Option Prices, Takeover Announcements, and Stock Returns

Edward J. Podolski[a] , Cameron Truong[a] , and Madhu Veeraraghavan[a,b]

[a] Department of Accounting and Finance, Monash University, Clayton Campus, Melbourne, Australia
[b] Centre Associate, Australian Centre for Financial Studies, Melbourne, Australia

Preliminary draft: Please do not quote or cite without permission. Comments welcome.

Abstract

This study examines the price discovery role of the options market around takeover announcements, as well as the underlying takeover factors which drive the information content of option prices. We find that options listing enhance information incorporation into stock prices in the lead up to a public takeover announcement. Additionally, we report that options prices contain incremental information over the stock market around takeovers, and that liquid options are incrementally more informative. Most significantly, we find that option prices are more informative when the informational transparency between targets and acquirers is reduced.

JEL Classification: G14, G30, G34
Keywords: Takeovers, Informed trading, Market efficiency, Stock return predictability

We thank Sugato Chakravarty, David Yermack, Ben Jacobsen, Christine Brown, Binh Do and George Tanewski for providing comments on an earlier draft of this paper. The usual caveats apply.

I. Introduction

This study contributes to the body of literature on the informational role of options markets. We specifically addresses, two related issues in the context of takeover announcements: do information leakages affect information incorporation into option prices, and does the options market enhance the informational efficiency of stock prices? Two competing theories exist on how availability of private information affects the information content of security prices. Models of competitive insider trading with no regulation (Holden and Subrahmanyam, 1992, 1994), argue that securities are more informative when more people have access to private information. In contrast, models of insider trading under regulation (DeMarzo, Hanen and Fishman, 1998; Acharya and Fishman, 2010), posit that due to higher probability of detection, insider trading is limited in such environments. In testing the validity of these two competing theories, we provide evidence on whether the current anti-insider trading regulatory regime, deters insiders from trading in the options market.[1] Our examination of the implications that options listing has on the price discovery process of stock markers, empirically tests the theoretical propositions of Back (1993) and Easley, O'Hara and Srinivas (1998), that options transmit valuable information to the stock market.

Our main findings can be summarized as follows. Firstly, we find that option listing enhances the informational efficiency of equity prices in the lead up to a takeover announcement. We therefore conclude that options play an important role in the price discovery process. Secondly, consistent with prior literature, we find that option prices of target stocks contain incremental information over the stock market before takeover announcements. More significantly, we find that option prices are more informative when when more private information pertaining to the takeover spills into the market.[2] This finding

[1] If we find that models of competitive insider trading are more accurate in explaining the informational efficiency of option prices than models of insider trading under regulation, then we can conclude that the current regulatory regime does little in achieving its desired goal of eradicating insider trading.

[2] Our proxy for information leakage before the takeover is made public, is the level of information asymmetry between the merging parties. This approach is consistent with the work of Acharya and Fishman (2010).

suggests that consistent with the competitive insider trading models, option prices are more informative when more people have access to private information.[3] The current regulatory regime is therefore unsuccessful in discouraging insider trading. In their entirety, our study shows that the way that firms engage in the takeover negotiation process has implications for the informational efficiency of financial markets.

We conduct our empirical examination around takeover announcements, because the trading environment before these events is expected to be highly informative, and dominated by insiders.[4] Takeover announcements are associated with higher abnormal returns relative to other corporate events, and therefore likely to entice a larger number of insiders to trade on their private information. For instance, target stock prices increase by an average of 30% upon takeover announcements,[5] compared to an average abnormal return of 5.5% for earnings announcements (Frazzini and Lamont, 2007; Wysocki, 2000). Consistent with this intuition, Meulbroek (1992) reports that about 80% of the insider trading cases prosecuted by the Securities and Exchange Commission (SEC) during 1980-1989 are takeover related.

Another differentiating aspect of the pre-announcement informational environment of takeovers is that despite being major corporate events, they are not planned and even the fact that such an announcement is pending is not publicly known. As a result most abnormal trading activity in the pre-announcement period is highly informative. In contrast, with pre-scheduled earnings announcements, certain firms are known to have a history of consistently beating analyst forecasts and hence some traders make speculative bets, even if they have no superior information. The literature shows that non-informed trading makes up a large portion of trading activity prior to earnings announcements (see Hong and Stein, 2006; Chordia, Huh and Subrahmanyam, 2007; and Sarkar and Schwartz, 2009 amongst

[3] This finding seems almost axiomatic. Nonetheless, models of optimal insider trading under regulations argue that more informed trading will not occur during times of high information leakages.

[4] In the first research question, we define "insiders" as any individual who possesses non-public information. The trading activity of all "insiders", however, does not have to be illegal. For example some insiders may obtain private information from superior forecasting models, or through rumours.

[5] Jensen and Ruback (1983), Jarrell, Brickley, and Netter (1988), Amdrade, Mitchell and Stafford (2001), Holmstrom and Kaplan (2001), and Betton, Eckbo and Thorburn (2008).

others). The pre-announcement period around takeovers is therefore considerably more informative relative to other corporate events, and therefore most appropriate for examining drivers of informed trading.[6]

We concentrate on the information content of option prices rather than stock prices, because the literature has shown that most informed trading takes part in the options market (Finucane, 1999, Lee and Yi 2001, Chakravarty, Gulen and Mayhew, 2004; and Pan and Poteshman, 2006), especially before takeover announcements (Cao, Chen and Griffin, 2005).[7] Back (1993) and Mayhew, Sarin and Shastri (1995) justify this observation on the basis that lower transaction costs, greater leverage and the ability to trade on future direction of volatility makes the options market the preferred venue for informed trading. Similarly, Diamond and Verrecchia (1987) argue that options offer informed investors a cheaper and less constrained method of synthetically short selling stocks.[8] Additionally, insiders acting on their private information in the options market are less likely to be prosecuted by the SEC (Dolgopolov, 2010), making it the preferred venue of insider trading.

Understanding both the price discovery function of options markets and the takeover factors which influence the information content of option prices is primarily of interest to policy makers. Regulators are charged with ensuring that financial markets are informationally efficient for a number of reasons. First, a firm's share price may act as a signal in directing production decisions within the firm (Leland, 1992). Second, greater share price efficiency may provide an incentive for firm's management to make better investment decisions. This is because more efficient prices better reflect the investment decisions that are being made (Fishman and Hagerty, 1989). Third, more efficient stock prices reduce the

[6] Hallett (2007) shows that message board takeover rumors generate significant positive abnormal returns and trading volumes. Their finding suggests that some information about an impending deal might be publicly known before the announcement date. Similarly, Jarrell and Poulsen (1989) show that rumors are responsible for the pre-announcement stock run-up. Nonetheless, it can be safely assumed that takeover announcements are anticipated to a much smaller extent than other types of announcements, such as earnings announcements.

[7] The literature shows that demand side pressures have a strong influence on option prices (Bollen and Whaley, 2004; Anand and Chakravarty, 2007), which implies that informed trading in the options market translates into informed option prices. Observing information content of option prices is therefore akin to observing the level of informed trading in options.

[8] Consistent with the theoretical literature Cao, Chen and Griffin (2005) and Pan and Poteshman (2006) find that informed investors do trade in the options market before trading in the stock market.

informational asymmetry between firms and prospective investors, thus limiting the distortions induced by adverse selection when firms raise external capital (Myers and Majluf, 1984). Understanding the factors which enhance informational efficiency allow policy makers to introduce regulations which are more likely to achieve their desired goals.

Our paper relates to several strands of the empirical literature. First, our analysis of the drivers of informed trading is related to the literature dealing with insider trading around takeover announcements. Agrawal and Jaffe (1995) examine whether the level of trading by top managers in takeover targets is abnormal during the sample period of 1941-1961. Agrawal and Nasser (2010) build on their study by utilizing a newer (1988-2008) dataset, and examining whether registered insiders pursue active or passive trading strategies in the lead up to the takeover announcement. The weakness of these papers, as well as similar studies by Harlow and Howe (1993) and Madison, Roth and Saporoschenko (2004), is that they concentrate only on registered insider trading in the equity market, which is unlikely to attract much insider/informed trading. We build on these studies by observing the trading behavior of informed traders in the more attractive options market.[9] Additionally, Jarrell and Poulsen (1989) show that registered insiders are responsible for only a small portion of informed trading around takeover announcements. We therefore do not restrict ourselves to an observation of the trading patterns of registered insiders, but rather look at the factors driving the incorporation of private information into options markets.

Second, our analysis of the drivers of information embedded in option prices around takeovers is connected to both the theoretical and empirical stream of literature dealing with the information content of option markets. The theoretical backbone for these papers is the Easley et al. (1998) model, which predicts an important role for the volume of particular types of option trades. Consistent with this model, Chakravarty, Gulen and Mayhew (2004), Cao, Chen and Griffin (2005), Pan and Poteshman (2006), and Roll, Schwartz and

[9] Options offer informed investors both legal and transactional advantages. Insiders are less likely to suffer criminal sanctions for trading on private information in the options market, as well as options offer lower transaction costs and greater leverage from the stock market.

Subrahmanyam (2010) find that option trading contains information about the future direction of the underlying stock price. Bollen and Whaley (2004) and Garleanu, Pedersen and Poteshman (2009) show that demand side pressure is the predominant driver of option prices (and therefore informative options trading results in informative option prices). We extend the literature by examining how information content of option prices is affected by different takeover characteristics.

Third, our analysis of the price discovery role of options is related to the strand of literature dealing with the impact of options listing on the underlying stock. Manaster and Rendleman (1982) argue that options affect the manner in which stock prices adjust to the release of information, because they provide a preferred outlet for informed investors. Consistent with this hypothesis, the empirical papers of Jennings and Starks (1986), Skinner (1990), and Chern et al. (2008) show that optioned stocks react faster than non-optioned stocks to the information contained in earnings announcements and stock splits. Similarly, Chakravarty et al. (2004) find direct evidence of significant price discovery in options. We extend this literature, by exploring whether optioned stocks incorporate more private information relating to a takeover announcement compared with non-optioned stocks. Because takeover announcements are associated with a higher portion of informed trading than earnings announcements or stock splits (Keown and Pinkerton, 1981; Cao, Chen and Griffin, 2005), our study provides more dependable evidence on the impact that options have on the incorporation of private information into equity prices.

Our main contribution to the literature is twofold. First, we show that information asymmetry between merging parties, rather than expected profits, are the main driver of informed trading prior to takeover announcements. Although prior literature has shown that informed trading takes place before takeover announcements (Agrawal and Jaffe, 1995; Strasburg and Bray, 2009; and Bray, 2010), and that informed trading in options has implications for stock prices (Chakravarty, Gulen and Mayhew, 2004; Cao, Chen and Griffin, 2005), no study to date has shown what takeover factors contribute to information content of option prices (and, due to the price discovery role of option markets, also stock prices).

Second, we show that models of competitive insider trading are better in explaining the realities of insider trading in the options market relative to models of insider trading under regulation. Models of insider trading under regulation (DeMarzo, Hansen and Fishman, 1998; Acharya and Johnson, 2010) argue that when more people have access to private information they will trade less aggressively, as the risk of detection and prosecution rises in such environments. Conversely, models of competitive insider trading without regulation (Holden and Subrahmanyam, 1992; Holden and Subrahmanyam, 1994), argue that when more people have access to proprietary information, each trader will trade more aggressively. We show that informed traders appear to behave in accordance with competitive insider trader models. This finding is consistent with the view that the current regulatory regime is insufficient in deterring insiders from trading on their private information in the options market.

Our analysis is based on a sample of takeover announcements spanning the period January 1996 to December 2008. The recent dataset employed in this study is significant, considering that the legal and informational environment has changed drastically in the last two decades.[10] For instance, in the 1997 case of *US v O'Hagan*[11] the US Supreme Court recognized the 'misappropriation' principle.[12] As a result of this landmark case, a wider range of informed investors fall under the definition of illegal insiders. In addition, considerable progress has been made to the way that information is disseminated between market participants.[13]

[10] For example, Chakravarty, Gulen and Mayhew (2004) examine a sample of 60 stocks between 1988 and 1992, while Cao, Chen and Griffin (2005) look at 78 stocks between 1986-1994.
[11] 521 U.S. 642 (1997)
[12] Broadly defined, the misappropriation principle states that individuals are guilty of insider trading if they obtain private information without the consent of those to whom the information 'belongs'.
[13] According to World Bank Development Indicators internet usage amongst US citizens was below 10% in 1995, jumping to roughly 16% in 1996 and growing at an average rate of 14% per year to reach a high of 76% in 2008. The growth was the strongest between 1996 and 2002 averaging 25% a year.

II. Literature Review and Development of Hypotheses

A. Options and Price Discovery

The first question tackled by this study is: do options enhance the informational efficiency of stock prices? The seminal paper of Grossman and Stiglitz (1986) proposes the impossibility of informationally efficient markets. They argue that if the equilibrium stock price is fully revealing, then all information is revealed to uninformed traders creating no incentives for informed traders to engage in costly arbitrage. An equilibrium level of disequilibrium is proposed to overcome the apparent paradox. One criticism of the Grossman and Stiglitz (1980) model is that it does not allow for insiders who have access to private information for free.

The models of Kyle (1985), Holden and Subrahmanyam (1992), and Foster and Viswanathan (1996) address the question of price efficiency with insider trading. Kyle (1985) develops a model in which a single privately informed trader with long-lived information optimally exploits his monopoly power over time. Kyle's (1985) main results are that the informed trader will trade in a gradual manner so that his information is incorporated into prices at a slow, almost linear rate, and as auctions are held continuously, the depth of the market is constant over time. In contrast, Holden's and Subrahmanyam's (1992) model involves numerous informed traders who compete with each other to retain their informational advantage. In their model, each trader tries to beat the other to the market, with the result that their information is revealed almost immediately. The Foster and Viswanathan (1996) model, which assumes heterogeneously informed traders strikes a middle ground, where informed traders not only compete with each other for trading profits, but also learn about other traders' signals from the observed order flows.

Insider trading off course is illegal. Section 10b of the Securities Exchange Act of 1934, and Securities and Exchange Commission (SEC) Rule 10b-5 make it a criminal offense for corporate insiders to trade on their private information in the equity market.

Indeed the empirical studies of Seyhun (1992), Agrawal and Jaffe, and Agrawal and Nasser (2010) find that insider trading is limited in equity markets, especially following the enactment of stronger enforcement mechanisms in the 1980's. Similarly, Chakravarty and McConnell (1999) show that insider trades do not move stock prices. In light of this evidence it would appear that the model of Grossman and Stiglitz (1980) should hold.

The equity market, however, is not the only market in which insiders can trade. A more appealing trading venue for insiders (and other informed traders) is the options market. The law relating to insider trading in options is considerably more lenient, with the practice only being a civil offence.[14] Additionally, options offer insiders greater leverage and lower transaction costs (Back, 1993; Mayhew, Sarin and Shastri, 1995). Consistent with this intuition, Manaster and Rendleman (1982) argue that if options are actually priced according to the Black and Scholes (1973) model, option prices enhance the informativeness of stock prices. The underlying assumption that the Black and Scholes (1973) model holds has subsequently been strongly attacked (see Figlewski, 1989). Nevertheless, the idea that options play an important role in price discovery has survived. Back (1993) shows that under certain conditions option prices signal incremental information to the equity market. Likewise, Easley, O'Hara and Srinivas (1998) argue that option trades have an important informational role, and show the linkage between stock and option markets in exchanging information. This strand of theoretical literature, therefore, suggests that prices of optioned stocks are more informative relative to their non-optioned counterparts.

Numerous empirical studies have examined the contribution of the options market to price discovery. Jennings and Starks (1986) find that prices of optioned stocks adjust more quickly to earnings announcements relative to non-optioned stocks. Damodaran and Lim (1991) show that after option introduction, there are significant increases in both the number of analysts who follow the stock and the number of articles that mention the stock published in *The Wall Street Journal*. Chakravarty, Gulen and Mayhew (2004) directly show that

[14] Insider Trading Sanctions Act of 1984.

option prices contribute 17% to price discovery. Finally, Chern, Tandon and Webb (2008) show that abnormal returns associated with stock splits are significantly lower for optioned compared with non-optioned firms.

Given the unique informational environment surrounding takeover announcements, we examine the price discovery role of the options marker around this important corporate event. The above discussion leads to the first hypothesis expressed in the alternative form:

Hypothesis 1 (H1). Options listing enhances the informational efficiency of stock prices.

A rejection of H1 could be driven by the options market being dominated by un-informed traders (De Long et al., 1990), or options simply not contributing to price discovery.

B. Information Content of Option Prices

The second question we tackle is: are option prices incrementally informative around takeover announcements, and what takeover factors affect the information content of options? Black and Scholes (1973) devise an option pricing model based on arbitrage-free assumptions, where the option contract is deemed redundant. Under arbitrage-free option pricing, the option can be combined with the underlying asset into a hedged position that is riskless for local changes in the asset's price and time and must therefore earn the riskless interest rate. This leads to a theoretical value for the option such that profitable arbitrage is ruled out. Under such option pricing approach, the option price is bound by a no arbitrage condition, and hence do not contain any incremental information above what is reflected in the stock price.

Bollen and Whaley (2004) argue that due to market incompleteness, option prices are not driven by no-arbitrage conditions, but rather by net buying pressure. They report that time variation in implied volatility of an option series is directly related to net buying pressure. Similarly, Garleanu, Pedersen and Poteshman (2009) document that demand helps explain the overall expensiveness and skew patterns of index options. These papers document that options trading is not redundant because the demand side pressure influences option prices. Consistent with this strand of literature, if informed investors choose to trade options rather than the underlying shares, then option prices can be incrementally informative.

A number of reasons have been put forward for why informed investors might prefer to disseminate their private information in the options market ahead of the stock market. Firstly, lower transaction costs and greater leverage may induce informed traders to trade options instead of the underlying asset (Black, 1975; Back, 1993; Mayhew, Sarin and Shastri, 1995). Secondly, investors who possess private information about the volatility of the underlying asset can only make their bet on volatility in the options market (Back, 1993). Consistent with the demand side approach to option pricing (Bollen and Whaley, 2004), these papers suggest that in incomplete markets option prices are non-redundant.

The models of Back (1993) and Easley et al. (1998) are of particular interest to our work. Back (1993) shows that in practice, it is not possible to replicate an option with the underlying stock and a risk-free asset. As a result, options are non-redundant and in asymmetric informational environments where option and stock volumes convey different information. Consistent with Back (1993), the empirical work of Finucane (1999), Lee and Yi (2001), Cao, Chen and Griffin (2005) and Anand and Chakravarty (2007) find that informed trading occurs in the options market. Cao, Chen and Griffin (2005) show that option volume is informative about future stock price changes around extreme informational events.

Easley et al.'s (1998) sequential trade model is particularly enlightening as to the impact informed trading can have on option prices. The model features uninformed liquidity traders who trade in both the equity market and the equity options market for exogenous reasons, and informed investors who must decide on their trading venue. Informed traders who are privy to positive signals can buy the stock, buy a call or sell a put. Alternatively, traders' privy to negative signals can sell the stock, buy a put or sell a call. As a result, positive or negative perceptions of future firm prospects are encapsulated in price changes.[15,16] Accordingly, if informed investors choose to trade in the options market ahead of the stock market, option prices will be more informative compared to stock prices as long as the market is in a "pooling equilibrium" in the sense that the informed traders trade in both the stock market and the options market.

When evaluating the impact that informed traders have on option prices, a relevant consideration is their trading behavior. The trading activity of informed traders is driven by the need to camouflage their transactions from detection by market makers and regulators.[17] Consistent with the stealth trading hypothesis, Lee and Yi (2001) and Anand and Chakravarty (2007) report that informed investors use small to medium trades in the options market to avoid detection. These findings suggest that despite the fact that options offer a greater level of anonymity compared with the stock market, the fear of detection is still a relevant factor for options traders. Within this stealth trading framework, the Easley et al. (1998) model predicts that informed traders will only be able to impact option prices if two conditions are met: (i) portion of informed trading in the options market is high, and (ii) liquidity in the options market is high. The conditions are intuitive - when the portion of informed trading in the options market is low, then the small to medium trades initiated by informed traders will be unable to move option prices sufficiently to make them informative.

[15] Buying a call or selling a put is a trade that both increases call prices relative to prices and that carries positive information about future stock prices. Thus within the model, increases in call implied volatility or deviations from put-call parity can predict subsequent returns on the underlying stock.

[16] Buying a call or selling a put can be a hedging transaction which does not possess any incremental information. Hedging transactions, however, are expected to occur uniformly through time, and therefore the informativeness of option prices should not be affected by such transactions.

[17] The preferred venue of trading for corporate insiders, who fall under the definition of informed investors, is largely driven by legal factors. Report of the Special Study of the Options Market to the Securities and Exchange Commission (December 1978) compares market surveillance practices across various option exchanges, as well as the New York Stock Exchange. The Report concludes that the market surveillance system of the Chicago Board Options Exchange is more complete than the New York Stock Exchange system. On the other hand, due to insider trading in options attracting only civil penalties, the SEC has pursued insiders in options markets with less vigor than it does in equities.

Additionally, low option liquidity makes detection by market makers and regulators easier,[18] thus making the option market a less favorable venue for trading on information.

In this study, we examine the informativeness of option prices around takeover announcements. Takeover announcements are one of the most economically significant events in the corporate landscape market, associated with substantial equity market consequences (Bradley et al., 1983; Jensen and Ruback, 1983). Unlike pre-scheduled earnings announcements, takeover announcements are not planned, with even the fact that such an announcement is pending not being publicly known. This is an important difference, because in the case of pre-scheduled earnings announcements, certain firms are known to have a history of consistently beating analyst forecasts and hence some traders make speculative bests, even if they have no superior information. In contrast, abnormal pre-takeover announcement trading is likely to be started by traders who possess material information (Cao, Chen and Griffin, 2005). Such events are therefore ideal for studying whether informed trading translates to informed option prices.

Specific characteristics pertaining to takeovers are expected to have a significant effect on the information content of option prices. Information leakages will be greater when the information asymmetry between the target and acquirer is more severe. This conjecture is based on the notion that greater information asymmetry results in reduced trust between merging parties (Fukuyama, 1995; Humphrey and Schmitz, 1996), thus requiring more resources to be dedicated into evaluating the acquiring or target company (Acharya and Johnson, 2010). As a consequence, the number of people with knowledge of the deal increases, escalating the possibility of any leakages of insider information occurring.[19] What is less clear is how a greater number of informed traders will affect option prices.

---

[18] Dolgopolov (2010) argues that market markets have a strong incentive to dedicate resources into detecting insider trading in the options market, because unlike in the spot market, losses to market makers in the options market stemming from the trading activity of corporate insiders are significant.

[19] See Rajan and Zingales (2001), and Zabojnik (2002), and Baccara and Razin (2003) for analyses of information leakage concern in situations in which the crucial information is leaked outside the firm through its employees or former employees.

Two competing hypotheses exist in the literature on this point. The first, based on models of insider trading under regulation (DeMarzo, Fishman, and Hagerty, 1998; Acharaya and Johnson, 2010), suggest that more insiders do not result in more insider trading as this would increase the likelihood of detection and punishment. These theorists therefore argue that prices will not be more informative when more people have knowledge of the takeover bid. The counter argument, based on models of competitive insider trading (Holden and Subrahmanyam, 1992; Holden and Subrahmanyam, 1994; and Baruch, 2002), is that when more people have access to private information each insider will trade more aggressively on this information in order to beat others to the market. Acharya and Johnson (2010), contrary to their theoretical model of optimal insider trading regulation but in support of the competitive insider trading models, find that more insiders result in more insider trading in equities.

We utilize two proxies of information asymmetry between the target and acquirer. The first proxy of information asymmetry is medium of exchange. Medium of exchange refers to whether the acquirer proposes to pay for the acquisition with cash or with stock. Paying for acquisitions with stock is equivalent to issuing new equity. Due to the inherent information asymmetry between firm managers and outside investors, equity issues send a negative signal to the market, and therefore are the least attractive method of raising capital (Mayers and Majluf, 1984).[20] Hansen (1987) and Fishman (1989), however, point out that due to information asymmetry between the merging parties, stock might be the preferred medium of exchange. Their argument is based on the notion that in all-cash offers the bidder bears the entire cost of any overpayment, since the payment is independent of the true value of the target ex post. On the other hand, an all-stock offer means that the bidder shares some of the target mispricing with the target.

[20] Additionally, according to Ross (1977) a firm can signal out a high-quality project through debt financing. This is because investors realize that the firm uses debt financing only if the probability of default is small and hence correctly infer this action as implying a high-quality project. Due to the positive signal that debt financed acquisitions send, this should be the preferred medium of exchange employed in takeovers.

Similarly, Eckbo, Giammarino and Heinkel (1990), show that bidder value is monotonically increasing and convex in the fraction of the total offer that consists of cash. The theoretical argument behind their model is that a high portion of cash consideration signals that the bidder is confident in creating synergy gains, whereas a high portion of the offer consisting of equity signals that the bidder is uncertain about any synergy gains. Consistent with these models, equity is more likely to be the preferred method of payment where information asymmetry is more prevalent.[21]

The relative size of target to the acquirer is another factor affecting the information asymmetry between merging firms. A comprehensive body of empirical evidence documents a negative relation between relative size of target to acquirer and target and bidder announcement day abnormal returns (Lang, Stulz and Walkling, 1991; Dong, Hirshleifer, Richardson and Teoh, 2006; Officer, 2007; Boone and Mulherin, 2007). Specifically, Bhagat, Dong, Hirshleifer and Noah (2005) examine the relation between relative size and a number of measures of value improvements in takeovers. They report a negative relation between relative size and each measure of value improvements. Officer (2007) and Bhagat, Dong, Hirshleifer and Noah (2005) argue that the lower abnormal returns reported for deals where the target is small relative to the acquirer, are due to the higher information asymmetry between merging parties in such deals.[22]

The above discussion leads to the next three hypotheses expressed in the alternative form:

[21] An alternative explanation of the choice of medium of exchange argues that managers are inefficiently disciplined by market forces and pursue actions that do not contribute to shareholder wealth, but instead increase firm size and enhance managerial compensation (Jensen, 1986; Shleifer and Vishny, 1989; and Jensen and Murphy, 1990). This argument suggests that an asset for equity sale could place a block of buyer equity in friendly hands strengthening the prospect that incumbent managers will maintain control. Slovin, Sushka and Polonchek (2005) find stronger evidence supporting the information asymmetry hypothesis rather than the alternative argument.

[22] Another potential proxy of informational transparency between target and acquirer could be whether the takeover was hostile or friendly. Schwert's (2000) argues that most deals described as hostile in the press are not distinguishable from friendly deals in economic terms, except that hostile transactions involve publicity as part of the bargaining process. Consistent with their argument we do not use the hostile/friendly classification as a proxy of information asymmetry. In any case, we believe that the method of exchange proxy would capture any information asymmetry brought on by a degree of hostility in the negotiation phase.

Hypothesis 2 (H2). Option prices are incrementally informative around takeover announcements.

Hypothesis 3 (H3). Option prices are incrementally more informative in liquid options relative to illiquid options.

Hypothesis 4 (H4). Option prices are incrementally more informative when information asymmetry between merging parties is large

A rejection of H2 could be driven by either an absence of informed trading generally, or informed trading occurring in the underlying stock in our sample period. This could imply that the Securities Exchange Commission is capable of detecting insider trading more easily in the option market as a result of many option contracts being thinly traded, or options being associated with higher proportional trading costs (Cao, Chen and Griffin, 2005). Alternatively, a rejection of H2 could be due to US security markets beings sufficiently complete, rendering option contracts redundant.

A rejection of H3 could be due to greater informed trading in the options market being accompanied by an equally large increase in uninformed noise traders. As a result, options with higher liquidity could have more noisy (and therefore less informative) prices than options with low liquidity (De Long et al., 1990).

A rejection of H4 would suggest that informed trading in options is strongly influenced by anti-insider trading regulations. Acharya and Johnson (2010) argue that the aggressiveness with which regulators pursue insiders increases with the level of insider trading. The implication of their model is that insider trading actually reduces with the number of people with private information, as the probability of being detected and prosecuted rises.

III. Sample Selection and Preliminaries

Our sample period is from January 1996 to December 2008. Options data are obtained from OptionMetrics which provides end-of-day bid and ask quotes, open interest, and volume on every call and put on individual stocks traded on a U.S. exchange.[23] OptionMetrics also computes implied volatilities for all listed options using the binomial tree model. We obtain takeover bid data for the period between January 1996 and December 2008 from the Security Data Corporation (SDC) database. SDC provides us with details of the announcement date, identity of the merging parties, the trading classification of the merging parties (public or private), total assets of the merging parties, the consideration offered, and the completion date of the deal. Daily stock prices, daily stock volumes and market returns data are obtained from the Centre for Research in Security Prices (CRSP). We only concentrate on stocks and stock options of takeover targets.

We include into our final sample, only those takeover bids where the target is publicly listed and has options listed on the Chicago Board of Option Exchange (CBOE). In line with the literature, we further exclude bids where the deal value is below $1 million, and the bid is for less than 90% of the ownership stake. Consistent with Schwert (1996), an announcement day is defined as the first day an official takeover bid is publicly announced. An official bid refers to either a merger or tender offer. To ensure that the announcements are original, we examine only target firms that had received no other offers in the previous year. Jarrell and Poulsen (1989) find that rumours in the news media about an impending bid, is the strongest explanatory variable in accounting for unanticipated premiums and pre-bid run-up. We exclude the possibility of rumours in the news media influencing our results by verifying the announcement date against the first newspaper article of the acquisition on the Factiva news retrieval service.

We use implied volatility as a direct proxy for options value rather than option prices, because implied volatility is a useful summary measure of option value that is independent of variations in the underlying stock price and other factors, such as time to maturity, interest

[23] Very often, we observe more than three million option observations per month.

rate, and strike price (Ang, Bali and Cakici, 2010; Truong and Corrado, 2010). Daily changes in implied volatility are therefore more likely than option prices to capture the arrival of new information.[24]

OptionMetrics computes the interpolated implied volatility surface separately for puts and calls. This is done using a kernel smoothing algorithm for at-the-money options with various maturities. For an option to be classified as at-the-money, the options ratio of the strike price to stock price is required to be between 0.95 and 1.05. Implied volatilities are calculated using binominal trees which allow for early exercise and dividends expected over the life of the option. The kernel smoothing approach calculates the daily implied volatility of a hypothetical stock option with 30 days left to maturity. We use daily implied volatility data for each stock option in our sample to calculate daily changes in implied volatilities. Daily changes in implied volatility for each stock on each day are calculated as follows:

(1) $$\Delta CIV_{i,t} = \frac{CIV_{i,t} - CIV_{i,t-1}}{CIV_{i,t-1}}$$

(2) $$\Delta PIV_{i,t} = \frac{PIV_{i,t} - PIV_{i,t-1}}{PIV_{i,t-1}}$$

where $CIV_{i,t}$ is the call implied volatility for firm *i* on day *t,* and $PIV_{i,t}$ is the put implied volatility for firm *i* on day *t.* $\Delta CIV_{i,t}$ and $\Delta PIV_{i,t}$ are changes in call and put implied volatilities for firm *i* on day *t,* respectively. In order to ensure that changes in implied volatility are not associated with market wide changes in the CBOE Market Volatility Index (VIX), we concentrate only on the component of change in option implied volatility that is independent of market-wide changes. We calculate the independent component of implied volatility as follows:

(3) $$\Delta ACIV_{i,t} = \Delta CIV_{i,t} - \Delta VIX_t$$

(4) $$\Delta APIV_{i,t} = \Delta PIV_{i,t} - \Delta VIX_t$$

[24] For example, changes in option prices could be due to changes in the underlying stock price or interest rate, while a change in implied volatility should only occur as a result of the arrival of new information.

where ΔVIX_t is daily change in the VIX index. $\Delta ACIV_{i,t}$ and $\Delta APIV_{i,t}$ are the independent component of daily changes in call and put implied volatilities for firm *i* on day *t*, respectively.

Following, Cao, Chen and Griffin (2005) we require that firms have at least 200 trading days of valid preannouncement stock price data. Our final sample consists of 3687 takeover targets of which 816 are optioned. Table 1 reports the sample selection criteria used in this study. Column 5 shows the original number of takeover bids obtained from the SDC database and falling within our selection criteria. Columns 6, 7 and 8 report the number of bids left after merging with the CRSP and OptionMetrics datasets. Our sample is tilted towards deals where stock is the main form of consideration.

[Insert Table 1 here]

Table 2 provides summary statistics of option volume, open interest, option implied volatility changes, share volume, number of trades and cumulative abnormal returns. For a given firm, we calculate the daily average of each variable over the benchmark [-200,-100], pre-announcement run-up [-30,-8], and immediate pre-announcement [-8,-1] periods. Numbers in parentheses refer to the number of days before the takeover announcement, where the takeover announcement is day 0. We then obtain the cross-sectional median of the variable across firms.

Table 2 shows that the average share trading volume increases between the benchmark and pre-announcement period from 277.3 million shares to 294.2 million shares. The share trading volume increase is more dramatic between the pre-announcement and immediate pre-announcement period, rising to 406,840 shares. This reflects an increase of 38%. A similar increase in option trading before the takeover announcement is also observed. On average there are 32 call option contracts traded per firm per day in the benchmark period. This increases to 79 in the run-up period and 183 immediately before the announcement. Each option contract corresponds to 100 underlying shares. Based on this convention ratio, the daily call volume is 1.15% of stock volume in the benchmark period, but increases to 4.50% of the daily stock volume immediately before the announcement. This suggests that the increase in call volume is greater than the corresponding increase in the underlying share (suggesting that more informed trading occurs in call options relative to the underlying stock).

Puts also experience an increase in trading volume in the lead up to takeover announcements (5 trades in the benchmark period, increasing to 10 in pre-announcement period and 20 in the immediate pre-announcement period). However, the increase in put trading volume is lower than the corresponding increase in call trading volume. This is consistent with the trend observed by Cao, Chen and Griffin (2005) that informed traders concentrate their trading on call options rather than put options before takeovers.

The results reported in Table 2 pertaining to call and put trading volume in the lead up to takeover announcements are presented in Figure 1. The figure shows the cross-sectional daily average of call and put trading volume over 100 days leading up to the takeover announcements. Call trading volume begins to increase substantially within 8 days of the takeover announcement. In contrast, the increase in put volume appears to occur much closer to the announcement, and is considerably more minor.

[Insert Figure 1 here]

In addition to average volume, changes in call and put implied volatilities in the three periods are also reported in Table 2. We first calculate the daily average of changes in call and put implied volatilities for each stock in each of the three periods. We then calculate the cross-sectional median across sample firms for each period. Changes in implied volatility measure the incorporation of new information into options market. We can see from Table 2 that implied volatility innovations are larger immediately before the takeover announcement compared with the benchmark period. The increase in average daily changes in implied volatility is 214% for calls and 143% for puts.

Finally, we also look at the cumulative abnormal returns (CAR) for each period. Abnormal returns are calculated as prediction errors from the market model regression of firm's continuously compounded stock returns on the continuously compounded return on the CRSP equally weighted index with dividends. Abnormal returns for each firm and day are calculated using the following specification:

(5) $$AR_{i,t} = r_{i,t} - (\alpha_i - \beta_i \times r_{m,t})$$

where $AR_{i,t}$ is the abnormal return for firm *i* on day *t*, $r_{i,t}$ is the raw continuously compounded return for firm *i* on day *t*, and $r_{m,t}$ is the continuously compounded return on the market index (CRSP equally weighted index with dividends) on day *t*. α_i and β_i parameters are calculated based on the market model, specified as:

(6) $$r_{i,t} = \alpha_i + \beta_i \times r_{m,t} + \varepsilon_{i,t} \ .$$

The market model estimation period includes event days -200 to -100.

We first aggregate abnormal returns for each firm in the benchmark, pre-announcement, and immediate pre-announcement periods. We then aggregate the abnormal returns in each of the three periods across firms. CARs are insignificantly different from zero in the benchmark period. In contrast they are statistically significant and positive in the two pre-announcement periods, although higher immediately prior to the announcement (5.67%) relative to the run-up period (2.51%). The average CAR for both periods is lower than the 12.9% reported in Cao, Chen and Griffin (2005), or 13.3% reported by Schwert (1996). Nonetheless, the positive CARs suggest that informed traders purchase target shares prior to the takeover announcements.

[Insert Table 2 here]

Figure 2 visually presents the daily changes in implied volatilities and abnormal returns over the 100 days leading up to the takeover announcement. Between 100 and 10 days before the takeover announcement implied volatilities for both calls and puts appear to be roughly equal. This is consistent with the put-call parity. In the 8 days leading up to the takeover announcement both call and put implied volatilities increase substantially. Call implied volatilities increase more than put implied volatilities, suggesting that the bulk of the informed trading occurs in calls. This is consistent with a sharper increase in call trading volume relative to put trading volume reported in Table 1 and Figure 1. Figure 2 also shows that abnormal returns increase by the largest amount in the 8 days leading to the takeover announcement. It is interesting to note, however, that the greatest increase in stock abnormal returns (around 3 days before the takeover announcement) occurs after a sharp increase in implied volatility has already occurred.

[Insert Figure 2 here]

Table 3 reports the cross-sectional average of announcement day abnormal returns. We can see from the table that optioned stocks are considerably less sensitive to the takeover announcement relative to non-optioned stocks. Optioned stocks response to the takeover announcement is 17% compared with 22% for non-optioned stocks. This suggests that options do enhance the informational efficiency of stock prices. Consistent with extant literature, we also see that cash deals, and deals between firms with a small relative size difference yield the highest abnormal returns.

The descriptive statistics discussed in this section lend support for the notion that options are incrementally informative, and that they enhance the price discovery process. In the next section we formally test whether options enhance price discover, whether options contain incremental information over stock prices, and whether the informativeness of option prices is determined by the information asymmetry of the merging parties.

IV. The Informativeness of Option and Stock Markets

A. Information Incorporation and Option Listing

First, we examine the price discovery role of the options market. We do this by observing whether takeover announcement abnormal returns are lower for optioned stocks compared with non-optioned stocks. If this is the case then we can conclude that private information is factored into stock prices faster for optioned firms, implying that options are non-redundant around takeover announcements. We measure announcement day abnormal returns as the cumulative abnormal returns over the two day announcement period including both the announcement day and the following day (days 0 and 1). In this analysis we employ a cross-sectional regression and utilise the following model:

(7) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3 Option_i} + \beta_4 D_i^{Cash} + \beta_5 D_i^{Diff} + \beta_6 D_i^{Auction} + \varepsilon_i$

where $\mathrm{CAR}[0,1]_\mathrm{i}$ is the 2-day cumulative abnormal return from day 0 to day 1, CAR[-30, -8] is the cumulative abnormal return from day -30 to day -8, and CAR [-8, -1] is the cumulative abnormal return from day -8 and -1. Day 0 is the announcement day. $Option_i$ is a dummy variable assigned the value of 1 if the target firm has options listed and 0 otherwise. $\mathrm{D}^{\mathrm{Cash}}$, $\mathrm{D}^{\mathrm{Diff}}$, and $\mathrm{D}^{\mathrm{Auction}}$ are dummy variables for whether the primary method of payment is cash, whether the relative size difference between the target and acquirer is large, and whether the takeover was through an auction or single-bidder negotiation. These three factors have been identified in the literature as key drivers of announcement day abnormal returns to shareholders of public targets (see Eckbo, 2009; Hansen, 2001).

A value of 1 is assigned to $\mathrm{D}^{\mathrm{Cash}}$ if more than 50% of the consideration offered is cash, and 0 otherwise. In terms of relative size difference, a value of 1 is assigned to $\mathrm{D}^{\mathrm{Diff}}$ if the size differential between the total assets of the bidding and target firm is large. Size differential is calculated by dividing total assets of the target firm by the acquiring firms' total assets. Target firms are then ranked by their relative size difference from largest to smallest, with those targets in the upper half of the ranked sample classified as 'large size differential'. A value of 1 is assigned to $\mathrm{D}^{\mathrm{Auction}}$ if the takeover bidding process involved an auction between numerous bidders.

We further test whether options listing leads to private information being incorporated into share prices faster, by utilising interaction terms into our model specification. We interact our option listing dummy with CAR[-30,-8] and CAR[-8,-1] in the following specification:

(8) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-4]_i + \beta_2 CAR[-4,-1]_i + \beta_3 Option_i + \boldsymbol{\beta_4 CAR[-30,-8]_i} \times \boldsymbol{Option_i} + \boldsymbol{\beta_5 CAR[-8,-1]_i} \times \boldsymbol{Option_i} + \beta_6 D_i^{Cash} + \beta_7 D_i^{Diff} + \beta_8 D_i^{Auction} + \varepsilon_i$

where variable definitions are the same as for Equation (7).

In Equation (7) the coefficient of interest is β_3 which measures the effect that options listing has on abnormal returns of the takeover target. If option listing enhances price discovery in equity markets, then we would expect β_3 to be negative and significant. Such a finding would suggest that more private information is introduced into optioned stocks prior to the takeover announcement and hence, the announcement conveys less information to the market. In Equation (8) the coefficients of interest are β_4 and β_5, which measure option listing influence on the incorporation of private information into share prices prior to the public announcement. If option listing increases the speed with which information is embedded into share prices, then we would expect β_4 and β_5 to be negative. Assuming that options increase the speed of information incorporation significantly, then β_4 should be more negative then β_5, implying that more information is entered into the stock market during the period [-30,-8] then in the period [-8,-1]..

Table 4 reports results for the models specified in Equations (7) and (8). The first specification (I) presents results based on the model in Equation (7), while the second specification (II) presents results based on the model specified in Equation (8). Regressions are based on a total of 3687 takeover announcements of publicly listed targets, of which 816 had optioned stocks. Consistent with our expectations, β_3 reported in Specification I is negative (-0.0259) and significant (t-stat of -3.08) at the 1% level. This means that announcement day returns of optioned targets are lower than those of non-optioned targets. This finding implies that for optioned stocks a larger portion of information relating to the takeover is factored into the share price prior to a public announcement being made.

The β_4 and β_5 coefficients reported in Specification II provide limited support for the notion that information is introduced into share prices faster when the underlying firm has options listed. We find that β_4 is negative (-0.0271) suggesting that the relation between CAR[0,1] and CAR[-30,-8] is stronger for optioned stocks. On the other hand β_5 is positive (0.0922) suggesting that the relation between CAR[0,1] and CAR[-8,-1] is weaker for optioned stocks. The negative β_4 coefficient and positive β_5 coefficient imply that optioned stocks incorporate the majority of private information over the -30 to -8 day period, with little information remaining to be introduced over the -8 to -1 day period. Although the interaction terms are not statistically significant, the directions of the coefficients are nonetheless informative.

The results in this section show strong support for hypothesis 1. This finding suggests that option trading is non-redundant around takeover announcements. In the next section we examine whether option prices are incrementally informative.

[Insert Table 4 here]

B. Option Implied Volatility Relation with Event-Day Returns

In this section we empirically test hypotheses 2 and 3 (H2 and H3). Towards this goal we first examine whether changes in option implied volatilities are related to abnormal returns on the announcement day, and whether this relation is greater for options with higher liquidity. Easley et al. (1998) conjecture that informed investors anticipating an increase in the underlying share price can either buy a call or sell a put. We therefore predict that if informed trading occurs in options before takeover announcements, then a positive relation between abnormal returns and changes in call implied volatilities will be observed (due to the increased demand side pressure), and a negative relation will be observed for changes in put implied volatilities (due to increased supply side pressure).

We test H2 by examining whether a relation exists between changes in option implied volatilities and CAR[0,1]. In this analysis we employ a cross-sectional regression and employ the following models:

(9) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3 \Delta ACIV_{i,[-8,-1]}} + \beta_5 D_i^{Cash} + \beta_6 D_i^{Diff} + \beta_7 D_i^{Auction} + \varepsilon_i$

(10) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3 \Delta APIV_{i,[-8,-1]}} + \beta_5 D_i^{Cash} + \beta_6 D_i^{Diff} + \beta_7 D_i^{Auction} + \varepsilon_i$

where $\Delta ACIV_{i,[-8,-1]}$ and $\Delta APIV_{i,[-8,-1]}$ are the changes in call and put implied volatilities (independent of changes in the VIX index) over the seven day period preceding the takeover announcement (between days -8 to -1).

Equation (9) measures the relation between CAR[0,1] and changes in call implied volatilities ($\Delta ACIV_{i,[-8,-1]}$), while Equation (10) measures the relation between CAR[0,1] and changes in put implied volatilities ($\Delta APIV_{i,[-8,-1]}$). The information content embedded in stocks before the announcement, is captured by β_1 and β_2. The coefficient of interest is β_3. If all private information is incorporated into the stock market then β_3 is expected to be 0. In contrast, a statistically significant β_3 would support H2, that options are informative before extreme informational events.

We test H3 by testing the effect that liquidity has on the relation between changes in implied volatilities and CAR[0,1]. We do this by adding interaction terms to the models specification in Equations (9) and (10):

(11) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3 \Delta ACIV_{i,[-8,-1]}} + \boldsymbol{\beta_4 \Delta ACIV_{i,[-8,-1]}} \times \boldsymbol{LIQ_i^{Call}} + \beta_5 D_i^{Cash} + \beta_6 I_i^{Diff} + \beta_7 I_i^{Auction} + \varepsilon_i$

(12) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3 \Delta APIV_{i,[-8,-1]}} + \boldsymbol{\beta_4 \Delta APIV_{i,[-8,-1]}} \times \boldsymbol{LIQ_i^{Put}} + \beta_5 D_i^{Cash} + \beta_6 I_i^{Diff} + \beta_7 I_i^{Auction} + \varepsilon_i$

where LIQ_i^{Call} and LIQ_i^{Put} refer to the relative liquidity of the target firms call and put options in the immediate pre-announcement period (days -8 to -1). LIQ_i^{Call} and LIQ_i^{Put} are dummy variables, assigned a value of 1 if the average relative option trading volume as a percentage of stock trading volume is above the cross-sectional median. Concentrating on relative liquidity rather than nominal liquidity is in the spirit of Easley et al. (1998), who argue that option prices will be most informative when stock liquidity is low and option liquidity is high.

Equation (11) measures the interaction between changes in call implied volatilities and liquidity, while Equation (12) measures the interaction between put implied volatilities and liquidity. The coefficients of interest are β_3 and β_4. β_3 can be interpreted as the relation between CAR[0,1] and option implied volatility when liquidity is small, while β_4 measures how this relation changes for high liquidity options (LIQ_i assigned a value of 1). The relation between CAR[0,1] and changes in option implied volatilities for high liquidity options is given by the sum of β_3 and β_4. We therefore expect that β_4 will be positive and significant. Additionally, we expect that $\beta_3 + \beta_4$ will be greater than β_3, implying that the information content of option contracts is higher for more liquid options.

Table 5 reports the regression results for models specified in Equations (9) to (12). Specification I of each Panel presents results for regressions testing H1 (Equations (9) and (10)). Specification II of each Panel presents results for regressions testing H2 (Equations (11) and (12)). Panel A examines the relation between changes in call implied volatilities and CAR[0,1], while Panel B examines the relation between changes in put implied volatilities and CAR[0,1]. Therefore, Specification I of Panel A shows regression results to Equation (9), Specification II of Panel A shows regression results to Equation (11) and so on.

We start by examining what our results say about H2 (Panel A Specification I, and Panel B Specification I). The β_3 coefficient in Specification I of Panel A is positive (0.0894), suggesting that call options in the immediate pre-announcement period contain incremental information about announcement day returns. This observation is consistent with H2 which states that private information about an impending takeover deal is factored into option prices. The positive coefficient is significant at the 5% significance level. β_1 and β_2 coefficients are negative (-0.0636 and -0.1865, respectively), however only β_2 is statistically significant. This finding suggests that the majority of private information gets impounded into the share price within 8 days of the takeover announcement. This is not surprising and consistent with other literature (Jarrell and Poulsen, 1989; Conrad and Niden, 1993; Chae, 2005; Graham, Koski, and Loewenstein, 2006). The fact that β_3 is statistically different from 0 after controlling for the stock price run-up (CAR[-30,-8] and CAR[-8,-1]) suggests that not all information is factored into stock prices, and that call options are not redundant instruments before takeover announcements.

We report that β_3 in Specification I of Panel B is positive (0.0892) but only significant at the 10% level. This suggests that less information about an impending takeover announcement is factored into put options relative to call options. Once again this is not a surprising finding given that takeover announcements are events that have a positive impact on the stock price of target firms, and therefore put options (which provide a positive payoff when share prices go down) are not attractive to informed investors.

We now examine what our results say about H3 (Specification II of Panel A, and Specification II of Panel B). We document that β_3 in Specification II of Panel A is -0.0296 and not statistically significant. This is lower than β_3 reported in Specification I (Panel A), suggesting that call options are less informative when liquidity is low. The interaction term captured by β_4 is strongly positive (0.2263) and significant at the 1% level. This finding means that the relation between changes in call implied volatilities and CAR[0,1] is stronger when liquidity is high. In fact, our results tell us that call options only contain incremental information above that reflected by stock prices when the option contract is liquid. This is consistent with H3.

β_3 in Specification II of Panel B is positive (0.0238) and not statistically significant. The interaction between put implied volatility change and liquidity (captured by β_4) is much more strongly positive (0.1232) but statistically insignificant. Although both β_3 and β_4 are insignificant we cannot conclude that liquidity has no influence on the informativeness of put options. The relation between changes in put implied volatility and CAR[0,1] for liquid options is given by the sum of β_3 and β_4. We therefore, perform the Wald test to test the null hypothesis that $\beta_3 + \beta_4 = 0$. The null hypothesis is rejected at the 1% level of significance. As a result we can conclude that liquid put options contain incremental information, although it seems that considerably less information is impounded into puts than calls.

[Insert Table 5 here]

C. Option Implied Volatility, Event-Day Returns and Deal Characterisitcs

In this section we empirically test H4. H4 states that option prices are more informative when the information asymmetry between target and acquirer is large. We use two proxies of information asymmetry between merging firms: method of payment and relative size difference. We start by conducting statistical analysis with the first proxy. Towards this goal we examine whether changes in implied volatilities are more strongly related with CAR[0,1] for deals where stock is the main consideration offered. We employing the following set of cross-sectional regression models:

(13) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3 \Delta ACIV_{i,[-8,-1]}} + \boldsymbol{\beta_4 \Delta ACIV_{i,[-8,-1]}} \times \boldsymbol{D_i^{Cash}} + \beta_5 D_i^{Cash} + \beta_6 D_i^{Diff} + \beta_7 D_i^{Auction} + \varepsilon_i$

(14) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3 \Delta APIV_{i,[-8,-1]}} + \boldsymbol{\beta_4 \Delta APIV_{i,[-8,-1]}} \times \boldsymbol{D_i^{Cash}} + \beta_5 D_i^{Cash} + \beta_6 D_i^{Diff} + \beta_7 D_i^{Auction} + \varepsilon_i$

where variable definitions are the same as for Equation (9) and (10). Equation (13) measures the effect that medium of exchange (script offer or cash offer) has on the relation between changes in call implied volatilities and CAR[0,1]. Equation (14) measures the effect that medium of exchange has on the relation between put implied volatilities and CAR[0,1].

The β_3 coefficient in Equations (13) and (14) measures the relation between implied volatilities and CAR[0,1] when the predominant method of payment is stock (D_i^{Cash} dummy assigned a value of 0), while β_4 captures how the relation changes when the predominant method of payment is cash. It is assumed in this study that when a stock offer is made the information asymmetry between the merging parties is greater, leading to more information being leaked into the market. We therefore expect that β_3 will be greater than $\beta_3 + \beta_4$ (β_4 will have the opposite sign to β_3).

Table 6 presents the regression results. Specification I of both Panels A and B present regression results to models specified in Equations (13) and (14). Results in Specification I of Panel A are based on Equation (13), while results in Specification I of Panel B are based on Equation (14). The β_3 coefficient in Panel A is positive (0.1022) and significant at the 10% level. In contrast, β_4 is negative (-0.0531), however not significant. Despite β_4 not being significant, the negative sign suggests that the relation between call implied volatility and CAR[0,1] is weaker for deals where consideration is predominantly cash. In order to see whether the informativeness of call options is greater for stock deals compared with cash deals, we employ the Wald test to test the null hypothesis that $\beta_3 + \beta_4 = 0$. Table 6 shows that the null hypothesis is not rejected even at the 10% level (F-statistic equal to 0.38). The fact that β_3 is positive and significant, while $\beta_3 + \beta_4$ is not statistically significant suggests that call option prices are more informative for predominantly stock deals compared with predominantly cash deals. This is consistent with H4.

Results reported in Specification I of Panel B report the effect that medium of exchange has on the relation between put implied volatility and CAR[0,1]. Results are very similar to those reported in Panel A. The β_3 coefficient is positive (0.1083) and significant at the 10% level, while the β_4 coefficient is negative (-0.0801) but insignificant. Once again, the Wald test does not reject the null hypothesis that $\beta_3 + \beta_4 = 0$, suggesting that put options contain more information in the lead up to script offers.

Next we use our second proxy measuring the information asymmetry between merging parties. Towards this goal we utilize the following two model specifications:

(15) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3} \Delta \boldsymbol{ACIV}_{\boldsymbol{i},[-\mathbf{8},-\mathbf{1}]} + \boldsymbol{\beta_4} \Delta \boldsymbol{ACIV}_{\boldsymbol{i},[-\mathbf{8},-\mathbf{1}]} \times \boldsymbol{D_i^{Diff}} + \beta_5 D_i^{Cash} + \beta_6 D_i^{Diff} + \beta_7 D_i^{Auction} + \varepsilon_i$

(16) $CAR[0,1]_i = \alpha + \beta_1 CAR[-30,-8]_i + \beta_2 CAR[-8,-1]_i + \boldsymbol{\beta_3} \Delta \boldsymbol{APIV}_{\boldsymbol{i},[-\mathbf{8},-\mathbf{1}]} + \boldsymbol{\beta_4} \Delta \boldsymbol{APIV}_{\boldsymbol{i},[-\mathbf{8},-\mathbf{1}]} \times \boldsymbol{D_i^{Diff}} + \beta_5 D_i^{Cash} + \beta_6 D_i^{Diff} + \beta_7 D_i^{Auction} + \varepsilon_i$.

where variable definitions are the same as for Equation (9) and (10). Equation (15) measures the effect that relative size differential has on the relation between changes in call implied volatilities and CAR[0,1]. Equation (16) measures the effect that relative size differential has on the relation between put implied volatilities and CAR[0,1].

β_3 and β_4 are once again the coefficients of interest. Consistent with H4, it is expected that option implied volatilities will be more informative for deals where the relative size difference of target and acquirer is large. This conjecture is consistent with the strand of literature arguing that information asymmetry between merging parties is positively related with relative size difference (Bhagat, Dong, Hirshleifer and Noah, 2005; Officer, 2007). β_3 measures the relation between implied volatility and CAR[0,1] for deals with a small relative difference, while β_4 captures how this relation changes when the relative size difference is large. Consistent with H4 we expect that $\beta_3 + \beta_4$ will be greater than β_3.

Table 6 present the regression results. Specification II of Panel A reports results based on Equation (15), while Specification II of Panel B reports results based on Equation (16). In Panel A, the β_3 coefficient is positive (0.0314) but not significant even at the 10% level. The interaction term (β_4) is positive (0.1447), and statistically significant at the 10% level. The positive and significant β_4 coefficient suggests that option implied volatilities are more informative for deals with a large size differential. To confirm this observation formally we perform the Wald test to test the null hypothesis that $\beta_3 + \beta_4 = 0$. The null hypothesis is strongly rejected at the 1% level, implying that call options are statistically related with CAR[0,1] when the relative size difference between target and acquirer is large. This is consistent with H4, as our results suggest that call options are more informative for those deals where size of the merging parties is large. Coefficients measuring the information content of put options (reported in Specification II of Panel B) are similar, only slightly weaker.

[Insert Table 6 here]

V. Conclusions

This paper provides a comprehensive analysis of the information role of option markets around takeover announcements. We document that options play an important price discovery function around takeover announcements, option prices are incrementally informative before takeovers, and that the level of information asymmetry between merging firms is responsible for the information content of option prices. Our results on the impact that takeover factors have on information incorporation are interesting in that they illustrate the self-balancing role of financial markets. – prices are most informative exactly when firm managers try to withhold this information from others.

References

Agrawal, Anup, Jeffrey Jaffe, and Gershon Mandelkler, 1992, The post-merger performance of acquisition firms: A re-examination of an anomaly, *Journal of Finance* 47, 1605-1621.

Anand, Amber, and Sugato Chakravarty, 2007, Stealth trading in options markets, *Journal of Financial and Quantitative Analysis* 42, 167-188.

Ang, Andrew, Turan Bali, and Nusret Cakici, 2010, The joint cross-section of stocks and options, *Working Paper.*

Back, Kerry, 1993, Asymmetric information and options, *Review of Financial Studies* 6, 435-472.

Baruch, Shmuel, 2002, Insider trading and risk aversion, *Journal of Financial Markets* 5, 451-464.

Bhagat, Sanjai, Ming Dong, David Hirshleifer, and Robert Noah, 2005, Do tender offers create value? New methods and evidence, *Journal of Financial Economics* 76, 3-60.

Black, Fisher, and Myron Scholes, 1973, The pricing of options and corporate liquidity, *Journal of Political Economy* 81, 637-654.

Bollen, Nicolas, and Robert Whaley, 2004, Does net buying pressure affect the shape of implied volatility functions, *Journal of Finance* 59, 711-753.

Boone, Audra, Harold Mulherin, 2007, How are firms sold?, *Journal of Finance* 62, 847-875.

Brown, David, and Michael Ryngaert, 1991, The mode of acquisition in takeovers: Taxes and asymmetric information, *Journal of Finance* 46, 653-669.

Chae, Joon, 2005, Trading volume, information asymmetry, and timing information, *Journal of Finance* 60, 413-442.

Cao, Charles, Zhiwu Chen, and John Griffin, 2005, Informational content of option volume prior to takeovers, *Journal of Business* 78, 1073-1109.

Carlton, Dennis, and Daniel Fischel, 1983, The Regulation of Insider Trading, *Stanford Law Review* 35, 857-895.

Chakravarty, Sugato, Huseyin Gulen, and Stewart Mayhew, 2004, Informed trading in stock and option markets, *Journal of Finance* 59, 1235-1257.

Chakravarty, Sugato, and John McConnell, 1999, Does insider trading really move stock prices? *Journal of Financial and Quantitative Analysis* 34, 191-209.

Chan, Kalok, Peter Chung, Wai-Ming Fong, 2002, The informational role of stock and option volume, *Review of Financial Studies* 15, 1049-1075.

Chern, Keh-Yiing, Kishore Tandon, Susana Yu, and Gwendolyn Webb, 2008, The information content of stock split announcements: Do options matter? *Journal of Banking and Finance* 32, 930-946.

Conrad, Jennifer, and Cathy Niden, 1993, Order flow, trading costs and corporate acquisition announcements, *Financial Management* 21, 22-31.

Cremers, Martijn, David Weinbaum, 2010, Deviations from put-call parity and stock return predictability, *Journal of Financial and Quantitative Analysis* 45, 335-367.

Damodaran, Aswath, Joseph Lim, 1991, The effect of options listing on the underlying stock's return processes, *Journal of Banking and Finance* 15, 647-664.

De Long, Bradford, Andrei Shleifer, Lawrence Summers, and Robert Waldmann, 1990, Noise trader risk in financial markets, *Journal of Political Economy* 98, 703-738.

Dennert, Jurgen, 1991, Insider Trading, *KYKLOS* 44, 181-202.

Diamond, Douglas, and Robert Verrecchia, 1987, Constraints on the short-selling and asset price adjustment to private information, *Journal of Financial Economics* 18, 277-311.

Dolgopolov, Stanislav, 2010, Risks and hedges of providing liquidity: The impact of insider trading on options market makes, *Fordham Journal of Corporate & Financial Law* 15, 387-438.

Dong, Ming, David Hirshleifer, Scott Richardson, Siew Hong Teoh, 2006, Does investor misevaluation drive the takeover market, *Journal of Finance* 61, 725-762.

Easley, David, Maureen O'Hara, and P.S. Srinivas, 1998, Option volume and stock prices: Evidence on where informed traders trade, *Journal of Finance* 53, 431-465.

Eckbo, Espen, 2009, Bidding strategies and takeover premiums: A review, *Journal of Corporate Finance* 15, 149-178.

Eckbo, Espen, Ron Giammarino, Robert Heinkel, 1990, Asymmetric information and the medium of exchange in takeovers: Theory and tests, *Review of Financial Studies* 3, 651-675.

Estrada, Javier, 1995, Insider trading: Regulations, securities markets and welfare under risk aversion, *Quarterly Review of Economics and Finance* 35, 421-445.

Figlewski, Stephen, 1989, Options arbitrage in imperfect markets, *Journal of Finance* 44, 1289-1311.

Finucane, Thomas, 1991, Put-Call parity and expected returns, *Journal of Financial and Quantitative Analysis* 26, 445-457.

Fishman, Martin, 1989, Preemptive bidding and the role of the medium of exchange in acquisitions, *Journal of Finance* 44, 41-57.

Fishman, Martin, Hagerty, Kathleen, 1992, Insider trading and the efficiency of stock prices, *Rand Journal of Economics* 23, 106-122.

Garleanu, Nicolae, Lasse Heje Pedersen, Allen Poteshman, 2009, Demand-based option pricing, *Review of Financial Studies* 22, 4259-4299.

Graham, John, Jennifer Koski, and Uri Loewenstein, 2006, Information flow and liquidity around anticipated and unanticipated dividend announcements, *Journal of Business* 79, 2301-2336.

Hallett, Aiden, 2007, The impact of electronic message board takeover rumours on the US equity market, *Working Paper.*

Hansen, Richard, 1987, A theory for the choice of exchange medium in mergers and acquisitions. *Journal of Business* 60, 75-95.

Holden, Craig, and Avanidhar Subrahmanyam, 1992, Long-lived private information and imperfect competition, *Journal of Finance* 47, 247-270.

Hyland, David, Sali Sarkar, Niranjan Tripathy, 2003, Insider trading when an underlying option is present, *Financial Analyst Journal* 59, 69-77.

Jarrel, Gregg, and Annette Poulsen, 1989, Stock trading before the announcement of tender offers: Insider trading or market anticipation?, *Journal of Law, Economics & Organizations* 5, 225-248.

Jennings, Robert, and Laura Starks, 1986, Earnings announcement, stock price adjustments and the existence of options markets, *Journal of Finance* 41, 107-125.

Keown, Arthur, and John Pinkerton, 1981, Merger announcements and insider trading activity: An empirical investigation, *Journal of Finance* 36, 855-869.

Meulbroek, Lisa, 1992, An empirical analysis of illegal insider trading, *Journal of Finance* 47, 1661-1699.

Kooli, Maher, Mohamed Kortas, Jean-Francois L'Her, 2003, A new examination of the private company discount, *Journal of Private Equity* 6, 48-55.

Lang, Larry, Rene Stultz, and Ralph Walkling, 1991, A test of the free cash flow hypothesis: The case of bidder returns, *Journal of Financial Economics* 29, 315-335.

Lee, Jason, Cheong Yi, 2001, Trade size and information-motivated trading in the options and stock markets, *Journal of Financial and Quantitative Analysis* 36, 485-501.

Manaster, Steven, and Richard Rendleman, 1982, Option prices as predictors of equilibrium stock prices, *Journal of Finance* 37, 1043-1057.

Mayhew, Stewart, Atulya Sarin, and Kaldeep Shastri, 1995, The allocation of informed trading across related markets: An analysis of the impact of changes in equity-option margin requirements, *Journal of Finance* 505, 1635-1654.

Myers, Stewart, and Nicholas Majluf, 1984, Corporate financing and investment decisions when firms have information that investors do not, *Journal of Financial Economics* 13, 187-221.

Ofek, Eli, and Mathew Richardson, 2003, DotCom Mania: The rise and fall of internet stock prices, *Journal of Finance* 58, 1113-1137.

Ofek, Eli, Matthew Richardson, Robert Whitelaw, 2004, Limited arbitrage and short sale restrictions: Evidence from the options market, *Journal of Financial Economics* 74, 305-342.

Officer, Micah, 2007, The price of corporate liquidity: Acquisition discounts for unlisted targets, *Journal of Financial Economics* 83, 571-598.

Pan, Jun, and Allen Poteshman, 2006, The information in option volume for future stock prices, *Review of Financial Studies* 19, 871-908.

Pan, Jun, and Allen Poteshman, 2008, Volatility information trading in the option market, *The Journal of Finance* 63, 1059-1091.

Roll, Richard, Eduardo Schwartz, and Avinidhar Subrahmanyam, 2010, O/S: The relative trading activity in options and stock, *Journal of Financial Economics* 96, 1-17.

Ross, Stephen, 1977, The determination of capital structure: The incentive signalling approach, *Bell Journal of Economics* 8, 23-40.

Sacksteder, Elizabeth, 1988, Securities regulation for a changing market: Option trader standing under rule 10b-5, *Yale Law Journal* 97, 623-643.

Schwert, William, 1996, Markup pricing in mergers and acquisitions, *Journal of Financial Economics* 41, 153-192.

Skinner, Douglas, 1990, Options markets and the informational content of accounting earnings releases, *Journal of Accounting and Economics* 13, 191-211.

Truong, Cameron, and Charles Corrado, 2010, Option trading volume and stock price response to earnings announcements, *Working Paper.*

Xing, Yuhang, Xiaoyan Zhang, Rui Zhao, 2009, What does individual option volatility smirks tell us about future equity returns? *Journal of Financial and Quantitative Analysis* 45, 641-662.

Figure 1

Call and Put Volume in the Lead-Up to the Takeover Announcement

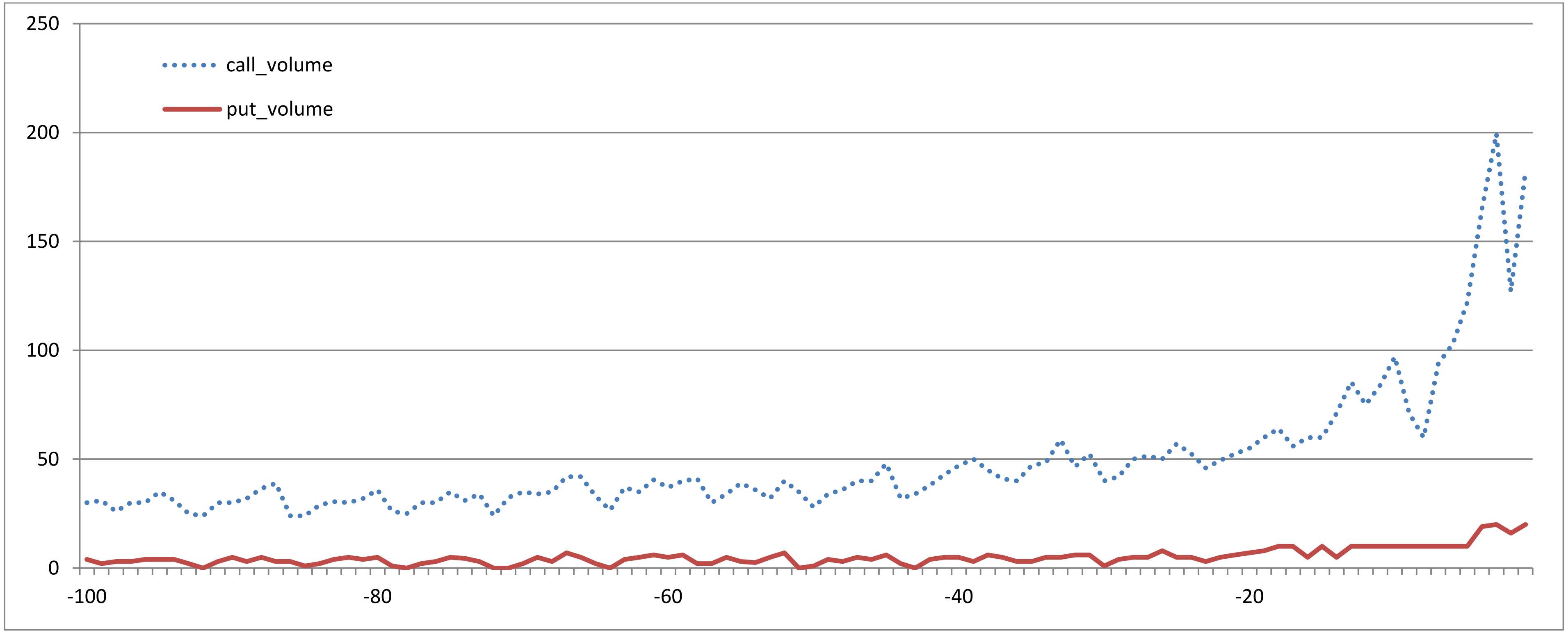

Figure 1 presents the daily call and put volume in the 100 days leading up to the takeover announcement. Daily volume data is obtained from OptionMetrics and is averaged across all options with underlying firms included in our takeover sample.

Figure 2

Percentage Changes in Option Implied Volatility and Abnormal Returns in the Lead-Up to a Takeover Announcement

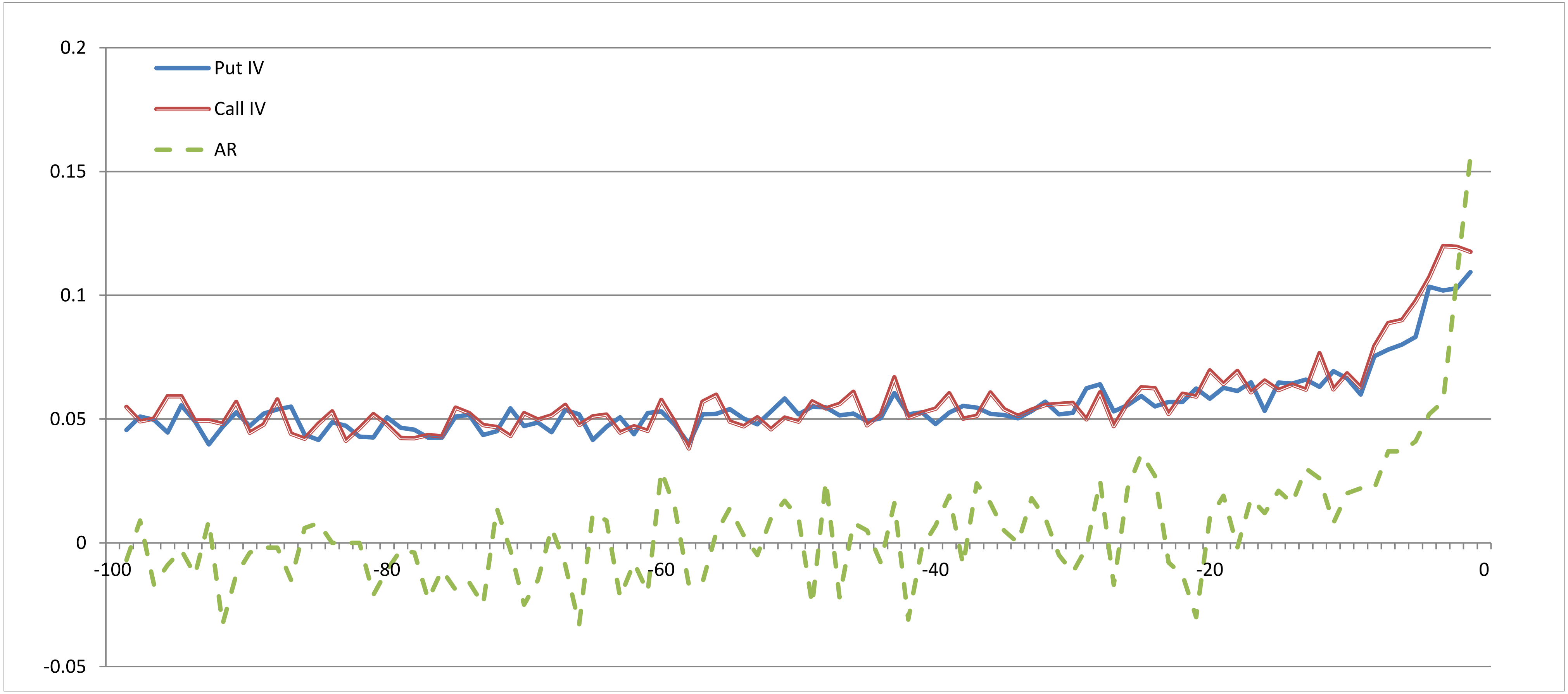

Figure 2 presents the daily stock price abnormal returns and daily changes in call and put implied volatilities in the 100 days leading up to the takeover announcement. Abnormal returns for each firm are the residual from market model returns, where market model estimates are obtained over the benchmark period spamming from 200 to 100 days before the takeover announcement. Call and put implied volatility changes are the daily percentage change in implied volatility. Implied volatilities are calculated from at-the-money options with time to maturity of 30 days. Abnormal returns, and call and put changes in IV are aggregated over all the firms in our sample.

Table 1

Sample Selection Criteria

Table 1 reports the sample selection criteria used to obtain the final dataset employed in this study. Each column represents the number of qualifying target firms left after including additional filtering constraints. We only look at takeover bids for US targets made between 1996 and 2008. Our takeover sample is obtained from the SDC database. A takeover bid is defined as either a merger of tender offer. We require that target companies are publicly listed at the time the offer is made, the deal value is above $1m and that a bid is made to acquire over 90% of the ownership stake in the target firm. We obtain daily stock price and volume data on all qualifying takeover targets from the CRSP database. We exclude those targets that do not have at least 200 trading days of stock price data before the announcement date. We merge the stock price data with implied volatility (IV) data provided by OptionMetrics. The last column represents our final sample for different categories of deals.

	SDC Platinum M&A Database				CRSP (US)		OptionMetrics
	#Targets (1996-2008)	#Targets (Public)	#Targets (Value>1m)	#Targets (Ownership>90%)	#Firms	#Firms (200 trading days)	#Firms
All Deals	146,638	27,491	22,974	5,899	2349	1,141	816
Method of Payment							
Cash	64,387	22,111	20,398	3,937	1011	364	262
Stock	82,251	5380	2,576	1,962	1338	690	554
Firm Size Differential							
Large Size Differential	73,319	13,745	11,487	2,949	1,174	570	408
Small Size Differential	73,319	13,746	11,487	2,940	1,175	571	408

Table 2

Descriptive Statistics – Pre-announcement Period

Table 2 presents the cross-sectional averages across firms of the daily call and put volume, open interest, IV changes, share volume, number of trades and percentage cumulative abnormal returns. The sample period is January 1996 to December 2008. $\Delta ACIV$ and $\Delta APIV$ are daily percentage changes in call and put implied volatilities (independent of changes in the VIX index) respectively. For each type of security, statistics are provided over the benchmark period [-200, -100], pre-announcement run-up period [-30, -8] and immediate pre-announcement period [-8, -1]. This breakdown is based on the trends reported in Figures 1 and 2. '% of Share Volume' is calculated as the daily option volume multiplied by 100 and then divided by the share price volume. This approach is consistent with the market convention that 1 option underwrites 100 shares. The null hypothesis that the CARs, $\Delta ACIV$ and $\Delta APIV$ in the three periods are not different from zero is tested using the *t-test,* where *** indicates significance at 1% level. The sample is 816 takeover targets.

		[-200, -100]	[-30, -8]	[-8, -1]
	Calls			
Volume		32	79	183
% of Share Volume		1.15%	2.69%	4.50%
Open Interest		1912	2728	3053
$\Delta ACIV$		0.07***	0.06***	0.09***
	Puts			
Volume		5	10	20
% of Share Volume		0.18%	0.34%	0.49%
Open Interest		799	974	1013
$\Delta APIV$		0.07***	0.06***	0.08***
	Shares			
Volume ('000)		277.30	294.19	406.84
Number of Trades		487	519	669
Cumulative Abnormal Return (%)		0.01	2.51%***	5.67%***

Table 3

Descriptive Statistics – Announcement Day

Table 3 presents the takeover announcement abnormal returns for the entire sample, and specific deal characteristics, as well as the number of deals over the sample period. The sample period is January 1996 to December 2008. Panel A reports the announcement day abnormal returns. Abnormal returns are calculated as prediction errors from the market model regression of the firms continuously compounded stock return on the continuously compounded return on the CRSP equally-weighted index with dividends. The market model estimation period includes event days -200 to -100. Announcement day abnormal return is the cumulative abnormal return over the two day announcement period including the announcement day and the following day. The null hypothesis that the abnormal returns are not different from zero is tested using the *t-test,* where *** indicates significance at 1% level. Panel B reports the number of takeover bids for sample firms in each two year period included in our final sample. The sample is 816 takeover targets.

Panel A – Announcement Day Returns By Deal Characteristics

Abnormal Returns (AB) – Optioned	17%***
Abnormal Returns (AB) – Non-optioned	22%****
AB (Optioned) – All Cash Deals	21%***
AB (Optioned) – All Stock Deals	12%***
AB (Optioned) – Large Size Difference	14%***
AB (Optioned) – Small Size Difference	20%***

Panel B – Number of Deals is Sample Years

1996-1997	99
1998-1999	248
2000-2001	158
2002-2003	63
2004-2005	110
2006-2007	137
2008	0

Table 4

Option Listing and Information Incorporation into Stock Prices

In Table 4, data are obtained from CRSP (for stock price and market returns), Compustat (for total assets of acquiring and target firms), OptionMetrics (for options data), and SDC Platinum (for takeover announcement dates and deal characteristics). Our sample period is January 1996- December 2008. Regression results are based on 3687 observations, of which 816 are non-optioned targets. The dependent variable in our regression is the announcement day abnormal return for firm *i.* Abnormal returns are calculated as prediction errors from the market model regression of the firms continuously compounded stock return on the continuously compounded return on the CRSP equally-weighted index with dividends. The market model estimation period includes event days -200 to -100. Announcement day abnormal return is the cumulative abnormal return over the two day announcement period including the announcement day and the following day. In our regression we are testing the cross-sectional effect that option listing has on the announcement day abnormal returns. Regressions are based on Equations (7) and (8). The coefficient of interest is the variable $Option_i$, which is assigned the value of 1 if the takeover target has options traders, and 0 otherwise. $CAR[-30,-8] * Option$ and $CAR[-8,-1] * Option$ are dummy variables which measure the effect that options listing has information incorporation into the share price leading up to the takeover announcement. $CAR[-30,-8]$ and $CAR[-8,-1]$ measure the stock price run-up before the takeover announcement. $CAR[-30,-8]$ is the cumulative abnormal return over the period -30 to -8 days before the announcement. $CAR[-8,-1]$ is the cumulative abnormal return for the period -8 to -1 days before the announcement. D^{Cash}, D^{Diff}, $D^{Hostile}$ are dummy variable accounting for whether the predominant method of payment is cash, whether the relative size difference between the merging parties is large, and whether the deal is a hostile takeover, respectively. In computing *t-statistics* we use the standard errors that are White's (1980) heteroscedasticity consistent estimators. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

Dependent Variable $\boldsymbol{CAR[0,1]_i}$

		α	CAR[-30,-8]	CAR[-30,-8] *Option	CAR[-8,-1]	CAR[-8,-1] *Option	Option	D^{Cash}	D^{Diff}	$D^{Auction}$	$Adj.\,R^2$
I.	Coeff.	0.2165	-0.0737		-0.2550		**-0.0259**	0.0704	-0.0511	-0.0039	4.87%
	t-stat	25.26***	-2.05**		-5.01***		**-3.08*****	7.27***	-6.02***	-0.35	
II.	Coeff.	0.2169	-0.0689	**-0.0271**	-0.2710	**0.0922**	**-0.0281**	0.0703	-0.0512	-0.0042	4.84%
	t-stat	24.38***	-1.59	**-0.42**	-4.47***	**1.03**	**-2.65*****	7.25***	-6.03***	-0.37	

Table 5

Information Content of ATM Option Implied Volatility Around Takeover Announcement

In Table 5, data are obtained from CRSP (for stock price and market returns), Compustat (for total assets of acquiring and target firms), OptionMetrics (for options data), and SDC Platinum (for takeover announcement dates and deal characteristics). Our sample period is 1996-2008. The dependent variable in our regression is the announcement day abnormal return for firm *i.* Abnormal returns are calculated as prediction errors from the market model regression of the firms continuously compounded stock return on the continuously compounded return on the CRSP equally-weighted index with dividends. The market model estimation period includes event days -200 to -100. Announcement day abnormal return is the cumulative abnormal return over the two day announcement period including the announcement day and the following day. In our regression, we are testing the hypothesis that changes in option IV are related to announcement day abnormal returns. The coefficients of interest are therefore $\Delta ACIV$ and $\Delta APIV$. $\Delta ACIV$ is the percentage change in call ATM implied volatility between days -8 and -1. $\Delta APIV$ is the percentage change in put ATM implied volatility between days -8 and -1. $\Delta ACIV * LIQ$ and $\Delta APIV * LIQ$ are interaction terms, which capture how the relation between option IVs (call and put IV changes, respectively) and announcement day returns differ across different levels of option liquidity. LIQ is a dummy variable assigned the value of 1 if the relative call or put trading volume to stock volume is above the cross sectional median. $CAR[-30,-8]$ and $CAR[-8,-1]$ measure the stock price run-up before the takeover announcement. $CAR[-30,-8]$ is the cumulative abnormal return over the period -30 to -8 days before the announcement. $CAR[-8,-1]$ is the cumulative abnormal return for the period -8 to -1 days before the announcement. $D^{All\ Cash}$, $D^{Size\ Diff}$, $D^{Hostile}$ are dummy variable accounting for whether the predominant method of payment is cash, whether the relative size difference between the merging parties is large, and whether the deal is a hostile takeover, respectively. Specification I of Panel A report regression results to the model specified in equation (9), while Specification I of Panel B report regression results to the model specified in Equation (10). Specification II of Panel A report regression results to the model specified in Equation (11), while Specification II of Panel B report regression results to the model specified in Equation (12). In computing *t-statistics* we use the standard errors that are White's (1980) heteroscedasticity consistent estimators. Wald Test reports the F-statistic from the Wald test which tests the null hypothesis that the sum of the interaction term with the primary term is equal to 0. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. Regression results are based on 816 observations.

Dependent Variable $CAR[0,1]_i$

		α	CAR[-30,-8]	CAR[-8,-1]	ΔACIV	ΔACIV $*$ LIQ	ΔAPIV	ΔAPIV $*$ LIQ	D^{Cash}	D^{Diff}	$D^{Auction}$	$Adj. R^2$
	Panel A. Change in Call IV Relation with Announcement Day Returns											
I.	Coeff.	0.1876	-0.0636	-0.1865	**0.0894**				0.0694	-0.0699	-0.0571	7.74%
	t-stat	14.40***	-1.36	-3.28***	**1.98****				4.79***	-5.28***	-2.68***	
II.	Coeff.	0.1870	-0.0626	-0.1922	**-0.0296**	**0.2263**			0.0712	-0.0723	-0.0564	8.56%
	t-stat	14.39***	-1.32	-3.37***	**-0.53**	**2.73*****			4.91***	-5.48***	-2.57**	
	Wald Test				**9.53*****							
	Panel B. Change in Put IV Relation with Announcement Day Returns											
I.	Coeff.	0.1890	-0.0651	-0.1890			**0.0892**		0.0685	-0.0707	-0.0573	7.61%
	t-stat	14.78***	-1.40	-3.31***			**1.80***		4.74***	-5.34***	-2.71***	
II.	Coeff.	0.1896	-0.0649	-0.1955			**0.0238**	**0.1232**	0.0681	-0.0716	-0.0559	6.56%
	t-stat	14.82***	-1.39	-3.35***			**0.30**	**1.29**	4.71***	-5.41***	-2.51**	
	Wald Test						**7.43*****					

Table 6

Effect of Information Asymmetry on Relation Between Option Implied Volatility and Announcement Day Abnormal Returns

In Table 6, data are obtained from CRSP (for stock price and market returns), Compustat (for total assets of acquiring and target firms), OptionMetrics (for options data), and SDC Platinum (for takeover announcement dates and deal characteristics). Our sample period is 1996-2008. The dependent variable in our regression is the announcement day abnormal return for firm *i.* Abnormal returns are calculated as prediction errors from the market model regression of the firms continuously compounded stock return on the continuously compounded return on the CRSP equally-weighted index with dividends. The market model estimation period includes event days -200 to -100. Announcement day abnormal return is the cumulative abnormal return over the two day announcement period including the announcement day and the following day. $\Delta ACIV$ is the percentage change in call ATM implied volatility between days -8 and -1. $\Delta APIV$ is the percentage change in put ATM implied volatility between days -8 and -1. In our regression, we are testing the hypothesis that changes in option implied volatility are more strongly associated with certain deal types (method of payment and relative size difference of merging parties). $CAR[-30,-8]$ and $CAR[-8,-1]$ measure the stock price run-up before the takeover announcement. $CAR[-30,-8]$ is the cumulative abnormal return over the period -30 to -8 days before the announcement. $CAR[-8,-1]$ is the cumulative abnormal return for the period -8 to -1 days before the announcement. D^{Cash}, D^{Diff}, $D^{Hostile}$ are dummy variable accounting for whether the predominant method of payment is cash, whether the relative size difference between the merging parties is large, and whether the deal is a hostile takeover, respectively. Results in Specification I of Panels A and B are based on Equations (13) and (14). Results in Specification II of Panels A and B are based on Equations (15) and (16). In computing *t-statistics* we use the standard errors that are White's (1980) heteroscedasticity consistent estimators. Wald Test reports the F-statistic from the Wald test which tests the null hypothesis that the sum of the interaction term with the primary term is equal to 0. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively. Regression results are based on 816 observations.

Dependent Variable $CAR[0,1]_i$

		α	CAR[-30,-8]	CAR[-8,-1]	$\Delta ACIV$	$\Delta ACIV * D^{Cash}$	$\Delta ACIV * D^{Diff}$	D^{Cash}	D^{Diff}	$D^{Auction}$	$Adj. R^2$
Panel A. Interaction Between Call IVs and Deal Characteristics											
I.	Coeff.	0.1859	-0.0640	-0.1604	**0.1022**	**-0.0531**		0.0754	-0.0704	-0.0592	7.61%
	t-stat	14.07***	-1.36	-2.25**	**1.81***	**-0.54**		4.42***	-5.31***	-2.82***	
	Wald Test					**0.38**					
II.	Coeff.	0.1918	-0.0647	-0.2233	**0.0314**		**0.1447**	0.0702	-0.0791	-0.0583	7.90%
	t-stat	13.77***	-2.66	-2.84***	**0.53**		**1.78***	4.84***	-4.97***	-2.76***	
	Wald Test						**9.83***				
		α	CAR[-30,-8]	CAR[-8,-1]	$\Delta APIV$	$\Delta APIV * D^{Cash}$	$\Delta APIV * D^{Diff}$	D^{Cash}	D^{Diff}	$D^{Auction}$	$Adj. R^2$
Panel B. Interaction Between Put IVs and Deal Characteristics											
I.	Coeff.	0.1873	-0.0667	-0.1599	**0.1083**	**-0.0801**		0.0754	-0.0716	-0.0603	7.51%
	t-stat	14.48***	-1.42	-2.22**	**1.77***	**-0.74**		4.48***	-5.38***	-2.85***	
	F-stat					**0.10**					
II.	Coeff.	0.1917	-0.0690	-0.2206	**0.0521**		**0.0958**	0.0697	-0.0773	-0.0594	7.53%
	t-stat	14.08***	-1.47	-2.83***	**0.81**		**1.02**	4.79***	-4.93***	-2.80***	
	Wald Test						**4.65****				

Appendix

Variable	Source	Definition
Stock Return Data		
Stock Returns	CRSP	Logarithmic returns of daily stock prices (incl. dividends).
Stock Volume	CRSP	Daily number of shares that changed hands.
Number of Trades	CRSP	Daily number of share transfer transactions.
Market Returns	CRSP	Logarithmic returns of daily Value Weighted Index (incl. dividends) prices.
Options Data		
Option Volume	OptionMetrics	Daily number of option transactions.
Option Open Interest	OptionMetrics	The total number of options contracts that are not closed or delivered on a particular day.
Option Implied Volatility	OptionMetrics	Implied volatilities calculated using binominal trees which allow for early exercise and dividends expected over the life of the option.
Merger Data		
Public Target	SDC Platinum	Target whose equity was publicly traded on a centralized market when the bid was made
Ownership Stake	SDC Platinum	The percentage of equity that the bidding firm offered to purchase.
Method of Payment	SDC Platinum	The primary consideration offered by the bidder. If more than 50% of the consideration is cash than the deal is classified as predominantly a cash deal, and vice versa.
Hostile Bid	SDC Platinum	A bid where the target firm board rejects the bid.
Successful Bid	SDC Platinum	A bid which resulted in a successful merger within 2 years of the bid being made.
Firm Size Differential	SDC Platinum	Total assets of the target firm divided by total assets of the bidding firm.