiration implied by pre-announcement option prices exhibit a time-series profile that anticipates the stock price behavior. This evidence supports Varson and Selby's findings that options lead stocks.

Joy, Litzenberg, and McEnally (1977) find that information in quarterly earnings is not fully impounded into stock prices at the time of the announcement, and Whaley and Chung (1982) find that the information content in quarterly earnings announcements is not fully achieved in option prices until the end of the announcement week. Consequently, old samples will have a corrupt effect when testing a lead/lag relationship. Atiase (1985), however, finds that a significant portion of the information disclosed through quarterly earnings announcements is reflected in security prices preceding the report month. This could be the result of leakage and not necessarily evidence of a lead/lag relationship. Recent studies (such as Varson and Selby's) show that securities move before the announcement. Consequently, the information may be contained in the security before the announcement, which would undermine Varson and Selby's results. The samples from Varson and Selby and from Joy, Litzenberg, and

McEnally are from the 1970s, which creates a certain aged sample bias. A sample from the 1970s differs from a 1990s sample; option trading has changed a great deal. Furthermore, abnormal returns could have been earned almost at any time during the 1970s, unlike the 1980s, according to Rendleman, Jones, and Latané's (1982) study. Phillips and Smith (1980) conclude, however, that these abnormal returns are obliterated when transaction costs are considered. Helmuth, Robin, and Zdanowicz (1994) show no discernible pattern of abnormal returns after the event day, but they do not study intraday adjustments. If there is a leakage of information before the earnings announcement, then the study must test for a lead/lag relationship around the information arrival, as do Varson and Selby, rather than testing over random three-month periods.

Option listing improves the informational efficiency of the market for the underlying stock. Unlike Jennings and Starks (1986), Skinner (1990) finds no evidence that option listing causes these informational changes (improvements). Mean reversion tendencies are present in stock prices. Further, Wright (1994) finds that stock prices overreact to some general piece of information that creates inefficient market behavior. These prices will then revert afterwards, and these matters of direct observation create problems when determining a lead/lag relationship. In order to find a lead/lag relationship, both markets should not behave at irregular intervals. Sizable differences in the bid and ask spreads exist between the markets, which implies informational inefficiency. The bid and ask spread is also related to firm size according to Roll (1984), and firm size will impact the lead/lag relationship study as well. Authors generally do not provide enough information about the data collected, so the results could differ considerably depending on whether the data come from the AMEX or NYSE. In addition, studying option behavior is also burdensome when it comes to the volatility of the data. Whiteside, Dukes, and Dunne (1983) find the following trend "... decreased price volatility and increased variability in the number of shares traded daily is shown in the underlying security shortly after option trading begins." Therefore, the results will be substantially altered depending on how close to the date of option trading introduction one pulls a sample from and on how large that sample is.

Ho and Liu (1997) conclude that there is a significant turnaround in price behavior surrounding option introduction. Again, this implies that one should not sample data close to option introduction when testing for lead/lag relationships in order to avoid price bias. Other authors also find information deficiencies between other related markets. Peterson and Tucker (1988) extend the Manaster and Rendleman methodology to include call options on foreign currency. Foreign currency options contain information outside what is presented in their underlying spot market exchange rates. They proclaim that the currency options market leads the currency spot market. Likewise, Peterson and Tucker show that the spot rates implied by currency options lead currency returns, which contributes evidence that derivative prices lead their corresponding underlying prices.

In sum, there appear to be informational differences between the options market and the stock market. Moreover, the reactions of option and stock prices differ. We do not know if either one leads the other. Much of the discrepancies in these studies can be explained by the differences in sample selection, use of different methodologies, time periods studied, data selection methods, and analytical techniques used. The next section provides the various methodologies, the lead/lag relationship studies, and a discussion how these variations contribute to contradictory findings.

Methodological Issues

Table 1—Summary of the Five Main Studies on the Potential Lead/Lag Relationship

Time-Period Sample	Summary of Findings
Panel A: Varson and Selby (1997) *European Journal of Finance* 3: 49-72	
First quarter of 1979. CBOE options with 135 announcements	Implied stock values lead their corresponding observed stoc prices by about 15 minutes throughout the five trading day preceding earnings announcements. The lead is at least on hour before the public announcement, and after th announcement the lead disappears
Panel B: Chan, Chung, and Johnson (1993) *Journal of Finance* 5: 1957-1967	
First quarter of 1986. Only include options with 144 transactions during the day	Confirmed Stephen and Whaley's results. Stocks lea options by 15 minutes. Not even deep-out-of-the-mone options lead stocks
Panel C: Stephen and Whaley (1990) *Journal of Finance* 55: 191-220	
First quarter of 1986. Only include options with 144 transactions during the day	Price changes in the stock market tend to lead those in th options market by as much as 15 minutes. Although th options market is more attractive than the stock market abnormal intraday patterns in both markets give rise to stoc price leads over option prices
Panel D: Bhattacharya (1987) *Journal of Financial & Quantitative Analysis* 22: 1-15	
June 2, 1977 to August 15, 1978. Options on 96 stocks traded on CBOE (the options with the greatest volume)	Option prices do contain some information not contained i contemporaneous stock prices, thus option prices lead stoc prices
Panel E: Manaster and Rendleman (1982) *Journal of Finance* 37: 1043-1057	
April 26, 1973 to June 30, 1976 (daily closing prices). 172 stocks	Closing prices include information concerning equilibriu stock prices that are not completely reflected in observe closing prices of the underlying stock

Methodologies Used to Conclude Options Lead Stocks

Varson and Selby (1997) collect data from firms with CBOE-traded options that made 145 earnings announcements during the first four months of 1979. 135 of those announcements are identified with exact times. This sample is too old (aged sample bias) to prove a significant lead/lag relationship in today's market environment. Since 1979, the options market has increased extensively in volume, and the overall financial

environment has changed dramatically. To verify that the earnings announcements delivered significant information, Varson and Selby use the standardized announcement return (SAR) measurement defined as follows:

(1) $SAR_j = (EDR_{j,o} + EDR_{j,-1})/ESE$

where:

$EDR_{j,o}$ = The excess return on announcement day;
$EDR_{j,-1}$ = The excess return on the previous day; and
ESE = The estimated standard of error of the two-day return.

Using daily returns, Varson and Selby calculate SAR_j for each of the 135 available announcements and rank them. Varson and Selby partition the trading day into 24 15-minute intervals (24*15 = 360 minutes or six hours of trading). They select the last available quoted price for every call option series and underlying stock for each firm and interval. Then they calculate the joint implied parameters that minimize the following objective function denoted by Q:

$$(2)\,\text{Min}Q \equiv \sum_{X=F}^{L} \sum_{i=1}^{M} [C_{i,x} - SH_{ix}(S_i V)]^2$$

where:

$C_{i,x}$ = The observed price of the ith call option in interval X;
F = The first of the N intervals;
L = The last of the N intervals;
M_x = The number of available call options on the specified stock in interval X;
N = The number of 15-minute intervals in the relevant trading period;
S_x = The implied stock price in interval X;
$SH_{i,x}(S_i V)$ = The corresponding Selby-Hodges price for the American call (whereas Manaster and Rendleman use the Black-Scholes price for the call); and
V = The implied variance for the relevant trading period.

Varson and Selby derive the proportional error and holding period excess returns to infer the pattern of a lead/lag relationship between the two markets. They examine the 240 trading intervals centered on each announcement and partition them into ten *pseudo-days* of 24 intervals each. Varson and Selby's methodology is sufficient, but the sample is too old. Although they use information content measurements and implied parameter estimations effectively, their conclusion cannot be assumed accurate today due to aged sample bias.

Manaster and Rendleman (1982) use price data from the Center for Research in Security Prices (CRSP) options tape which contains daily closing prices and maturity dates for listed options traded from April 26, 1973, to June 30, 1976. They use a similar technique to that of Varson and Selby, but they use closing prices instead of intraday prices. They calculate the disparity between a firm's observed stock price and the stock value implied by that firm's call option price. Options with large dividends are excluded due to the limitations of the Black-Scholes model. They calculate the implied stock prices and proportional errors for each of the 172 stocks on each available observation

date. Their frequency distribution of the errors shows that implied prices differ from observed prices, thus signaling informational differences. Their data show closing stock transaction data regularly occur following closing option transactions. Their conclusions are not robust because of the use of closing data instead of intraday transaction data (security price bias). Furthermore, the two markets close at different times, making their results unreliable. Also, their sample is too dated. Finally, Manaster and Rendleman and other authors do not examine the relationship at the time of the release of information, as do Varson and Selby.

Bhattacharya (1987) uses the Berkeley Options Data Base with transaction data from June 2, 1977, through August 15, 1978 (302-trading day span, old sample bias) using options on 96 stocks traded on the CBOE. Bhattacharya chooses the options with the greatest volume (large volume bias) because the greater the option volume, the larger the number of intraday records (the greater the creditability of the intraday holding period returns used in hypothesis testing). Bhattacharya is thus weakening the evidence for cross-market inefficiency by not using smaller holding period returns. Bhattacharya's non-overlapping span for stock j at time t is defined in return terms as follows:

$$(3)\Delta_{jt} \frac{S_{jtbid} - S_{jtask}}{(S_{jtbid} + S_{jtask})/2}.$$

If implied stock values are higher than observed stock prices, then:

$$(4)\ \Delta_{JT} = \frac{\hat{S}_{jtask} - S_{jtbid}}{(S_{jtbid} + S_{jtask})/2}$$

where:

S_{bid} and S_{ask} = The stock's observed value;

$\check{S}_{jt\,bid}$ and $\check{S}_{jt\,ask}$ = The stock bid and ask values implied from the bid prices and the ask prices, respectively, of a pair of identical short maturity options on the underlying stock; and

Δ = An arbitrage signal that occurs when the implied stock bid and ask span does not overlap the observed bid and ask span.

Bhattacharya calculates implied stock prices from only two option price recordings (small sample bias), which does not significantly prove a lead/lag relationship.

Methodologies Used to Conclude Stocks Lead Options

Stephen and Whaley (1990) collect intraday transaction data for the period January 2, 1986 through March 31, 1986 (aged sample bias). The implied volatility is estimated using the previous day's transactions. Volatility is not constant from day to day,

however, resulting in volatility bias. Like Manaster and Rendleman, the stock's return volatility is computed by regressing observed call option prices on model prices across all option transactions on a particular stock in a given day. Stephen and Whaley translate each call option transaction price into an implied stock price by inverting the option price formula. After adjusting for both the effects of bid and ask spreads in the stock and options markets and after standardizing the number of transactions and trading volume to remove scale differences, they find that stocks lead options. Unfortunately, Stephen and Whaley do not examine the lead/lag relationship around information arrival, which may account for the different result that Varson and Selby attain.

Chan, Chung, and Johnson (1993) confirm Stephen and Whaley's results using stock and option price data from the same quarter that Stephen and Whaley use (first quarter of 1986, hence the same aged sample bias). The transaction prices are from the Berkeley Options Data Base as well, and they follow Stephen and Whaley's sample and only use options that have at least 144 transactions during the day to reduce the sample, which creates large volume bias. Chan *et al.* use Manaster and Rendleman's inaugural notion of implied stock price to compare it with the actual price (as do Stephen and Whaley). Chan *et al.* use the nonlinear system equation approach [initially used in finance by Gibbons (1982)].

$$(5)\ \Delta C_{i,t} = \alpha_{i,t} + \sum_{k=-3}^{3} \beta_k h_i \Delta S_{i,t+k} + \epsilon_{i,t} \quad i = 1, 2, ..., N \quad t = 1, 2, ..., T$$

where:

$\Delta C_{i,t}$ and $\Delta S_{i,t}$ = Call price change and stock price change for firm i from time t - 1 to time t;
h = The delta value (price risk);
N = Number of option days in the sample;
T = Number of intervals during the day; and
ϵ = Error term.

They use the Gauss-Newton procedure to estimate β_k and h_i through ordinary least squares estimation by iterating successively on the parameter vector (β, h). Chan *et al.* obtain the same results whether they use the average of the bid and ask, just the bid, or just the ask in their test. They do not perform volatility estimates (volatility bias), and they do not use implied stock prices. By not testing around the arrival of information, Chan *et al.* and Stephen and Whaley cannot find evidence of leakage. The leverage effect (also called *omega* or *gearing*) makes an option move more infrequently than a stock. The tick for options with prices greater than $3 is also an eighth (less than $3 carry a tick of one-sixteenth), but requires a much greater percentage move in the option price. Minor moves in the stock price will usually not be instantaneously reflected in the option because the change in theoretical value of the option is less than the tick—and so the option does not trade. The stock must make more than a move in one direction before the option trades (Chan, Chung, and Johnson, 1993). Accordingly,

if the option is supposed to move, there cannot be a move in the stock by just a fraction because the move is not significant enough to make the option move due to leverage. This could explain why some prior research has found that stocks lead options according to Chan *et al.* As options have become more popular over the years, more investors have begun to invest in the options market, making it more efficient compared to a decade ago. Detemple and Jorion (1990) show that the options market tends to have a stabilizing effect in the sense that it reduces the volatility of the underlying securities (stocks). This means that when new options are listed, the underlying stocks have lower risk than before the option introduction. If prior research concludes a lead/lag relationship when using data around option introduction and pre-introduction, those data are biased and not sufficient to use as a sample.

Analysis

The results of prior research are mixed and depend on methodology, selection sample, and time period of study. Moreover, the results differ depending on whether the author examines the relationship before, at, or after information arrival.

Stocks Lead Options

Chan, Chung, and Johnson (1993), and Stephen and Whaley (1990) find that stocks lead options by 15 minutes. The lead can be explained, however, by the way stocks and options are traded. Furthermore, the age of their samples does not add value to their studies because option and stock trading has increased in complexity over the years. Their results cannot be supported until their studies are modified with current samples of intraday transaction data. Both studies use a three-month time interval to test the relationship. Moreover, they do not test for a relationship around the arrival of information (as do Varson and Selby) and therefore miss arbitrage opportunities in the pre-announcement period (specifically, one hour before the announcement). Their use of current volatility as drawn from the previous day's implied volatility further dilutes their findings. Hence, their methodology is not sufficient to identify a lead/lag relationship between the options market and the stock market.

Options Lead Stocks

The Manaster and Rendleman (1982) study is too dated to apply to today's markets. Their use of closing prices instead of intraday transaction prices severely clouds their study. When making an *ex post* study one can easily obtain biased results by not using a time-stamped history of bid and ask prices for both securities. Vijh (1988) concludes that one has to account for the bid and ask bounce and the nonsynchroneity between stock and option prices—when the two are in equilibrium, it gives the impression that option prices lead stock prices. Manaster and Rendleman were the first to test for a lead/lag relationship between the options market and the stock market. Consequently, their sample is also the oldest (from 1976), which makes their results

inapplicable today. They use the same (biased) methodology as Chan *et al.* and Stephen and Whaley, which is not satisfactory in determining a lead/lag relationship between the two markets.

Bhattacharya's (1987) imprecise results are somewhat biased. The study does not include price data from the announcement day; thus, it is false to capture any lead/lag relationship that was restricted to that day. This bias in the methodology together with the old and small sample (small and aged sample bias) may be the explanation why the results are ambiguous. Moreover, the result may be weaker only using high volume firms because high volume firms' securities tend to be more efficient (high volume bias). That is, they may have higher informational efficiency because they are followed by a larger number of analysts and investors. Correspondingly, Manaster and Rendleman, Chan *et al.*, and Stephen and Whaley do not examine data around information arrival, thus creating biased results.

Varson and Selby (1997) conceivably conduct the best (and most recent) study to date on the lead/lag relationship because they examine the relationship at the time of information arrival and before information arrival (including trading on private information), but their sample is from the first four months of 1979 (aged sample bias). In 1979, there was a small amount of hedging activity, no circuit breakers or trading curbs (trading suspension in order to calm down the market), no stock volume around the measure of a billion stocks a day on the NYSE, no index options activity, limited instances of massive institutional trading, and so forth. It is unfortunate that they choose a sample that old because this weakens their results. Their methodology is superior to earlier studies; nevertheless, the sample was selected from the late 1970s, so the results cannot be assumed to apply today.

Summary and Suggestions for Future Research

The studies performed to date on the potential lead/lag relationship between the options and stock markets are not sufficient to demonstrate a significant relationship over time or across samples. All previous studies use samples that are too old (decayed) which dilutes the evidence of a lead/lag relationship no matter which market is found to lead the other. Further, although some of the earlier studies are well conducted, the differences in the results are caused by the different methodologies (jointly with the biased samples). Varson and Selby use the best methodology for testing a lead/lag relationship, but their sample is too old. Hence, future research needs to be conducted using a methodology consistent with Varson and Selby (1997), using data not only from a much more recent period, but from several periods. Only then is it feasible to determine if the lead/lag relationship exists in one direction constantly over time or if there are certain periods where stocks lead options and other periods where options lead stocks.

Because obtaining a population of intraday stock and option prices over a long period of time would involve billions of observations, we must rely on a sample. In

selecting the sample, it is crucial to keep the sample consistent over time. Furthermore, several different types of announcements need to be examined. Thus far, either no announcement has been used (which introduces bias) or only earnings announcements have been used. Why not examine the potential lead/lag relationship in reference to the numerous additional price altering events, such as mergers, Federal Reserve policy changes, dividend declarations, or general economic information?

This is an area of research that is at best not well understood. (It is more likely misunderstood.) Furthermore, the lead/lag relationship has tremendous ramifications concerning where investors should invest when new information arrives at the marketplace. Exchanges should also strive to achieve a market with the fastest price discovery. Being a distant second means losing investors to the faster market, which will result in a lower level of liquidity, higher bid-ask spreads, and less efficiency.

All market participants want to know which market reflects new information first; future research needs to be conducted to answer this question. Future studies should be conducted in accordance with these four precepts:

- Studies should use recent data, as both the stock and option markets have changed considerably in the past several years;
- The sample must remain constant over the examination period;
- The Varson and Selby (1997) methodology should be employed; and
- Reactions to various announcements, not just earnings announcements, must be examined.

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