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Why Option Prices Lag Stock Prices: A Trading-based Explanation

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ABSTRACT

While many studies find that option prices lead stock prices, Stephan and Whaley (1990) find that stocks lead options. We find no evidence that options, even deep out-of-the-money options, lead stocks. After confirming Stephan and Whaley's results, we show their results can be explained as spurious leads induced by infrequent trading of options. We show that the stock lead disappears when the average of the bid and ask prices is used instead of transaction prices. Hence, we find no evidence of arbitrage opportunities associated with the stock lead.

IN A PERFECT MARKET, price discrepancies should be instantly arbitraged away. In particular, option prices should neither lead nor lag stock prices. In real markets, only very short leads should occur. Traders with private information who are confident that their information is valid and that they will not be detected generally want highly leveraged positions to exploit their advantage. Thus, we might expect options, with their greater leverage, to lead stocks, if information trading is important. Manaster and Rendleman (1982), Bhattacharya (1987), and Anthony (1988) find evidence that options in fact lead stocks.[1] However, Stephan and Whaley (1990) find just the opposite. A stock lead of a few minutes could be explained by invoking reporting lags or other considerations. But Stephan and Whaley report a stock lead of fifteen to twenty minutes. Such a lead, if real, is difficult to understand.

In this paper we reexamine the evidence. Most previous researchers have computed implied stock prices by inverting the Black and Scholes or another option-pricing equation. We use instead a nonlinear multivariate regression model, first used in finance by Gibbons (1982). This approach is simpler than the approach used earlier in the literature because it requires less information to be implemented. For instance, this approach can be used without knowing the dividend ex-date. However, the traditional approach and the one used here lead to the same results over comparable samples. In particular, we

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[1] Finucane (1991) finds a similar lead using S & P 100 Index options. However, the case of index options could be different for a variety of reasons, including the infrequent trading of stocks in the index.

are able to replicate the results of Stephan and Whaley (1990) with our approach.

We propose an explanation for the puzzling lead of stocks over options. The minimum move or tick for a stock is typically one-eighth. The tick for options with prices greater than three dollars is also an eighth, but entails a much larger percentage move in the option price. Thus, small moves in the stock will usually not be immediately 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 option will trade after the stock has made more than one move in the same direction. Hence, we should observe the stock leading the option. For options with prices below three dollars, the tick is one-sixteenth, but the same effect should still occur. This explanation produces very specific testable predictions about the circumstances in which a lead should or should not be observed, and we conduct these tests.

If the option tick is the key to understanding the stock lead, then it makes sense to look at bid-ask quote data as well. Bid and ask quotes are also discrete, but they can be changed more easily than the transaction price. The market maker for the option can adjust either the bid or the ask or both instantaneously—there is no need to wait for an order to arrive. Thus, if the observed stock lead is due to the way stocks and options are traded, this lead should diminish or even disappear if the average of the bid and ask is used in the tests instead of the transaction price.

In the next section we discuss the competing hypotheses. Section II describes the data used in this study. Section III describes the methodology. Section IV gives our results, and Section V is a summary.

I. The Hypotheses

No arbitrage opportunities should exist in a perfect market. Hence, option prices should neither lead nor lag stock prices. In real markets there will be no significant leads or lags provided transaction costs are sufficiently low and traders have quick, easy access to both markets. Hence, the No-Arbitrage Hypothesis predicts no significant leads or lags.

Utility-maximizing traders with private information must in general consider many factors: margin requirements and other borrowing constraints, the probability of detection, aversion to risk that remains even with the private information, transaction costs, liquidity of the markets, etc. However, if the probability of detection is low and the potential profits from trading on their information are high, then such traders should prefer the market affording the greatest leverage. Since options provide greater leverage than stocks, the Private Information Hypothesis predicts the options market will lead the stock market. Furthermore, since deep out-of-the-money options provide the greatest leverage, they should have the longest leads over the stock market.

Since option prices do not move as much in absolute terms as the underlying stock, a stock price will not cause any move in the option if the stock price change is so small that the change in value of the option is not enough to cause the market price of the option to move a tick (the minimum price change). Several stock price changes in the same direction can occur before the option price changes. In other words, the tick size prevents options from trading immediately in response to small price changes. Hence, the stock is observed to lead the option. Thus, the Infrequent Trading Hypothesis predicts that stocks will lead options. Furthermore, this hypothesis makes some very specific predictions. When the option price, OP, is below three dollars, the tick is $1/16$; otherwise, it is $1/8$. Hence, if OP < 3 and $h\Delta S < 1/16$, where h is the delta value and ΔS is the change in the stock price, then the value of the option will not generally change enough to cause any observable market price change. A similar relation holds when the tick is $1/8$. Hence we have a four-way table:

1. if OP < 3 and $h\Delta S < 1/16$ stock leads option
2. if OP < 3 and $h\Delta S > 1/16$ no lead
3. if OP > 3 and $h\Delta S < 1/8$ stock leads option
4. if OP > 3 and $h\Delta S > 1/8$ no lead

Furthermore, in cases 1 and 3 the lead coefficients should be correlated with the size of $h\Delta S$.

While some of the transaction costs, such as transfer taxes, are small and can probably be safely ignored for our purposes, we must consider the effect of the bid-ask spread. Since the market maker for the option need not wait for an incoming order to change the bid or ask, the bid and ask quotes are easier to adjust and should reflect information more quickly than the transaction price. The discreteness of the tick implies that the bid and the ask must also be changed by at least one tick, but the market maker has more freedom in choosing the midpoint of the spread because it is not necessary to change both the bid and ask at the same time. The bid-ask spread is frequently larger than one tick, but this in no way implies that the transaction price must change by more than one tick, since the bid and ask can be adjusted one tick at a time. Thus, it is easy to imagine situations where the stock price changes by a tick, the option market maker adjusts either the bid or the ask or both, but the option transaction price does not change. (See also Jang and Venkatesh (1991) for a discussion of quote revision.) Hence the infrequent trading hypothesis implies that the stock lead over the option should diminish or even disappear when the tests are conducted using the average of the bid and ask instead of the transaction price.

II. Data

We examine stock and option prices for the first quarter of 1986, the same period as Stephan and Whaley. Option transaction prices are obtained from the Berkeley Options Data Base. For each option contract we generate a five-minute option price series by choosing the latest option price in each five-minute interval. If no price is available for an interval, we use the price from the previous interval. The bid-ask quotes for options are also obtained from the Berkeley tapes. We generate the stock price series from the Transaction File of the Institute for the Study of Security Markets (ISSM), which is a record of all trades and bid-ask quotations on the New York Stock Exchange, the American Stock Exchange, and most regional exchanges. The ISSM File contains the time to the nearest second, the price, and volume for each transaction, and, for each quotation, the time, bid price, ask price, bid volume, and ask volume. We also generate an alternative stock price series by using the most recent stock price before the time of the option transaction, as given on the Berkeley tapes. The latter series gives a more conservative estimate of the stock's lead than the "transaction stock price data" from the ISSM File (the latest transaction stock price in the five-minute interval across all options for the same underlying stock).

The Berkeley tapes contain data for 73,309 option days (days on which a particular option contract was traded), representing 1,447,797 transactions and 19,075,617 contracts traded during the period January 2 to March 31, 1986. After deleting index and bond options, we have 72,124 option days left. In the initial sample we follow Stephan and Whaley and use only options that have at least 144 transactions during the day. This restriction greatly reduces the sample, leaving 639 option days with 156,574 transactions and 2,019,536 contracts traded. Stephan and Whaley, who use the Market Data Retrieval tapes of the Chicago Board Options Exchange instead, have 726 option days with 178,217 transactions and 2,502,334 contracts traded. We also require that each option have price data starting at 9:05 A.M. Chicago time, to ensure at least 71 price observations for the day. We are left with 572 option days.[2]

III. Methodology

Manaster and Rendleman (1982) introduce the notion of implied stock price. By comparing the actual stock price with the stock price implied by the observed option price, one can determine leads and lags between the option price series and the underlying stock price series. Stephan and Whaley use the same procedure.

We use a nonlinear system equation approach, first used in finance by Gibbons (1982):

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

[2] The system equations approach used here requires that data be available for all the options for each time interval. On the relatively rare occasion that no trade occurs we use the price from the previous five-minute interval. To handle the problem of missing data at the beginning of the day due to late openings, we delete the first thirty minutes of trading. We have replicated our results using all but the first fifteen minutes of trading and find that the results are essentially unchanged.

where $\Delta C_{i,t}$ and $\Delta S_{i,t}$ are the call price change and stock price change for firm i from time $t-1$ to time t, h_i is the delta value, N is the number of option days in the sample, and T is the number of intervals during the day. Of course, the same equation applies to puts. We estimate $\alpha_{i,t}$, β_k, and h_i from equation (1). Since the lead/lag coefficients, β_k, are always multiplied by h_i's, there is an indeterminacy that we resolve by normalizing the β's so that $\Sigma_{k=-3}^{3}\beta_k = 1$. The h_i's are assumed constant throughout the day.

The equations in (1), which can be thought of as single time series regressions with T observations in a pooled system of N equations, are estimated with the Gauss-Newton procedure, using the SYSNLIN procedure in SAS. The parameters, β_k and h_i, are estimated jointly, and the solution is found through ordinary least squares estimation, by iterating successively on the parameter vector, (β, h), and on the covariance matrix until it converges. The estimation is consistent and asymptotically efficient with an asymptotic normal distribution. However, small sample properties may not be good: the standard error estimates are asymptotically valid but may not be trustworthy in small samples. Thus, individual t tests for each parameter are only asymptotically valid. For our smallest samples, the significance of the t's may be overstated. Moreover, assuming the delta value is constant throughout the day may introduce an errors-in-variables problem. For more details on our method, see Gibbons (1982).

IV. Results

First, we examine the total sample of 572 actively traded calls. We report the call option leads (β_1 and β_2) and lags (β_{-1}, β_{-2}, and β_{-3}) and the contemporaneous coefficient (β_0) in Table I, using the latest (up to the second) stock price in the five-minute interval for the underlying stock (from the ISSM tapes). We also run the tests using the most recent stock price before a call trade (from the Berkeley tapes). The results are qualitatively similar. In both cases, the stock leads the call by 15 minutes. Also included in Table I are the results for puts. The stock leads the put by 15 minutes as well.

A powerful test of the infrequent trading hypothesis is to calculate leads and lags using the averages of the bid and ask prices instead of transaction prices. We find that there is no systematic lead of the stock bid-ask over that of the calls or the puts (see Table II).

We find that the results are essentially the same whether we use the average of the bid and ask, just the bid, or just the ask in the tests. We also find that the stock average bid and ask leads the option transaction price but does not lead its own transaction price. However, the option bid-ask does lead its own transaction price. Hence, we conclude that the stock lead is spurious, caused by the way options are traded.

We also stratify the sample by volume, moneyness, absolute stock price change, delta value, and option price. We merely mention the results here in passing, as they are not very striking. In particular, we find no evidence that the stock lead over the option turns into a lag for deep out-of-the-money calls,

Table I

Leads and Lags Using Transaction Prices

Parameter estimates from nonlinear system equations model of five-minute price changes of 572 active[a] call options and 108 active put options on lagged, contemporaneous, and leading five-minute underlying stock price changes during the period from January 2, 1986 through March 31, 1986.[b,c,d]

$$\Delta C_{i,t} = \alpha_{i,t} + \sum_{k=-3}^{3} h_i \beta_k \Delta S_{i,t+k} + \epsilon_{i,t} \quad \text{S.T.} \quad \sum_{k=-3}^{3} \beta_k = 1, \quad i = 1, 2, \ldots, 572 \quad \text{for call options}$$

$$\Delta P_{i,t} = \alpha_{i,t} + \sum_{k=-3}^{3} h_i \beta_k \Delta S_{i,t+k} + \epsilon_{i,t} \quad \text{S.T.} \quad \sum_{k=-3}^{3} \beta_k = 1, \quad i = 1, 2, \ldots, 108 \quad \text{for put options}$$

where $\Delta C_{i,t}$ and $\Delta S_{i,t}$ are the call price change and stock price change for underlying stock i from time $t-1$ to time t; $\Delta P_{i,t}$ is the put price change for underlying stock i from time $t-1$ to time t; h_i is the delta value, assumed constant throughout the day.

	Calls						Puts					
	January '86		February '86		March '86		January '86		February '86		March '86	
No. of Observations	155 Option Days		211 Option Days		206 Option Days		43 Option Days		29 Option Days		36 Option Days	
β_2	0.015	(1.18)[e]	0.040	(3.74)	−0.008	(−0.67)	0.021	(1.15)	0.014	(0.57)	0.057	(2.06)
β_1	−0.023	(−1.68)	0.089	(8.59)	0.045	(4.12)	0.085	(5.02)	0.025	(1.07)	−0.010	(−0.34)
β_0	0.308	(23.60)	0.343	(28.29)	0.209	(20.51)	0.267	(15.35)	0.219	(9.95)	0.279	(9.87)
β_{-1}	0.505	(27.37)	0.398	(29.87)	0.428	(30.79)	0.386	(17.94)	0.456	(14.55)	0.617	(12.94)
β_{-2}	0.115	(9.52)	0.171	(16.69)	0.263	(23.43)	0.217	(12.25)	0.149	(6.73)	0.148	(5.30)
β_{-3}	0.086	(7.00)	−0.045	(−3.70)	0.057	(5.29)	0.058	(3.24)	0.110	(4.93)	−0.031	(−0.98)

[a] More than 144 transactions per day.

[b] We report results separately for each month because SAS cannot handle more than 250 system equations at the same time.

[c] Since the lead/lag coefficients, β_k, are always multiplied by h_i's, there is an indeterminacy that we resolve by normalizing the β's so that $\Sigma_{k=-3}^{3} \beta_k = 1$. We cannot, therefore, obtain the parameter estimate for β_3.

[d] Intraday transaction prices for options are obtained from the Berkeley Options Data Base tapes. Corresponding transaction prices for the underlying stocks are obtained from the ISSM tapes.

[e] t-values in parentheses.

Table II

Leads and Lags Using Averages of Bid and Ask Prices

Parameter estimates from nonlinear system equations model of five-minute price changes of the average of bid-ask prices of 572 active[a] call options and 108 active put options on lagged, contemporaneous, and leading five-minute changes of the average of bid-ask prices of the underlying stocks during the period from January 2, 1986 through March 31, 1986.[b,c,d]

$$\Delta C'_{i,t} = \alpha_{i,t} + \sum_{k=-3}^{3} h_i \beta_k \Delta S'_{i,t+k} + \epsilon_{i,t} \quad \text{S.T.} \quad \sum_{k=-3}^{3} \beta_k = 1, \quad i = 1, 2, \ldots, 572 \quad \text{for call options}$$

$$\Delta P'_{i,t} = \alpha_{i,t} + \sum_{k=-3}^{3} h_i \beta_k \Delta S'_{i,t+k} + \epsilon_{i,t} \quad \text{S.T.} \quad \sum_{k=-3}^{3} \beta_k = 1, \quad i = 1, 2, \ldots, 108 \quad \text{for put options}$$

where $\Delta C'_{i,t}$ and $\Delta S'_{i,t}$ are the change in the average of bid-ask call prices and the change in the average of bid-ask prices for the underlying stock i from time $t-1$ to time t; $\Delta P'_{i,t}$ is the change in the average of bid-ask put prices from time $t-1$ to time t; h_i is the delta value, assumed constant throughout the day.

	Calls						Puts					
	January '86		February '86		March '86		January '86		February '86		March '86	
No. of Observations	155 Option Days		211 Option Days		206 Option Days		43 Option Days		29 Option Days		36 Option Days	
β_2	0.0419	(4.70)[e]	0.0136	(1.31)	−0.0047	(−0.55)	0.015	(0.96)	0.075	(4.39)	−0.024	(−1.15)
β_1	0.1408	(16.88)	0.2751	(26.66)	0.1340	(17.30)	0.140	(9.49)	0.075	(4.32)	0.125	(6.62)
β_0	0.6804	(39.29)	0.7978	(37.19)	0.6471	(45.67)	0.696	(23.29)	0.575	(19.42)	0.804	(19.33)
β_{-1}	0.0934	(10.96)	−0.0347	(−3.18)	0.1890	(24.36)	0.132	(8.83)	0.093	(5.49)	0.144	(7.60)
β_{-2}	0.0224	(2.47)	−0.1076	(−8.95)	0.0301	(3.60)	−0.011	(−0.65)	0.046	(2.58)	0.026	(1.25)
β_{-3}	0.0242	(2.66)	0.0146	(1.41)	0.0055	(0.65)	0.107	(6.96)	0.078	(4.46)	−0.020	(−0.89)

[a] More than 144 transactions per day.

[b] We report results separately for each month because SAS cannot handle more than 250 system equations at the same time.

[c] Since the lead/lag coefficients, β_k, are always multiplied by h_i's, there is an indeterminacy that we resolve by normalizing the β's so that $\Sigma_{k=-3}^{3} \beta_k = 1$. We cannot, therefore, obtain the parameter estimate for β_3.

[d] Intraday bid and ask prices for options are obtained from the Berkeley Options Data Base tapes. Corresponding bid and ask prices for the underlying stocks are obtained from the ISSM tapes.

[e] t-values in parentheses.

Table III

Test of the Infrequent Trading Hypothesis

We test the infrequent trading hypothesis using the equations[a,b,c]

$$\Delta C_{i,t} = \alpha_{i,t} + \sum_{k=-3}^{3} h_i \beta_k \Delta S_{i,t+k} + \epsilon_{i,t} \quad \text{S.T.} \quad \sum_{k=-3}^{3} \beta_k = 1, \quad i = 1, 2, \ldots, 409$$

$$\Delta P_{i,t} = \alpha_{i,t} + \sum_{k=-3}^{3} h_i \beta_k \Delta S_{i,t+k} + \epsilon_{i,t} \quad \text{S.T.} \quad \sum_{k=-3}^{3} \beta_k = 1, \quad i = 1, 2, \ldots, 81$$

where $\Delta C_{i,t}$ and $\Delta S_{i,t}$ are the call price change and stock price change for underlying stock i from time $t-1$ to time t; h_i is the delta value, assumed constant throughout the day; $\Delta P_{i,t}$ is the put price change for underlying stock i from time $t-1$ to time t; the h_i is negative for put options. When the option price is below three dollars, the tick is 1/16; otherwise, it is 1/8. Hence, if option price < 3 and $h\Delta S < 1/16$, the value of the option will not generally change enough to cause any observable market price change. A similar relation holds when the tick is 1/8.

Panel A. Stratification of Active[d] Call Options Sample by Tick Requirements

Parameter Estimates	Option Price > 3[e] $\lvert h\Delta S\rvert > 0.125$[g] $N = 50$ Option Days		Option Price > 3[f] $\lvert h\Delta S\rvert < 0.125$ $N = 119$ Option Days		Option Price ≤ 3 $\lvert h\Delta S\rvert > 0.0625$ $N = 76$ Option Days		Option price ≤ 3 $\lvert h\Delta S\rvert < 0.0625$ $N = 164$ Option Days	
β_2	0.004	(0.21)[h]	−0.015	(−1.11)	0.052	(3.86)	0.036	(3.05)
β_1	0.070	(4.18)	0.088	(7.08)	0.035	(2.52)	0.060	(5.21)
β_0	0.749	(21.78)	0.452	(25.76)	0.596	(27.08)	0.434	(28.44)
β_{-1}	0.184	(11.43)	0.272	(20.49)	0.177	(14.43)	0.285	(23.87)
β_{-2}	−0.009	(−0.51)	0.142	(11.86)	0.088	(7.18)	0.136	(12.39)
β_{-3}	−0.027	(−1.53)	0.057	(4.61)	0.057	(4.62)	0.045	(3.96)

Table III—*Continued*

Panel B. Stratification of Active Put Options Sample by Tick Requirements

Parameter Estimates	Option Price > 3 $\lvert h\Delta S\rvert > 0.125$ N = 7 Option Days		Option Price > 3 $\lvert h\Delta S\rvert < 0.125$ N = 10 Option Days		Option Price ≤ 3 $\lvert h\Delta S\rvert > 0.0625$ N = 31 Option Days		Option price ≤ 3 $\lvert h\Delta S\rvert < 0.0625$ N = 33 Option Days	
β_2	0.010	(0.22)	0.019	(0.39)	0.055	(2.62)	−0.010	(−0.37)
β_1	0.059	(1.39)	0.143	(3.20)	0.037	(1.72)	0.076	(3.28)
β_0	0.532	(8.40)	0.489	(7.12)	0.615	(17.32)	0.435	(13.87)
β_{-1}	0.271	(6.29)	0.327	(6.18)	0.279	(12.88)	0.264	(11.06)
β_{-2}	0.187	(4.55)	0.077	(1.65)	0.051	(2.46)	0.121	(5.40)
β_{-3}	−0.058	(−1.21)	−0.031	(−0.60)	−0.025	(−1.09)	0.045	(1.92)

[a] Intraday transaction prices for options are obtained from the Berkeley Options Data Base tapes. For the underlying stock price series, we use the most recent stock price before a specific option transaction, as given by the Berkeley tapes.

[b] Since the lead/lag coefficients, β_k, are always multiplied by h_i's there is an indeterminacy that we resolve by normalizing the β's so that $\Sigma_{k=-3}^{3} \beta_k = 1$. We cannot, therefore, obtain the parameter estimate for β_3.

[c] The sample sizes here, 409 for calls and 81 for puts, are smaller than the sample sizes (572 for calls and 108 for puts) in Table I or Table II. We look only at the options whose prices are either always greater than \$3 or never go above \$3 throughout the day to definitively test the Infrequent Trading Hypothesis.

[d] More than 144 transactions per day.

[e] Sample of options whose prices are always greater than \$3 throughout the day.

[f] Sample of options whose prices never go above \$3 throughout the day.

[g] Following the Infrequent Trading Hypothesis, we use only nonzero ΔS_i's to calculate $\lvert h_i \Delta S_i\rvert$ for stock i.

[h] t-values in parentheses.

as might be expected with the Private Information Hypothesis. We look very hard for such an effect by stratifying on the basis of the option moneyness and by examining the most extreme cases, but, no matter what we try, we still find the stock leading the option. Perhaps trading on private information is rare, and is swamped by other types of trades. Alternatively, insiders may try to disguise their trades (Kyle (1985)) by trading in options that are not out of the money (Biais and Hillion (1990)).

We also stratify our results by the four-way classification discussed in Section I. Because the sample sizes are small, we cannot insist that $h\Delta S$ always be above or below 1/8 or 1/16, so we stratify based on the average value of $h\Delta S$. In addition, for the purpose of computing $h\Delta S$, we use only nonzero ΔS's.[3] We also drop a few observations with very low values for h.[4] The results are not materially affected. Panel A of Table III gives the results for calls. The Infrequent Trading Hypothesis predicts that the β_{-1}, β_{-2}, and β_{-3} coefficients should be smaller in columns 1 and 3 than in columns 2 and 4, respectively. That is in fact the case in five out of the six cases.[5] Furthermore, since the β's must add to 1, we might expect the β_0 values for columns 1 and 3 to be larger than in columns 2 and 4, and they are. We note, however, that these results are much weaker if we use the transaction stock price data from the ISSM File. This is probably not surprising as the corresponding option prices may be stale due to less-frequent trading.[6] Hence, using the ISSM data will tend to give a stock lead even when $h\Delta S$ is large.

Since we use averages for $h\Delta S$ to stratify the sample, we are bound to have cases that are in fact misclassified. To correct for this, we impose a more stringent requirement by insisting that $h\Delta S$ on average be greater than *two* ticks. The results are much stronger. With this requirement, most of the noncontemporaneous coefficients become insignificant and the β_0 coefficients are very large. However, the sample sizes are quite small. Very similar results are obtained by stratifying the sample into deciles. For example, the β_0 coefficient for the calls with prices greater than three dollars is 0.832 for

[3] We drop the zero ΔS's because under the Infrequent Trading Hypothesis we do not expect any significant lead/lag pattern when the stock price does not change.

[4] We drop a few samples with hedge ratio (h_i) less than 0.1 to reduce potential statistical noise due to estimation errors. Recall that the h_i's are assumed constant throughout the day and estimated jointly with β_k.

[5] One might suspect that the explanatory power of the product ($h\Delta S$) may just come from the delta value (h) alone or the change in stock price (ΔS) alone. To investigate this possibility, we try a sequential stratification, first based on the delta value, then on the stock price change. We find that after controlling for the delta value, the stock's lead becomes gradually less significant as we move toward the larger stock price change quantiles. Therefore, we are assured that the explanatory power of the product does not come from only one of its components.

[6] As is noted in Stephan and Whaley (1990) regarding the choice of the stock price series, the ISSM stock price data are preferred if the frequency of trading for the option is the same as the stock. If the stock is more frequently traded than the option, however, the stock price data from the Berkeley tapes may be more appropriate.

the highest decile but only 0.223 for the lowest decile.[7] The results are much weaker for puts (see Panel B of Table III) than for calls, perhaps because the sample sizes are much smaller.

An obvious step to take is to relax the requirement, imposed by Stephan and Whaley and so far by us, that there be at least 144 option transactions for each option day. We can thereby increase our sample size, but at the cost of introducing noise from infrequent trading. We take this step for both puts and calls. We find that the infrequent trading problem is serious, but the results are qualitatively similar to those with the 144 transactions requirement.

If the tick story is valid, then positive autocorrelation in the stock prices should produce a stronger spurious lead. We look for such an effect using number of runs as a measure of autocorrelation, but are unable to detect it.

V. Summary

We find no evidence that trading on private information causes the options market to lead the stock market. Instead, we find that stocks lead options by fifteen minutes. This lead seems to be spurious, caused by the way stocks and options are traded. The relatively larger option tick causes option prices to appear to lag stock prices. We find that the stock lead vanishes when the tests are run with the average of the bid and ask instead of the transaction price. Thus, our results confirm those of Stephan and Whaley (1990), but also provide an explanation for the perplexing stock lead they discover.

[7] We also try stratifying on the basis of Δc instead of $h\Delta S$. We would expect smaller leads when the call price in fact changes. Again, as with $h\Delta S$, we cannot insist Δc is always changing and so must use some measure like average Δc. The results are qualitatively similar to the $h\Delta S$ results, but weaker. The relatively large call tick makes estimating Δc harder than estimating ΔS.

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