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Discordant Beliefs and Trading Activity In the Stock Options Market: Some Preliminary Empirical Evidence

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ABSTRACT

The economic interpretation of trading activity has assumed that trading activity is the result of differential beliefs among the market participants. As the belief structure becomes more diverse among the participants increased trading activity is required to achieve a new equilibrium position. This paper reports the results of an empirical investigation regarding the association between trading activity and three measures of discordance in the stock options market. The results generally support the notion of a link between discordance and trading volume.

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1.0 Introduction

The economic interpretation of trading volume in financial markets has been an intriguing topic for some time. Beaver [1968] first suggested that trading activity could be used to test investors' reactions to the release of public information. He argued that trading activity, in conjunction with price changes, reflects a lack of consensus regarding the interpretation of the information and the extent to which individual investor expectations change.

Since Beaver's research, some new insights as to the theoretical linkage between heterogeneity of beliefs and trading volume have been offered by Hirshleifer [1975], Verrecchia [1981], Hakannson, Kunkel, and Ohlsen [1982], and others. Morse [1980] offered some empirical evidence which supported the notion of a positive relationship between asymmetric information and trading volume.

In this paper empirical evidence is reported that is generally in support of a positive link between our proxy for heterogeneous beliefs and trading activity in the options market. Two types of measures are used to gauge the degree of discordance of investor beliefs regarding a key parameter which influences option value, the dispersion in the rate of return distribution of the underlying stock. It is reasoned that a greater (lesser) degree of variability in investor beliefs regarding the stock price return distribution will be associated with higher (lower) levels of trading volume in options of the underlying stock.

In Section 2.0 we summarize previous theoretical and empirical work that has sought to explain a linkage between discordant beliefs and trading activity. Section 3.0 is a brief description of the methods by which we measure discordant beliefs regarding the stock return dispersion parameter. Statistical tests are developed and performed in Section 4.0. The empirical results of these tests, using daily transactions data, are in support of the notion that a positive link exists between our measures of discordance and stock option trading activity. The results and implications of this research are summarized in Section 5.0.

2.0 Some Previous Work

Hirshleifer [1975] developed a theoretical relationship between discordant beliefs and speculative behavior. Given an initial state of general equilibrium and a subsequent information event, if all market participants agree in their revised expectations, then no trading will occur. Conversely, discordance among the market participants regarding their revised expectation leads to speculative pressure and trading occurs.

Morse [1980] set forth and tests a theory that asymmetric information leads to trading activity and monotonic changes in price. He reasoned that asymmetric information caused trading to occur because, "the greater the divergence between an investor's perception of the correct price and the actual price, the more the investor would want to trade."[1]

Morse recognized, of course, that the observed trading volume does not necessarily imply asymmetric information. He sought to solidify his argument by identifying another phenomenon that might be caused by asymmetric information, namely monotonic changes in price.[2] That is, to the extent that excess trading accompanied correlated residual returns, Morse inferred the existence of asymmetric information.[3] He acknowledged that neither trading volume nor correlated residuals were sufficient to infer asymmetric information, but he hoped that other confounding causes would tend to be neutralized in a large sample.

Verrecchia [1981] investigated the economic interpretation of observed trading activity and more fully developed the theoretical relationship between trading activity and discordant beliefs. He showed that zero trading volume was necessary and sufficient to infer "total consensus," or perfectly concordant beliefs. On the other hand, observation of positive trading activity does not necessarily mean discordant beliefs among investors. Since "total consensus" is a necessary but not sufficient condition for no trading to occur, inferences can be unambiguously drawn only when no volume reaction to information is observed.[4]

Verrecchia's work questions the relationship between discordant beliefs and trading activity assumed by previous research. In most previous empirical work, volume of trading has been taken more or less as a proxy for heterogeneous beliefs. Verrecchia's conclusions are contrary since he demonstrates that trading volume may result from conditions other than discordant beliefs. Hakannson, Kunkel, and Ohlsen [1982] rebut Verrecchia by demonstrating that no trading volume results from new information only if the endowed portfolios under the presignal beliefs are fully allocationally efficient and the market participants are identical or possess homogeneous information structures.

To investigate empirically the relationship between discordant beliefs and trading activity one must (1) observe the scheme of beliefs existant in the financial markets, (2) detect and measure the degree of heterogeneity, and (3) examine the relationship between that measure of heterogeneous beliefs and trading activity. We believe that observation of such a relationship may then be judged as unambiguous. As Verrecchia illustrated formally, one may not be able to draw unambiguous conclusions about discordance from observations of trading activity; but the reverse is not true. Observation of discordant beliefs accompanied by trading activity would allow an assessment of the inherent relationship between discordant beliefs, speculative pressure, and trading activity.

In order to approximate the scheme of beliefs prevailing in the financial markets, one needs a pricing model for the financial assets. The Black-Scholes [1973] Option Pricing Model represents one such model that enjoys considerable empirical support. In regard to research into the relationship between discordant beliefs and trading volume, the option pricing model has a feature which makes it particularly useful.

3.0 An Indirect Measure of Investor Assessments of Stock Price Variance

The Black-Scholes [1973] option pricing model is a closed form solution to a differential equation relating changes in the price of a call option to changes in price of the underlying stock. The five parameters needed to value the i^{th} call (C_{ijt}) on stock j at time t are:

T_{ij} = time to maturity, expressed as a fraction of a year, for the i^{th} call option;

R_{ft} = the risk free borrowing (and lending) rate, expressed in annual terms, in force during the life of the option;

X_{ij} = exercise price on the i^{th} call option, assumed constant or non-stochastic during the life of the option;

P_{jt} = price of the j^{th} stock at time t;

S^2 = instantaneous variance of the rate of return at time t;

These five parameters are inserted in the familiar Black-Scholes call pricing equation to arrive at C_{ijt}:

$$C_{ijt} = P_{jt}N(d_1) - X_{ij}e^{(-R_{ft}T_{ij})}N(d_2); \tag{1}$$

where N(•) is the cumulative standard normal probability density function evaluated at d_1 or d_2;

$$d_1 = \frac{\ln(P_{jt}/X_{ij}) + R_{ft} + S_j^2/2)T_{ij}}{S_j(T_{ij}{}^{1/2})}; \tag{2}$$

and $d_2 = d_1 - S_j(T_{ij}{}^{1/2})$. (3)

To value a call option with the Black-Scholes model, one needs the five parameters of the model. Four of the five parameters are observable while the fifth, the instantaneous variance of the rate of return on the underlying stock, is not observable, and thus it may be subject to differing beliefs. Since the call price, along with four of the parameters, is observable, the implied variance (standard deviation) can be computed. Three of the parameters are uniquely observable and, hence, are not subject to discordant beliefs. These three parameters are the time to maturity (T_{ij}), the current stock price (P_{jt}), and the exercise price (X_{ij}). One of the other two parameters, the riskless rate (R_{ft}), is not uniquely observable, but a widely accepted proxy exists in the Treasury Bill rate. Since the call price (C_{ijt}) is observable, the implied standard deviation of the rate of return (ISD) may then be found through iteration. From a strictly theoretical sense, S^2 is the only parameter of the model that is subject to differential beliefs among the market participants. In a practical sense, as long as we are willing to accept the T-Bill rate as a proxy for R_{ft}, then the process should lead to valid estimates of the instantaneous standard deviation.

Accordingly, if two investors disagree as to the instantaneous variance (standard deviation) on a particular security, they will disagree as to the appropriate price of an option on the stock. In a pure Black-Scholes world this discordance would not permit an equilibrium--no finite market clearing price would exist, since investors would demand infinite amounts of long (short) positions in the affected options. In reality, where demands are constrained by borrowing limits, margin requirements, etc., one would expect to see high trading volume and high spreads in bid-ask prices associated with discordant beliefs.

Alternatively, one could infer from evidence of different ISDs that the Black-Scholes model is misspecified. If this is true, of course, the ISDs themselves are not meaningful. We adopt the assumption throughout this paper that the model is correctly specified, and that divergent beliefs can still result in finite market-clearing prices due to external constraints on the volume of purchases.

4.0 Empirical Tests

As argued above, the implied standard deviation (IDS) from the Black-Scholes model reflects investor beliefs, and different simultaneous

ISD values for the <u>same stock</u> should represent divergence in beliefs. Also, if there exist discordant beliefs about the underlying asset's variance rate, bid-ask spreads should be relatively large.

Thus, the two measures of discordance used in this study are

(1) dispersion in the distribution of ISD's for the same stock at the same time, measured by both the sample standard deviation and the range; and

(2) the bid-ask spread for the option standardized by the closing price of the option.

The theoretical arguments linking trading volume and discordant beliefs are insufficiently rich to dictate a particular structure of the relationship. Consequently, we shall proceed initially with a simple linear relationship as shown in (4) below.

$$V_{jt} = a + b\,H_{jt} + e_{jt} \qquad (4)$$

where V_{jt} = the daily trading volume of a specific set of call options written on stock j at time t, and these vary by exercise price, maturity date, or both. V_{jt} is measured alternatively as the average of the n individual option trading volumes or simply the total of the volumes.

H_{jt} = a measure of the degree of discordance of beliefs about the underlying security. The metric for H_{jt} is (1) the standard deviation of the ISDs, (2) the range of the ISDs, or (3) the standardized bid-ask spread.

In order to gauge the relationship between heterogeneity of beliefs and trading volume, it was necessary to identify an information source containing prices and volumes for all options traded on a particular stock. We chose to use daily observations since a lower frequency such as monthly observations might dampen both price and volume movements. The requisite price and volume data was obtained from Rapidquote, a commercial financial data base of Rapidata, Inc.

Three stocks were chosen randomly from a list of stocks having at least five different call options listed on the Chicago Board Options Exchange (CBOE).[5] The stocks, ASA, AMF, and Digital Equipment (DEC), and the options are described in Table 1, below.

INSERT TABLE 1

The implied instantaneous variance (S_j^2) was estimated from the Black-Scholes model (1) by inserting the four non-variance parameters (R_{ft}, T_{ij}, X_{ij}, P_{jt}), plus the call price (C_{ijt}), then solving iteratively for S^2. The riskless rate of interest (R_{ft}) was the annual rate on 6-month T-bills quoted during the week of each daily observation. The time to maturity (T_{ij}) was the quotient of the number of days remaining to maturity divided by 365, and the exercise price (X_{ij}) was measured as the nominal striking price written in the original option agreement. None of the stocks experienced stock splits or stock dividends during the period, hence no adjustment was needed for X_{ij}.[6] The daily stock price (S_{jt}) and call price (C_{ijt}) were taken as the closing prices on each day. Descriptive statistics for the ISD's, bid-ask spreads, and volume data for each of the three firms are included in Table 2, below.

INSERT TABLE 2

The combined data included 398 ISDs for AMF, 626 for ASA, and 1015 for DEC.

A preliminary test of the hypothesis is to estimate equation (4) with discordance measured by the dispersion in the distribution of the ISD's. A similar equation linking the daily trading volume of a particular option to the associated standardized bid-ask spread is also estimated.[7] The results are reported in Table 3 below.

INSERT TABLE 3

For rejection of the null hypothesis on the regression coefficient in favor of the one-sided alternative, the significance levels are better than the .00001 level for ASA and DEC for all three discordance metrics. The results of AMF indicate a significant level of rejection for the null hypothesis of approximately $\alpha = .03$ when the range of ISD's is the measure of discordance. A significance level of .07 is obtained when the measure of discordance is the standard deviation of the ISD's. The results based on discordance measured by the standardized bid-ask spread have a significance level better than the .0005 level. These results support the research hypothesis that heterogeneity of beliefs regarding the variance of the return distribution are positively associated with trading activity.

To confirm these results we shall examine the relationship between H_{jt} (measured by the ISD's dispersion) and the trading volume in the underlying stocks. If discordant beliefs exist as to the stock return distributions, as evidenced by differing ISD's in the options market, then these discordant beliefs should also motivate trading in the underlying securities.

This is examined by estimating a model similar to (4).

$$VS_{jt} = a + b\ H_{jt} + e_{jt}, \qquad (5)$$

where VS_{jt} = total volume of shares traded on day t on the New York Stock Exchange for stock j. The results are in Table 4 below.

INSERT TABLE 4

For two of the three stocks, AMF and DEC, the regression coefficient linking trading activity of the stock to discordant beliefs is highly significant. The level of significance is better than the .001 level for all four regressions. In the third case, AMF, the regression coefficient is not significant.

It is to be expected that trading in the options will be related to trading in their underlying stocks. That is, events which cause trades in the stocks are apt to cause trades in the options, and this trading may be unrelated to discordance of beliefs. We first examine the relationship between V_{jt} and VS_{jt} for each stock by estimating equation (6).

$$V_{jt} = a + b\ VS_{jt} + e_{jt}. \qquad (6)$$

Results are in Table 5.

INSERT TABLE 5

The regression coefficient is highly significant for ASA and DEC but insignificant for AMF. For ASA and DEC there is a very strong relationship between the trading activity of the options and the trading activity in the underlying stock.

Finally, it is informative to see what portion of the variability in option trading volume is attributable to the heterogeneity measures, over and above the stock volume. That is, does H_{jt} still influence V_{jt} when we control for VS_{jt}? To determine this the following model is estimated.

$$V_{jt} = a + b\,H_{jt} + c\,VS_{jt} + e_{jt} \tag{7}$$

The results are reported in Table 6.

INSERT TABLE 6

For ASA the regression coefficients are significant for each of the discordant beliefs measures and the trading activity of the underlying stock. In addition, the regressions explain at least 50% of the variability in trading activity of the options of ASA.

The parameter estimates for DEC were similar to those for ASA. Interestingly, the results for AMF differ for the coefficient for VS_{jt}. These estimates are insignificant, while the estimates of the coefficient for H_{jt} are marginally significant.

Overall, for all three firms, the results of this analysis do support the notion that discordant beliefs regarding the variance of the return distribution are positively linked to trading activity. In addition, trading activity of the underlying stock is also positively linked to trading activity of the options for two of the three cases.

5.0 Conclusions and Summary

In this paper we have argued that the dispersion in ISD's obtained from the Black-Scholes model imply discordance of investor beliefs. In addition, the size of the bid-ask spread for call options implies the degree of discordance of beliefs. Using daily price and volume data for options of three stocks having multiple options listed on the CBOE, we have documented generally significant positive links between our measures of discordance and volume of trading in both the options and the underlying stocks.

Footnotes

[1] Morse [1980], p. 1131.

[2] This argument is a result of the work by Copeland [1976] dealing with sequential arrival of information.

[3] Correlated residuals are the empirical manifestation of monotonic price changes and are from the application of the market model.

[4] Verrecchia [1981], p. 274.

[5] The sample size is limited to three firms due to the cost of obtaining data from the commercial data base.

[6] The exercise price can change in the event of a split or stock dividend.

[7] The trading volume metric in this case is the natural logarithm of the daily trading volume for the option. Logarithms are used due to the large number of instances of zero trading volume.

TABLE 1
Description of Stocks and Options

AMF

Period: June 1, 1982 - July 31, 1982
Average Price: $15.00 Range: $12.25--16.75
Options: Exercise Prices = 10, 15, 20, 25 with call date November 1982;
Exercise Prices = 10, 15, 20, 25 with call date February 1983.

ASA

Period: July 1, 1982 - October 29, 1982
Average Price; $40.03 Range: $26.50--55.50
Options: Exercise Prices = 20, 25, ..., 60 with call date February 1983;
Exercise Prices = 30, 35, ..., 60 with call date of May 1983.

DEC

Period: July 1, 1982 - October 29, 1982
Average Price: $78.17 Range: $62.00--97.50
Options: Exercise Prices = 60, 65, ..., 95, 100, 110 with call date January 1983; Exercise Prices 85, 90, 95, 100, 110 with call date July 1983.

TABLE 2

Descriptive Statistics for Discordance Metrics and Trading Volume

Range of ISDs

	mean	low	high
AMF	.2297	.0450	.7450
ASA	.2845	.0050	.6850
DEC	.2095	.0100	.8000

Standard Deviation of ISDs

	mean	low	high
AMF	.0834	.0175	.2444
ASA	.1564	.0024	.2127
DEC	.0586	.0045	.1674

Standardized Bid-Ask Spread

	mean	low	high
AMF	.0986	.0000	.9123
ASA	.1292	.0000	1.0000
DEC	.1085	.0000	.6309

Total Daily Option Volume

	mean	low	high
AMF	51310	1200	96880
ASA	118600	2300	352200
DEC	371460	6100	2058600

TABLE 3
Regression Results: Option Volume as a Function of Measure of Discordance

ASA

H	$\hat{a}$	$\hat{b}$	SE($\hat{a}$)	SE($\hat{b}$)	t($\hat{a}$)	t($\hat{b}$)	r^2
Range of ISD's	-55603	453040	27363	67530	-2.03	6.709	.357
S.D. of ISD's	-70397	1208600	29698	181670	-2.37	6.653	.353
Bid-Ask Spread	5.2174	23.249	.1684	1.3207	30.982	17.604	.296

AMF

H	$\hat{a}$	$\hat{b}$	SE($\hat{a}$)	SE($\hat{b}$)	t($\hat{a}$)	t($\hat{b}$)	r^2
Range of ISDs	15180	157170	23835	84666	.638	1.856	.04
S.D. of ISD	18586	391930	25675	258900	.723	1.514	.027
Bid-Ask Spread	4.7046	5.0229	.19198	.96341	24.505	5.2137	.044

DEC

H	$\hat{a}$	$\hat{b}$	SE($\hat{a}$)	SE($\hat{b}$)	t($\hat{a}$)	t($\hat{b}$)	r^2
Range of ISDs	180050	913260	53556	197280	3.361	4.629	.205
S.D. of ISDs	135000	4037900	52376	703810	2.577	5.737	.284
Bid-Ask Spread	7.0316	9.3286	.14326	.98199	49.074	9.4997	.074

TABLE 4
Regression Model: Stock Volume as a Function of Measure of Discordance

ASA

H	$\hat{a}$	$\hat{b}$	$SE(\hat{a})$	$SE(\hat{b})$	$t(\hat{a})$	$t(\hat{b})$	r^2
Range of ISDs	305.92	1703.4	219.61	541.98	1.393	3.143	.109
S.D. of ISDs	177.87	5007.3	234.71	1435.7	.758	3.488	.131

DEC

H	$\hat{a}$	$\hat{b}$	$SE(\hat{a})$	$SE(\hat{b})$	$t(\hat{a})$	$t(\hat{b})$	r^2
Range of ISDs	3172.6	4107.6	301.58	1110.7	10.52	3.698	.142
S.D. of ISDs	2954.1	18432.0	299.59	4025.8	9.861	4.578	.202

AMF

H	$\hat{a}$	$\hat{b}$	$SE(\hat{a})$	$SE(\hat{b})$	$t(\hat{a})$	$t(\hat{b})$	r^2
Range of ISDs	655.5	116.91	90.748	322.35	7.223	.363	.002
S.D. of ISDs	640.10	506.27	97.011	978.24	6.598	.518	.003

TABLE 5

Regression Model: Option Volume as a Function of Stock Volume

	$\hat{a}$	$\hat{b}$	$SE(\hat{a})$	$SE(\hat{b})$	$t(\hat{a})$	$t(\hat{b})$	r^2
ASA	356370	86.338	153661	13.18	2.319	6.55	.353
DEC	-132290	124.89	66434	14.921	-1.991	8.370	.458
AMF	52560	-1.8313	24593	29.584	2.137	-.062	.000

TABLE 6

Regression Results: Option Volume as a Function of Discordance and Stock Volume

ASA

	Range of ISDs	S.D. of ISDs
a	-75315	-81613
b	343290	892820
c	64.433	63.058
SE(a)	23846	25999
SE(b)	61604	169960
SE(c)	11.923	12.265
t(a)	-3.158	-3.139
t(b)	5.573	5.253
t(c)	5.404	5.141
r^2	.529	.514

DEC

	Range of ISDs	S.D. of ISDs
a	-165240	-163680
b	466220	2174300
c	108.84	101.11
SE(a)	65055	63347
SE(b)	169280	646510
SE(c)	15.501	15.750
t(a)	-2.540	-2.584
t(b)	2.754	3.363
t(c)	7.023	6.419
r^2	.504	.524

AMF

	Range of ISDs	S.D. of ISDs
a	17796	21381
b	157640	394140
c	-3.990	-4.365
SE(a)	30673	31959
SE(b)	85245	260890
SE(c)	29.180	29.403
t(a)	.580	.669
t(b)	1.849	1.511
t(c)	.580	-.148
r^2	.041	.028

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