OPTIONS TRADING WHEN THE UNDERLYING MARKET IS NOT TRANSPARENT

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INTRODUCTION

One of the features of the London International Financial Futures and Options Exchange (LIFFE) is that, although it ranks in the top three in the world in terms of overall trading volume and its index futures and options are generally successful, the market for options on individual equities is thin. It has been suggested that this lack of liquidity arises because the market for the underlying shares is not transparent (large trades are not disclosed to the market until 90 minutes after the trade).[1] This delay in publication means that options market participants cannot be sure of observing the current stock price, and this reduces their participation in the options market. Participation in the options market may be further reduced if some spot market participants (those informed directly by the nontransparent trade) have an informational advantage over uninformed traders.

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[1]In this article, the term "transparency" is used to refer to the ability of investors to observe the current, or last trade, price. Other uses of the term relate to investors' ability to observe trade quantities and/or the identities of the parties to a trade.

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There is a lack of empirical evidence to support this argument, although it is often cited in regulatory discussion (e.g., Securities and Investments Board, 1994; Director General of Fair Trading, 1994; Hodson, 1994). Among the nonregulatory discussants, Barclay and Noll (1992) found that greater stock market transparency is associated with the success of derivative markets based on equities, while both Barclay (1994) and Raybould (1994) report the view of U.K. equity options traders that the lack of transparency in the spot market is a significant deterrent to effective equity options trading.

This article examines whether equity trades whose publication is delayed have a different effect on options market volume than equity trades with no delay in publication. It is found that the level of options trading does not increase around the time of large nontransparent equity trades, suggesting that the equity options market is not used for hedging and that the information asymmetries are not exploited in the options market.

The first section of this article briefly describes the requisite features of the equity and equity options markets in the United Kingdom and the various hypotheses tested in this article. The data used to test these hypotheses are described in the second section. The effects of large equity trades whose publication is delayed on various types of options volume are examined in sections three and four using daily and intraday data. The last section presents the conclusions.

MARKET MICROSTRUCTURE

This section briefly describes the aspects of the equity and equity options markets in London which are relevant to this study.

Equity

The U.K. equity market is an almost pure quote driven (or dealer) system in which registered market makers each quote bid and ask prices[2] at which they are prepared to trade. The highest bid and lowest ask prices are known as the touch, and the market makers offering these prices appear on the "yellow strip" of the screen display. Market makers' quotes are binding up to the quote size, which is usually the stock's "normal

[2]For each traded stock a number of firms may register as market makers. (There are few formal entry costs to market making and firms do enter and leave.) The obligation of a market maker is to provide continuous two-way quotes and to actively trade with all comers. For the largest stocks, such as those examined here, there are typically 15–20 market makers quoting competitively against each other. To encourage participation, market makers have a number of privileges including exemption from Stamp Duty.

market size" (NMS).[3] Trades above the quoted size are at negotiated prices. Indeed, trades at below the quoted size may also be negotiated, and a large proportion of trades takes place at prices which are inside the currently quoted prices (Board and Sutcliffe, 1995b). The feature of the London Stock Exchange which is of principal interest to this study is that, although all trades must be reported to the Exchange within three minutes of the trade taking place, the Exchange automatically delays the publication of large trades (defined as those of three times NMS or larger) by 90 minutes (see Board and Sutcliffe, 1996[4]). The effects of various transparency regimes on the equity market are examined extensively in Board and Sutcliffe (1995a), who also summarized the theoretical literature in this area.

Options

The market for equity options in the United Kingdom is organized as an open outcry market (i.e., order driven). However, because volumes are typically low in most options, LIFFE introduced a system of competitive market makers in options.[5] These market makers are obliged to provide continuous, but nonbinding, quotes at all times. Given the large number of options series, and the obligation to quote in all series, LIFFE introduced an automatic quote generation system, Autoquote, which uses a binomial option pricing model to generate quotes for all traded series. These automatic quotes are at the maximum spread permitted by LIFFE. Equity options market makers (OMMs) may base their quotes on the Autoquote values, or adopt their own. In addition, the quote immediately preceding a trade may differ from the trade price either because the finally agreed trade price is indeed away from the quote, or because the final quote is not recorded. As a result, any analysis of options market quotes or spreads may be misleading. This article does not attempt to examine the impact of equity market activity on options market quotes.

Connections between Spot Transparency and the Equity Options Market

In a competitive market, equity market makers (*EMMs*) may use the traded options market for two principal reasons: to hedge the inventory

[3]The NMS for each stock is essentially 2.5% of the average daily volume over the last year. Thus, other things equal, liquid stocks have NMS values of 50,000 shares or more. Illiquid stocks, as defined by the Exchange, have NMS values of 2000 or less.

[4]Since this study was completed, the size threshold has been raised to six times NMS, and the period of delay has been reduced to 60 minutes.

[5]In this article, the term "options market" should be taken as applying to the market for options on individual stocks.

risk of a large equity trade, and, if a large equity trade contains information, to trade advantageously in the options market as well as the stock market (Director General of Fair Trading, 1990).[6] Board and Sutcliffe (1995b) and Gemmill (1996) have shown that the occurrence of a large equity trade does have information content, with large trades being followed by changes in the share price of about 0.2% before the publication of the trade. Given this asymmetry, traders in the options market who do not have access to information about large equity trades will be disadvantaged, and will tend to lose whenever they trade with *EMMs* who are either hedging or taking speculative positions after a large equity trade.

THE EFFECTS OF DIFFERENT TYPES OF EQUITY TRADE

The effects of equity trades on options volume are classified in three ways—trade direction (buy or sell), trade type (between *EMMs* or between an *EMM* and a customer), and trade size—each of which may give rise to different types of options trade.

There will be two effects of the sale of an equity by a customer to an *EMM*. First, the *EMM's* inventory will rise, leading to the need to hedge the increased inventory. Second, to the extent that the customer's trade reveals information, the *EMM* could make information-based trades in the options market.[7] Either of these would lead to increased buying of put options or writing of calls, both being profitable should the stock price fall. In the case of a customer purchase, there may be an increase in the number of bought calls or written puts. This is called the *trade direction hypothesis* in that it predicts different patterns of options trading, depending on the trade direction.

A significant proportion (about a quarter by value in the sample) of trading on the London Stock Exchange is between *EMMs* as they reallocate inventory amongst themselves (i.e., a substitute for options hedging). As, by implication, these trades neither require hedging nor convey information, this suggests that inter-*EMM* trades are likely to lead to much less options market activity than corresponding customer trades. This is called the *trade type hypothesis* because it predicts that the effect of an equity trade on the options market varies with the type of trade.

[6]Of course, the information asymmetry in the latter motive applies both to the *EMM* and to the principal and their broker in the equity trade.

[7]This trading pattern could be intensified if the customer in possession of the bad news also enters the options market.

A different consequence of inter-*EMM* trading [and, in particular, of trades organized through the Inter-Dealer Broker (IDB)[8] systems] is that the prices of such trades tend to be closer to the mid-quote than the prices at which non-*EMM* participants trade (Board and Sutcliffe, 1995b). Since the type of trade is not revealed, an OMM would see that the last equity trade is at a different price to the penultimate trade, and would be unsure whether the most recent trade is motivated by information or just an inter-*EMM* trade. Therefore, at such times, OMMs face greater uncertainty, and may be reluctant to deal. This argument about greater uncertainty suggests that heavy inter-*EMM* trading may be associated with a decrease in options volume.

The larger the trade, the larger is the change in the inventory of the participating *EMM*. Thus, trades above 3 × NMS (which are subject to delayed publication) are more likely than small trades (which are transparent) to generate a desire to hedge inventory exposure in the options market. In addition, the information-asymmetry arguments above suggest that large (and nontransparent) trades are more likely to lead to a desire to trade options. Therefore, it is hypothesized that a large nontransparent equity trade is more likely to lead to options trading than is the same volume of trading in a number of small transparent trades. This is called the *transparency hypothesis* because the transparency of the equity trade determines the options market response.

It is possible that, since large equity trades are not published immediately, OMMs who suspect that a nontransparent trade has just occurred, but are uncertain as to its direction, might widen their spread (or otherwise withdraw from the market), thereby dampening any increase in actual options trading.

DATA

This study uses data on all the quotes and trades for a sample of 23 equity options traded on LIFFE between April 1992 and March 1994, together with data on all the quotes and trades in these 23 stocks on the London Stock Exchange over the same two-year period.[9] There are 78,466 options

[8]*EMMs* can trade with each other either directly through the normal equity market mechanisms or through one of the Inter-Dealer Broker (IDB) systems. The IDB systems are order driven and access to them is restricted to *EMMs*. Board and Sutcliffe (1995b) document that inter-*EMM* trades, and particularly those organized through the IDB systems, tend to be at narrower spreads than normal customer business.

[9]The sample companies are Allied Lyons, BAA, Barclays Bank, Boots, British Aerospace, British Gas, British Steel, BTR, Courtaulds, Forte, GEC, Glaxo, Guinness, Hanson, Hillsdown Holdings, Kingfisher, Rolls Royce, Sainsbury, Sears, Tarmac, Thorn EMI, Tomkins, and Vodafone. At the time of this study, equity options on about 70 stocks were traded. The 23 sample series were chosen, in consultation with LIFFE and the London Stock Exchange, to be representative of these options.

trades in the sample stocks during this period, corresponding to 3,286,131 million lots.[10] The equity trade data are drawn from an analysis of the 2,296,165 trades in the same stocks. Table I shows the number and breakdown of these trades, from which it can be seen that a very large proportion of customer trading (by value) is delayed.

Each of the stocks in the sample has both put and call options for three expiry months for each of a number of strike prices. The data show that 48% of trades and 53% of value are in the near (i.e., less than three months to expiry) contract. This suggests that trading in equity options is less concentrated in the near contract than is typically the case with equity index futures. Over the life of the contract, as the underlying stock price changes, new strike prices are added. Thus, the number of different options series available in any stock can become very large.[11] The data show that about 85% of trading is in the three series centered on the current stock price (i.e., in the nearest out-of-the-money, the at-the-money, and the nearest in-the-money options). The data also show that, both in terms of trade numbers and trading volume, the activity in call options is roughly twice that of put options.[12]

Since no information on either the identities or the trading capacities of the parties to each options trade is available, the direction of each trade was inferred by comparing the price of the trade to the most recent bid and ask quotes for the series, and trades closer to the bid than the ask were treated as sales (and those closer to the ask as buys).[13] Of the 75,125 trades classified in this way, 50.5% are buyer initiated (representing 49.6% of the volume).

Options trading in all expirations and all strike prices for a given stock are treated as equivalent, and the total number of lots traded in each stock on each day across strikes and maturities is used. This total volume of options traded is disaggregated into four components: the vol-

[10]Options are traded in *lots* which correspond to 1000 shares. Volumes used in this paper are adjusted to allow for this.

[11]On LIFFE, options are always available in the five series around the current stock price. Older series remain available, and new ones outside this range may be created.

[12]There are 53,894 call option trades compared to 24,572 put trades, corresponding to volumes of 2,081,637 and 1,204,494, respectively.

[13]This approach allows approximately 90% of the trades to be classified. For the remaining 10% of trades executed at the mid-quote, a trade is classified as a buy if the price is higher than the previous trade price, and a sale if it is lower (Lee and Ready, 1991). For trades at the same price as the previous trade, the trade is regarded as being in the same direction as the previous trade (e.g., if a trade occurs at a price of 9.5 when the current bid–ask is 9–10 and the previous trade, which is classified as a sale, also occurs at 9.5, then the current trade is treated also as a sale). Note that the number of unclassified trades is quite large (4%) because of the number of different stock/maturity/strike series involved, and, as the classification rules are not applied across days, the first trade of each day cannot be classified if it occurs at the mid-quote. The subsequent analysis which requires the classification of options trades into buys and sells omits these unclassified trades.

TABLE I

Number and Value of Equity Trades and Delayed Publication

	Inter-EMM	*Customer*	*Total*
Number of trades			
Total	161,255	2,134,910	2,296,165
Over 3 NMS	12,964	53,882	66,846
% delayed	8.04	2.52	2.91
Value (£m)			
Total	38,888	104,569	143,457
Over 3 NMS	9,914	56,484	66,398
% delayed	25.49	54.02	46.28

umes of calls bought, calls sold, puts bought, and puts sold. In addition, because they represent alternative ways of responding to the same spot market situation, the total volume of bought calls and sold puts, and the total volume of sold calls plus bought puts are also examined.

OPTIONS VOLUME AND SPOT TRANSPARENCY: DAILY DATA

A number of previous studies have examined the relationship between the volume of options and stock trading, but none of these has looked for the effects of delayed equity publication. Anthony (1988) found that daily volume in U.S. options tends to lead spot volume by one day. A similar conclusion was reached for Amsterdam by Fase (1994). However, using 5 minute data for the United States, Stephan and Whaley (1990) found that spot volume leads options volume by 30 minutes. Finally, using U.S. data for one-hour periods, Mayhew, Sarin, and Shastri (1995) discovered a synchronous positive correlation between volume in the spot and options markets.

Since this paper is concerned with the effect of equity trades whose publication is delayed on the volume of options trading, the explanatory variable of interest is the volume (measured by the number of shares) of equity trading in each stock. Equity volume is disaggregated in the three ways discussed in the previous section: whether the share deal is a buy or a sell[14]; whether the share deal is a customer or an inter-*EMM* trade;

[14]Whether an equity trade is a buy or a sell is given by the data for customer and inter-*EMM* trades which used an IDB system, and is determined using the mid-quote rule for inter-*EMM* trades that did not use an IDB system.

and whether the trade size of the share deal is under 3 × NMS (and published immediately), between 3 and 10 × NMS, between 10 and 35 × NMS, or above 35 × NMS.

Because options and equity trading are closely related, a strong correlation between equity and options volume should be expected. The principal issue is whether the relationship between the volumes in the two markets is affected by the composition of equity market trading. Of particular interest is whether options volume is greater when a given number of shares are traded in a small number of large (nontransparent) trades, rather than in a large number of small (transparent) trades—the transparency hypothesis.

To control for other influences on volume, the daily price volatility of the underlying asset is estimated using the Garman-Klass (1980) measure of volatility. In addition, dummy variables indicating whether the option is in the final week before its expiration, whether the date is within the last week of the Stock Exchange account, the day of the week, the month of the year, and the firm are also included.

The daily data contain some 12,000 observations (two years on each of 23 stocks) for each of the variables. Options trades for which the trade direction cannot be determined are omitted from the analysis. Two models are estimated, one based on the equity volume split using trade size and direction into eight variables [eq. (1)], and the other where equity volume is split into six variables using trade type and direction [eq. (2)][15]:

$$OpVol_t = \alpha + \sum_{v=1}^{4} \beta_v B_{vt} + \sum_{v=1}^{4} \gamma_v S_{vt} + \omega_1 \sigma_t^2 + \omega_2 Expiry_t + \omega_3 Account_t + \sum_{d=1}^{5} \delta_d Day_{dt} + \sum_{m=1}^{12} \mu_m Month_{mt} + \sum_{i=1}^{23} \phi_i Firm_{it} \quad (1)$$

[15]A similar analysis using equity market volume subdivided into 24 categories (e.g., buy and sell, customer, IDB, IMM, and four trade sizes) does not reveal any new insights and is, therefore, not reported.

$$OpVol_t = \alpha + \sum_{z=1}^{3} \beta_z B_{zt} + \sum_{z=1}^{3} \gamma_z S_{zt} + \omega_1 \sigma_t^2 + \omega_2 Expiry_t + \omega_3 Account_t + \sum_{d=1}^{5} \delta_d Day_{dt} + \sum_{m=1}^{5} \mu_m Month_{mt} + \sum_{i=1}^{23} \phi_i Firm_{it} \quad (2)$$

OpVol represents options volume; B_v and S_v indicate the daily volume (in thousands of shares) of bought and sold equity in size category *v*; and B_z and S_z show the daily volume (in thousands of shares) of bought and sold equity categorized by trade type z (customer, IDB, or IMM). IDB is an inter-*EMM* trade via an IDB system, and IMM is an inter-*EMM* trade conducted through the normal equity market mechanisms. Spot price volatility is σ^2, while *Expiry, Account, Day, Month,* and *Firm* are the relevant dummy variables. Equations (1) and (2) differ only in the subscripts on the *B* and *S* terms.

Analysis by Trade Size and Direction

Table II shows the six estimated equations (one per column) which result from fitting the model to explain each of the six different types of options volume using the eight categories of equity market volume. The table shows only the coefficients that are statistically significant at the 1% level. Those coefficients which are expected to be significant according to the trade direction hypothesis are shown in boldface. There are no systematic effects for the day of the week, month, end of the Stock Exchange account, or firm control variables. Those results therefore, are not reported.

The magnitudes of the coefficients in Table II generally provide support for the trade direction hypothesis that equity purchases are associated with the purchase of calls and the sale of puts. There is weaker support that equity sales are associated with the sale of calls and the purchase of puts. For small trades there is a symmetry in the coefficients for the combined strategies. Thus, the purchase of 1000 shares is associated with the purchase of calls on 87 shares (or the sale of puts on 87 shares, or a mixture of the two), and the sale of calls (or the purchase of puts) on 44 shares; while the sale of 1000 shares is associated with the sale of calls (or the purchase of puts) on 89 shares and the purchase of puts (or the sale of calls) on 43 shares.

TABLE II

Effects of Four Equity Trade Size Categories on Options Volume

		Dependent Variable					
Independent Variables	*Delayed*	*Buy Call*	*Sell Call*	*Buy Put*	*Sell Put*	*Buy Call + Sell Put*	*Sell Call + Buy Put*
Buy under 3 × NMS	No	**0.061**	0.027	0.018	**0.025**	**0.087**	0.044
Buy 3–10 × NMS	Yes	**0.019**	0.017	−0.007		**0.019**	
Buy 10–35 × NMS	Yes	**0.012**	0.013		**0.011**	**0.023**	
Buy over 35 × NMS	Yes	**−0.014**				**−0.020**	
Sell under 3 × NMS	No	0.019	**0.071**	**0.019**	0.024	0.043	**0.089**
Sell 3–10 × NMS	Yes			**0.016**			
Sell 10–35 × NMS	Yes		**−0.012**				**−0.014**
Sell over 35 × NMS	Yes						
Expiry		59.625	62.464	18.658		73.298	81.120
Volatility		0.015		0.021		0.019	0.021
R^2		0.129	0.132	0.071	0.073	0.152	0.163

Table II also shows that days with heavy equity trading through small, immediately published trades are associated with heavier options trading than are days with similar volumes, but in fewer, larger trades. This supports the transparency hypothesis. When trading is composed of large individual trades of over three NMS (and, therefore, subject to delayed publication) the effects on options volume, although still significant, are much smaller in magnitude. These positive coefficients are smaller (usually by over 50%) than those of equivalent volumes dealt in blocks of less than 3 × NMS. For example, if shares are purchased as part of a trade under 3 × NMS, there is an increase in call purchases that is 5 times larger than if these shares are purchased as part of a trade of 10–35 × NMS, while the increase in the volume of put option sales is doubled. This leads to a difference in the combined volume of calls and puts of almost four times. For some larger trade sizes, a few of the coefficients become negative, implying that large equity trades are associated with reductions in options trading.

The indication in Table II that options volume tends to be more strongly related to equity trades that are published immediately than to trades with delayed publication is consistent with the arrival of public information leading to both small- and medium-sized equity trades, and also to trading in the options market. The absence of a strong association between options volume and the volume of equity trades subject to de-

TABLE III

Effects of Three Equity Trade Type Categories on Options Volume

Independent Variables	*Buy Calls*	*Sell Calls*	*Buy Puts*	*Sell Puts*	*Buy Call + Sell Put*	*Sell Call + Buy Put*
Bought IDB	**0.053**	0.056		**0.040**	**0.093**	0.069
Bought IMM	**0.056**	0.033		**0.021**	**0.076**	0.039
Bought customer	**0.014**	0.008			**0.017**	0.009
Sold IDB		**0.052**	**0.025**	0.036	0.046	**0.077**
Sold IMM	0.060	**0.051**	**0.049**	0.021	0.080	**0.100**
Sold customer	−0.011				−0.010	
Expiry	59.667	61.522	18.595		73.088	80.116
Volatility	0.042	0.036	0.032	0.019	0.061	0.068
R^2	0.122	0.114	0.072	0.069	0.143	0.149

layed publication suggests both that *EMMs* do not use options for hedging large equity trades and that informed equity market participants do not exploit their information in the options market.

In almost all cases, the call option effects are larger than the put option effects, with coefficients up to three times larger. This is consistent with the earlier finding that call volume is roughly double put volume, indicating that traders strongly prefer using calls to puts. Of the control variables, equity market volatility and options volume are positively related, and options volume increases sharply in the last week before option expiration.

Analysis by Trade Type and Direction

Table III shows the results of a similar regression analysis in which a distinction is made between types of trade (customer, IDB, or IMM) rather than by size of trade. Inter-*EMM* volume is disaggregated into IDB and IMM to allow for a possible difference in the response of the options market to these two types of equity trade between *EMMs*. As in Table II, each of the six columns represents a separate regression, and the boldface coefficients are those which are expected to be significant according to the trade direction hypothesis.

The effects are much less clear than when volume is disaggregated by trade size, rather than trade type. Table III shows that inter-*EMM* trades do not conform with the trade direction hypothesis. For example, the purchase of shares leads to roughly equal numbers of calls being

bought and sold. It also conflicts with the trade type hypothesis in that inter-*EMM* trades give rise to much more options trading than do customer trades. The results in support of the trade direction hypothesis for customer trades are also weak for equity buys, and absent for customer sells.

As before, volatility and options expiration have significant positive effects on options volume. Examination of the significance of the other control variables reveals some suggestion of reduced options volume on Fridays.

Since both the information and hedging motives for options trading are induced by an original customer trade in the equity market, the finding that customer equity trading is associated with less options market activity than inter-*EMM* trading suggests that *EMMs* do not use the equity options market for either hedging or information trading related to customer trades.

Using daily data, Tables II and III suggest a positive linkage between the volume of transparent equity trading and the volume of put and call options bought and sold. However, contrary to the transparency hypothesis, there is no clear association between the volume of equity trades subject to delayed publication and options volume. There is no evidence of *EMMs* (or others) hedging their large (nontransparent) trades in the options market. Nor is there any evidence of the parties to an equity trade whose publication is delayed trying to exploit this information asymmetry in the options market. There is support for the trade direction hypothesis, but no support for the trade type hypothesis that options trading is linked with customer trades, rather than inter-*EMM* trades.

OPTIONS VOLUME AND SPOT TRANSPARENCY: INTRADAY DATA

It is possible that the effects of spot trades on the options market are short lived, and that higher frequency data are required to detect a significant effect. Therefore, the analysis of the previous section is repeated using data for 30-minute periods. The trading day is divided into 15 half-hourly sections beginning at 08:35 and ending at 16:05. Trading volume is aggregated within each interval.[16] Equity activity outside these times is ignored. Thus, there are 23 options series, each measured 15 times per day for two trading years, giving 162,390 observations in all. Transactions

[16]Trades between 16:05 and 16:10, the end of the LIFFE trading session, are treated as if they occur before 16:05 (i.e., the last interval is actually 35 minutes in length).

data are missing for a small number of days during the sample period, and these days are omitted. LIFFE does not keep a record of the time of day, price, and volume of each options trade, and so LIFFE reconstructed this information from the underlying data.

Table IV shows that in over 80% of the 30-minute periods, there is no options trading. Because the market is open during these periods, the volume is treated as zero rather than missing. This does not mean that the traded options market recorded no volume for the greater part of the sample period; simply that at any time, many series did not trade. In a study of U.S. options using one-hour intervals, Mayhew et al. (1995) found that there were no options trades in about half of the intervals. Even so, this large number of intervals with no options trade makes separate analysis of bought and sold puts and calls impracticable. Results, therefore, are presented only for the buy call/sell put, and sell call/buy put combinations.

As each large trade is unpublished for 90 minutes (i.e., three trading intervals) after the trade occurs, the volume of currently hidden trades from the two previous 30-minute periods for each of the three nontransparent size categories is included in the regression model. In each case buy and sell transactions are included separately. As before, the regression equations include a number of control variables to allow for other possible influences on options volume. These external effects are volatility, expiration (the last five days of trading in the option), Stock Exchange account (the last five trading days), the month of the year, the day of the week, the firm, and the time of day.

$$OpVol_t = \alpha + \sum_{v=1}^{4} \beta_{iv} BI_{vt} + \sum_{v=1}^{4} \gamma_{iv} SI_{vt} + \sum_{v=2}^{4} \beta_{hv} BH_{vt} + \sum_{v=2}^{4} \gamma_{hv} SH_{vt} + \omega_1 \sigma_t^2 + \omega_2 Expiry_t + \omega_3 Account_t + \sum_{k=1}^{15} \tau_k Period_{kt} + \sum_{d=1}^{5} \delta_d Day_{dt} + \sum_{m=1}^{12} \mu_m Month_{mt} + \sum_{j=1}^{23} \phi_j Firm_{it} \quad (3)$$

BI_{tv} and SI_{tv} represent the volume of shares bought (or sold) in size category v during the current 30-minute period, while BH_{vt} and SH_{vt} are the volume of shares bought (or sold) in size category v during the preceding two time periods which are currently hidden. The dummy variables now include *Period*, which represents the time of day. The results of fitting this model with 14 volume variables are summarized in Table V, where

TABLE IV

Trade Intervals

	Total Intervals	*Intervals with Trades*	*% with Trades*
Calls bought	162,390	19,907	12.26
Calls sold	162,390	17,860	11.00
Puts bought	162,390	8,941	5.51
Puts sold	162,390	10,481	6.45
Calls bought + puts sold	162,390	26,712	16.45
Calls sold + puts bought	162,390	24,265	14.94

TABLE V

Intraday Effects of Different-Sized Equity Trades on Options Volume

Independent Variables	*Buy Call/Sell Put*	*Sell Call/Buy Put*
Equity buys below 3 × NMS	**0.064**	0.028
Equity buys 3 — 10 × NMS	**0.020**	0.007
Equity buys 10 — 35 × NMS	**0.007**	
Equity buys over 35 × NMS		
Equity sells below 3 × NMS	0.020	**0.051**
Equity sells 3 — 10 × NMS		**0.009**
Equity sells 10 — 35 × NMS	0.005	
Equity sells over 35 × NMS	0.002	
Hidden equity buys 3 — 10 × NMS	**0.004**	0.003
Hidden equity buys 10 — 35 × NMS	**0.003**	
Hidden equity buys over 35 × NMS		
Hidden equity sells 3 — 10 × NMS		
Hidden equity sells 10 — 35 × NMS		
Hidden equity sells over 35 × NMS		
Volatility	0.003	0.004
Expiry	13.92	18.03
R^2	0.029	0.025

only coefficients significant at the 1% level are reported. Each of the two columns represents a separate regression, and the boldface coefficients highlight those which are expected to be significant according to the trade direction hypothesis.

In general, the results for the intraday model are consistent with those of the daily model. The volume of small transparent equity market trading has a significant positive effect on options volume. As predicted by the trade direction hypothesis, transparent equity buys have a larger positive effect on the buy call/sell put combination than do transparent

equity sales, while the reverse is true for the sell call/buy put combination. Nontransparent (or hidden) sells, which take place within the current 30-minute period, have a very small positive effect on buy call/sell put volume and sell call/buy put volume. Similarly, hidden equity buys which take place between 30 and 90 minutes ago have a very small positive influence on both buy call/sell put volume and sell call/buy put volume. Hidden sells appear to have no effect on options volume. This supports the earlier conclusion on the transparency hypothesis that equity market traders do not exploit their information concerning a large nontransparent trade in the options market.

In both equations options volume rises when the option is close to expiry, while equity volatility has a positive effect on options volume. The end of the Stock Exchange account has no effect on options volume, while the other control variables (month, day of week, time of day, and firm) have no consistent effects.

A number of other factors were examined using the intraday data. First, because equity market participants may know that a large equity trade is about to occur[17] and may seek to use this information in the options market, pretrade effects were allowed for by defining trades as hidden if they occur in the 90 minutes before, or in the 90 minutes after, the period in which the trade is actually executed. Neither the significance nor the size of the coefficients is different from that which is reported in Table V, suggesting that pretrade information does not affect options market activity. To examine the sensitivity of the model to the definition of the nontransparency variables, for each trade size and direction, the volume of hidden trades was aggregated across the current and two preceding time periods. This produces results very similar to those reported in Table V. Similarly, when all trades subject to delayed publication are placed in a single category, rather than allocated to three size bands, the effects of nontransparent equity buys and sells are smaller than those reported in Table V, but the pattern of coefficients is similar. Finally, when those intervals with zero options trading are omitted and the equations in Table V are reestimated, although the R^2 of the regressions and the size of the coefficients increase, the pattern of significant coefficients is the same as in the analysis of the full sample. These results suggest that the conclusions drawn from Table V are reasonably robust.

[17]In particular, the United Kingdom has a class of trade (so-called protected trades) in which the trade is agreed upon, but not executed until later in the day (when the *EMM* concerned may offer a price improvement to the customer). These trades are not identifiable from the data, but are thought to represent a significant proportion of large trades.

CONCLUSIONS

The relationship between options volume on LIFFE and the patterns of equity trading in the underlying stocks is analyzed at both a daily and intradaily level, with a primary focus on the effects of the equity market's transparency regime on the options market. This analysis can be seen as an example of a case where the same information asymmetries could be exploited in two or more related markets (another example is when the same stock is traded on two stock markets; Hasbrouck, 1995). Straightforward arguments suggest that both the hedging of large (nontransparent) trades and the exploitation of information asymmetries should increase options volume. The principal finding is that there is no clear association between the volume of equity trades subject to delayed publication and options volume. Complementary to this, it is found that *EMMs* do not exploit their information concerning large nontransparent equity trades in the options market.

At both the daily and intraday frequencies, there is a significant association between equity market activity and options volume. However, this association is primarily attributable to fully transparent equity market transactions (i.e., those at less than 3 × NMS). For equity market trades where publication is delayed, a much smaller effect is found. The intradaily analysis suggests that there are few measurable effects on options volume during the 90 minutes for which the publication of large equity trades is delayed. These results may be explained by the arrival of public information leading to both small- and medium-sized equity trades, and to trading in the options market. They appear inconsistent with both the use of traded options for hedging large equity trades and the exploitation of superior information by equity market participants. A third possibility is that, as a result of their privileges and the delayed publication regime, *EMMs* actually face no significant inventory risk, and so have no need to hedge in the options market. Finally, it may be that *EMMs* can hedge their risks in other ways than through equity options. For example, many *EMMs* make markets in a wide range of stocks, so that their portfolio will be well diversified with low unsystematic risk. The market risk of their inventory can then be hedged with index derivatives.

An alternative view of the results is that the lack of depth of the London equity options market hinders its effective use by *EMMs*. It is arguable, but untestable, that thinness is the cause of the reluctance of *EMMs* to use the options market, rather than the observed thinness being an effect of the lack of equity market transparency.

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