The Information Content of Options

Thesis submitted in fulfillment of the requirement for the degree of

Doctor of Philosophy

by

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Abstract

The objective of this thesis is to examine the information content of stock options in financial markets. A key question in financial economics is how information diffuses across markets and how quickly it is reflected in security prices. This thesis aims at exploring this question by investigating the informational role that options play in financial markets. This is achieved by exploring the joint cross section of option and bond prices, the informational role of options in seasoned equity offerings (SEOs), and the information content of options trading prior to announcements of changes to the S&P 500 Index.

The thesis comprises three essays, each exploring the information content of equity options trading from a different angle. The first essay examines the joint cross section of option implied volatility and corporate bond returns. Theoretical and empirical work in finance suggests that stocks and bonds of the same issuing firm should share common risk factors. Therefore, new information about a firm should affect both its stock and bond prices. However, if one market offers trading incentives over other markets, informed traders and traders with better ability to process information may choose to trade in that market over the others. As a result, markets that provide advantages to informed traders will incorporate information prior to other markets. The empirical analysis in this chapter reveals that options trading is strongly predictive of corporate bond returns. A strategy of buying (selling) the portfolio with the lowest (highest) changes in option implied volatility yields an average monthly excess bond return of 1.03%. This strategy is statistically highly significant and economically very meaningful and indicates that information is incorporated into option prices prior to bond prices. In contrast, I find no evidence that bond prices incorporate information prior to option or stock prices. Since bond investors are generally sophisticated institutional investors who process information efficiently and the predictive ability

of options is persistent, I conclude that informed trading rather than superior information processing abilities is responsible for the predictive ability of options.

The second essay explores the information content of option implied volatility around the announcements and issue dates of SEOs. The literature on SEOs indicates that announcements and issue dates contain important information about firms and therefore provide profitable opportunities for traders with private information. While prior research has focused on the information content of short sales around SEOs, this study focuses on the information content of options which can act as an alternative for short selling. The empirical analysis provides evidence of informed trading in the options market around SEO announcements. Around SEO issue dates, I find that higher demand for put options is significantly related to larger issue discounts which is consistent with the manipulative trading hypothesis. The results in this study indicate that regulators should consider extending the short-sale restrictions of Rule 105 to restrict trading in related securities.

Finally, the third essay investigates the information content of options prior to the S&P 500 Index inclusion and exclusion announcements. These announcements are unique events since they are not announced by the firm and, as stated by S&P, they should convey no new information. In addition, the large abnormal returns observed following these announcements make them distinctive ground for testing the informational role of options. Consistent with the notion that informed traders operate in the options market, the empirical results in this essay indicate that there is a significant relationship between options trading preceding index inclusion announcements and abnormal returns following these announcements. In contrast, I find no evidence for a relationship between options trading and abnormal returns following exclusion announcements.

Statement by Candidate

Declaration:

This is to certify that:

i. *The thesis comprises only my original work toward the degree PhD.*

ii. *Due acknowledgement has been made in the text to all other material used.*

iii. *The thesis is less than 100,000 words in length, exclusive of tables, maps, bibliographies, and appendices.*

iv. *The thesis contains no material that has been accepted for the award of any other degree or diploma in any university or other institution and to the best of my knowledge the thesis contains no material previously published or written by another person, except where due reference is made in the text of the thesis.*

Yonatan Navon

[redacted]

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Dedication

I dedicate this dissertation to my parents, Hilla and Meir Navon, and to my late grandmother, Sara Kashuv (Savtush). Words cannot describe my gratitude for all you have done for me. This journey would not have been possible without you. Thank you. I love you all.

Chapter 1 – Introduction

1.1 Background: The Information Content of Options

The objective of this thesis is to examine the informational role that stock options play in financial markets. The thesis consists of three essays, each exploring the information content of options in a different context. The first essay considers the joint cross section of option and bond prices. In particular, it explores whether information is incorporated into option prices prior to bond prices or vice versa. The second essay explores the informational role that options play around seasoned equity offerings (SEOs). Specifically, it examines whether options contain important information around both the announcement and issue dates of SEOs, an important corporate event aimed at raising new capital. The third essay considers the information content of options trading prior to announcements of changes to the S&P 500 Index. In particular, it explores if investors are informed about these announcements and whether they disseminate their information via the options market.

Each of the three essays has a unique motivation that drives the decision to focus on corporate bonds, SEOs, and changes to the S&P 500 Index, respectively. These motivations are discussed in detail in the following subsections. However, the decision to focus on the information content of options, the unifying theme of the three essays in this thesis, is motivated by a central question in financial economics: How does information diffuse across markets and how quickly is it incorporated into security prices? This important question lays the foundations for this thesis. Specifically, the choice to focus on option prices is justified by the finance literature examining whether options are redundant assets (Black and Scholes (1973)) or contain important information (Easley, O'Hara and Srinivas (1998)) and whether informed traders trade in the options market (Manaster and Rendleman (1982)) or not (Chan, Chung and Fong (2002)). It is therefore useful to review the literature on the evolution of the informational role of options over time. Since the literature on stock options is voluminous and spans a period of more than 50 years, I focus on the literature that is particularly pertinent to this research.[1]

The earlier literature on the pricing of stock options can be traced back to the early 1960s (e.g., Sprenkle (1961), Ayres (1963), Boness (1964), Samuelson (1965), Baumol, Malkiel and Quandt (1966), Chen (1970)). While this literature used warrants to express the valuation of options, these valuation formulas were not complete, since they included at least one arbitrary parameter. It was the seminal work of Black and Scholes (1973) on the valuation of options, introducing a complete options pricing model (depending only on observable variables), that pioneered the way for modern research in the pricing of options. In addition, their model was overwhelmingly adopted by practitioners in the marketplace, further increasing the popularity of options trading, along with the opening of the Chicago Board of Options Exchange (CBOE) in 1973.

While the immense contribution of Black and Scholes (1973) to the literature on the valuation of options is indisputable, their framework, which includes a world of complete and competitive markets with no transaction costs and short-sale restrictions, suggests that option prices should be informationally redundant. In reality, however, these assumptions of financial markets do not hold. Equity markets have high transaction costs, do not provide continuous liquidity or leverage for trading, and may restrict short selling. As a result, options

[1] Of course, looking beyond modern finance, option contracts on commodities can be traced back to ancient Greece and the famous tulip market in Holland in the early 1600s.

pricing models recognizing these real-world frictions have been proposed (e.g., Detemple and Selden (1991), Back (1993), Cao (1999), Buraschi and Jiltsov (2006), Vanden (2008).

In addition, information-based models predict that markets in which informed trading takes place will lead and incorporate information prior to markets where informed trading is less dominant. For example, Easley et al. (1998) propose an asymmetric information model in which informed traders may choose to trade in options or equity markets. They then use this model to show that option volumes contain information about future stock returns because informed traders may choose options over stocks.

Since markets in which informed traders prevail will incorporate information first, a key question, one that is especially pertinent to this research, asks why informed traders would prefer to trade in options prior to stocks and bonds. The literature indicates that option markets have significant advantages and incentives for informed traders, such as lower transaction costs, continuous liquidity, high leverage for trading, and no short-sale restrictions (e.g., Black (1975), Grossman (1977), Manaster and Rendleman (1982), Diamond and Verrecchia (1987), Chakravarty, Gulen and Mayhew (2004)). Thus, if informed traders choose to trade in options prior to stocks and bonds due to their advantages, option prices will incorporate information first. These observations are echoed by a number of recent studies documenting that information extracted from option prices, as reflected by their implied volatilities, is predictive of stock returns (e.g., Bali and Hovakimian (2009), Cremers and Weinbaum (2010), Xing, Zhang and Zhao (2010), Ang, Bali and Cakici (2010)). This evidence, however, is in contrast to prior research suggesting that informed traders do not operate in the options market. Stephan and Whaley (1990), for example, document that changes in stock prices lead changes in option prices. They suggest that the consensus that the options market leads the stock market may be wrong. In a similar vein, Chan et al. (2002) find that stock net trade volume, but not options net trade volume, predicts future stock and option quote revisions and that stock trades contain more information than option trades do. The authors conclude that informed investors initiate their trades in the stock market but not in the options market.

To summarize, the finance literature provides important insights into how information is incorporated into security prices. In particular, it examines what informational role options play in financial markets. While some studies suggest that informed traders do not operate in the options market and that stock prices lead option prices, most of the evidence supports the conjecture that informed traders operate in the options market prior to other markets due to the advantages options offer. Nevertheless, to provide a better understanding of how information diffuses across financial markets, a further careful analysis of the information content of options in different venues is warranted.

Since no prior research has examined the joint cross section of bond and option prices, the informational role of options around the announcement and issue dates of SEOs, and the information content of options prior to changes to the S&P 500 Index, this thesis makes a number of unique contributions to the finance literature. The following subsections introduce the contributions and motivations of each of the three essays, along with an overview. The theory, hypotheses, methodology, and empirical results are then discussed in detail in subsequent chapters.

1.2 The Joint Cross Section of Options and Bonds

1.2.1 Overview

This study explores the joint cross section of option and corporate bond prices. As discussed in the previous section, a key question in financial economics is how information (private and public) diffuses across markets and how quickly it is reflected in security prices. Theoretical and empirical work in finance suggests that stocks and bonds of the same issuing firm should share common risk factors. Therefore, new information about a firm should affect both its stock and bond prices (e.g., Merton (1974), Easton, Monahan and Vasvari (2009)). However, if one market offers trading incentives (such as higher leverage) over the other markets, informed traders and traders with better ability to process information may choose to trade in that market over other markets (e.g., Black (1975)). As a result, securities that offer advantages over other securities will incorporate information first. This study examines whether information is incorporated into option prices first and can therefore predict bond returns or vice versa. Specifically, the hypotheses tested are i) the options market contains information that is predictive of bond returns since informed traders prefer to trade in the options market due to its various advantages (e.g., better leverage) and ii) the corporate bond market contains information that is predictive of option prices since the corporate bond market is characterized by sophisticated and professional institutional investors (e.g., insurance companies and pension funds), which may have better ability to process information. It is important to note that these two hypotheses are not mutually exclusive. It is possible that some information will be incorporated first into options and some first to bonds. Ang et al. (2010), for example, find that option prices are predictive of stock prices and vice versa.

A large body of literature explores factors that are associated with future stock prices (e.g., Fama and French (1993)). For instance, Green, Hand and Zhang (2013) identify over 330 return predictive signals reported in the finance literature. Also pertinent to my research, is a recent strand of the literature that examines the prediction of stock prices using measures computed from options trading (e.g., Ang et al. (2010), Roll, Schwartz and Subrahmanyam (2010)). The predictive ability of options trading measures stems from the fact that informed traders favor the options market over the stock market due to various advantages the former offers, such as higher leverage and no short-sale restrictions (e.g., Black (1975), Chakravarty et al. (2004)). These advantages imply that if traders possess private information about a firm's future performance, they will trade in the options market prior to the stock market. As a result, options will incorporate information prior to stocks and consequently lead stock prices. Recent empirical studies have confirmed this conjecture by showing that measures of options trading such as the volatility skew and innovations in option implied volatilities are predictive of stock returns (e.g., Ang et al. (2010), Xing et al. (2010)).

The corporate bond market offers an interesting venue for testing the informational role of options in financial markets. For example, the corporate bond market is much more illiquid relative to the equity market; therefore, traders with private information may prefer to trade in stocks before bonds. This is reflected by some evidence that stock prices lead bond prices (e.g., Kwan (1996), Downing, Underwood and Xing (2009)). However, as mentioned above, informed traders may prefer options over stocks (and bonds) due to the various advantages they offer; thus, trading in options should logically take place prior to trading in bonds. Therefore, if informed traders trade on their information in options (and hence disseminate their information via options), options will incorporate information about the firm's future performance prior to bonds and will subsequently lead bond prices.

While it is reasonable to assume that informed traders may trade in options prior to bonds, it is important to recognize that the corporate bond market is characterized by sophisticated and professional institutional investors such as insurance companies, pension and retirement funds, mutual funds, commercial banks, and foreign investors (Campbell and Taksler (2003)). It is therefore plausible that these sophisticated bond investors have superior information processing ability over other investors. In addition, they may have access to private information available to options traders. Thus, if bond investors possess better information processing ability or access to private information and choose to disseminate this information via bond trading, bond prices will incorporate information prior to option prices. I discuss these two hypotheses in detail in Chapter 2.

The empirical evidence in Chapter 2 presents a statistically significant negative relation between changes in option implied volatility (on individual stocks) and future corporate bond returns. Specifically, sorting bonds into quintile portfolios based on changes in option implied volatility (in the month prior to measuring bond returns), I find that a strategy of buying the low volatility portfolio and selling the high volatility portfolio yields an average monthly bond return of 1.03% (in excess of the risk-free rate) that is statistically highly significant (at the 1% level) and economically very meaningful. Further examination of options' predictive ability in portfolio sorts indicates that these returns are not compensation for systematic risk, providing statistically significant alphas after controlling for six risk factors known to be priced in the cross section of bond returns (e.g., Fama and French (1993) and Gebhardt, Hvidkjaer and Swaminathan (2005)). In addition, changes in option implied volatility exhibit a strong ability to predict bond excess returns in a Fama–Macbeth regressions setting after controlling for five bond-specific factors commonly used in the literature (e.g., Lin, Wang and Wu (2011)). The predictive ability is also robust to the choice of the number of portfolios used, other option-derived measures, such as the volatility skew, the put–call spread, and the ratio of options to stock trading volume, and different sub-samples. Last, the predictive ability of options persists up to two months but is non-existent for a holding period of three months.

In contrast, when examining whether information is incorporated into bond prices prior to option prices, I find that changes in bond prices are not predictive of options nor are they able to predict stock returns. The findings in this study are therefore consistent with the notion that informed traders operate in the options market and that private information is incorporated into options prior to bonds. Importantly, since bond investors are generally sophisticated institutional investors that process information efficiently and the predictive ability of options is fairly persistent, I conclude that informed trading rather than superior information processing abilities is responsible for the predictive ability of options.

1.2.2 Contributions

To the best of my knowledge, this is the first study to examine the joint cross section of options and corporate bond returns. As such, it makes an important contribution to a number of major strands of the finance literature. First, this study is related to the literature on the informational role of options, mainly in equity markets, in which there is ample evidence that options are not redundant assets, and that options play an important informational role in the general financial markets. For example, Easley et al. (1998) propose an asymmetric information model in which informed traders may choose to trade in options or equity markets. They then use this model to show that option volumes contain information about future stock returns. In a similar vein, Chakravarty et al. (2004), Cao, Griffin and Chen (2005), Pan and Poteshman (2006), Roll et al. (2010), and more recently Johnson and So (2011) document that options trading contains information about the future direction of the underlying stock price. Bollen and Whaley (2004) and Gârleanu, Pedersen and Poteshman (2009) suggest that demand-side pressure is the driving force of option prices. If option end users have an informational advantage and choose to trade options, then options will lead underlying stock prices. This study contributes to this strand of literature by being the first to examine the informational role of options for future corporate bond returns. Since corporate bonds are part of the firm (the debt part) and play an important role in its financing, an examination of the informational role of options in the corporate bond market is warranted. I find that options incorporate information prior to bonds and attribute this finding to the fact that informed traders favor the options market over the bond market. This occurs because of the advantages that the options market offers over bonds (and stocks), such as low costs, higher leverage, greater liquidity, and no short-sale restrictions (see, e.g., Easley et al. (1998) and detailed discussion in subsequent chapters).

Second, this essay makes an important contribution to the literature on the predictability of returns. While this literature is voluminous, this study focuses on the new strand of literature on the predictability of returns using measures derived from option implied volatilities. Specifically, a number of recent studies find that option implied volatility, and statistics computed from it, contain important information and can predict stock returns. For example, the realized–implied volatility spread (Bali and Hovakimian (2009)), the call–put option implied volatility spread (Bali and Hovakimian (2009), Cremers and Weinbaum (2010)), the volatility smirk (Xing et al. (2010)), and innovations in implied volatility (Ang et al. (2010)) have all been found to be predictive of stock returns. This study is the first to investigate the predictive power of option implied volatilities on expected corporate bond returns. In particular, these measures capture information that is not captured by options trading volume. The relationship between the stocks and bonds of the same issuing firm and the common risk they share (Merton (1974)) implies that these measures should contain important information about both stock and bond prices. This research, therefore, provides important evidence on how option implied volatility and other measures derived from it are related to future bond prices.

Last, this study contributes to the literature exploring how information (private and public) diffuses across markets and how quickly it is reflected in security prices. If informed investors or investors with better information processing ability choose to trade on their information in the options market over the bond market, option prices will lead bond prices. In contrast, if they choose to trade in the bond market first, bond prices will lead option prices. The literature provides mixed evidence on how information is diffused across stock and bond markets. Kwan (1996) and Downing et al. (2009), for example, find that stock prices lead bond prices, but Hotchkiss and Ronen (2002) find no lead–lag relationship and conclude that stock and bond returns react jointly to common factors. My research contributes to this strand of literature by showing that option prices incorporate information prior to bond prices but not vice versa, again, due to the incentives that options offer over bonds.

1.3 The Information Content of Option Implied Volatility around SEOs

1.3.1 Overview

This study examines the informational role of options around SEOs. Specifically, I investigate options trading around two important SEO dates: the announcement date and the issue date. The literature on SEOs indicates that announcements and issue dates contain important information about firms and therefore provide profitable opportunities for traders with private information. While prior research has focused on the information content of short sales around SEOs (e.g., Gerard and Nanda (1993), Safieddine and Wilhelm (1996), Corwin (2003), Henry and Koski (2010)), this study focuses on the information content of options trading around SEOs. The motivation to focus on options trading around SEOs stems from the fact that traders with information about the approaching announcement can choose to either short sell the firm's stock or buy put options, since put options can act as an alternative for short selling a stock (Cox and Rubinstein (1985)). With regard to SEO issue dates, investors can manipulate the offer price and profit at the expense of the issuer (Gerard and Nanda (1993)) by short selling the firm's stock or by purchasing put options. Thus, this study offers a unique insight into the research on SEOs using options trading as an alternative to short sales (e.g., Cox and Rubinstein (1985) argue that put options may be preferred over short positions since the use of leverage is more efficient and commissions on options tend to be lower than those on share transactions).

Specifically, the literature indicates that informed traders have a number of incentives to trade in options over stocks and to prefer put options over short positions. For example, options offer lower transaction costs over stocks, as well as better liquidity, more efficient use of leverage for trading, and no short-sale restrictions (e.g., Black (1975), Cox and Rubinstein (1985), Chakravarty et al. (2004)). If traders possess private information about SEO announcements, they may choose to execute this information via the options market (over short selling the firm that is about to announce an SEO). As a result, option prices will incorporate information from informed traders prior to stocks (Easley et al. (1998)). Since SEO announcements are associated with economically meaningful and statistically significant negative average abnormal returns of more than 2% (e.g., Myers and Majluf (1984)) over a short period of one to three days, it is likely that investors have a strong incentive to acquire information about these announcements. Thus, the first research question of this chapter examines if investors are informed about SEO announcements and whether they disseminate this information via options trading.

In regard to SEO issue dates, the literature indicates that short selling activities around issue dates can be informative or manipulative. Informed investors with negative news can profit by short selling prior to issuance and subsequently cover their positions at the lower offer price (e.g., Henry and Koski (2010)). Manipulative traders can short sell the stock to push prices downward after SEO announcements and prior to issuance and cover their positions at a lower price following SEO issuance (e.g., Gerard and Nanda (1993), Safieddine and Wilhelm (1996), Kim and Shin (2004), Henry and Koski (2010)). Importantly, in April 1997, the U.S. Securities and Exchange Commission (SEC) adopted Rule 105 (formerly Rule 10b-21 until 1988) to prohibit short sellers from purchasing shares in an SEO to cover their short positions if the positions were established during the five business days preceding the offer date. If Rule 105 is binding, traders can either short sell six days prior to the issue date or circumvent Rule 105 by buying put options during the short-sale restriction period and closer to the issue date. While prior literature has focused on short selling around issue dates, the second research question of this chapter examines put options trading around issue dates, since put options can act as an alternative to short selling (Cox and Rubinstein (1985)). Specifically, the second research question tests if trading is informed or manipulative around issue dates by using the model of Gerard and Nanda (1993). According to their model, manipulative (informed) trading is predicted to lower (increase) market informativeness and increase (decrease) the issue discount (a detailed explanation of the model is provided in Chapter 3).

The empirical evidence in Chapter 3 indicates a statistically significant negative relation between options trading and cumulative abnormal returns (CARs) following SEO announcements. In particular, the results show that higher demand for out-of-the-money put (OTMP) options relative to at-the-money call (ATMC) options (the volatility skew) in the two days preceding the announcement is strongly associated *CAR* on days (0,1) following SEO announcements. Sorting CARs (0,1) into quintile portfolios based on levels of the volatility skew prior to SEO announcements, I find that the difference between the low and high portfolios is -1.93%, which is both statistically and economically highly significant. Cross-sectional regressions support these results. Further, these results are robust to pseudo *CAR* window testing and alternative measures of the volatility skew. In addition, the results indicate that informed investors prefer deeper OTMP options prior to SEO announcements (since these options provide greater profit relative to at-the-money put options).

Examining the results for the second research question (issue discount) in Chapter 3, I find that put option implied volatilities are associated with larger issue discounts. Specifically, regressing levels of the issue discount on levels of put option implied volatilities prior to the issue date yields positive and statistically highly significant coefficients. The results for the issue discount are robust to controlling for various factors known to influence the issue discount and to models with various levels of put option moneyness. In addition, abnormal levels of put option implied volatility are also associated with larger issue discounts. The empirical evidence in Chapter 3 is consistent with manipulative trading under the model of Gerard and Nanda (1993). That is, traders opt to manipulate the offer price downward by purchasing put options and subsequently purchasing stocks at the discounted offer price to cover their positions.

1.3.2 Contributions

Chapter 3 contributes to the finance literature in at least two important ways. First, to the best of my knowledge, this is the first study to document that informed traders trade on their private information about impending SEO announcements and that they disseminate this information in the options market in the period preceding the announcements. This is a unique contribution to the literature on SEOs, since prior research finds no evidence of informed trading via short selling prior to SEO announcements (e.g., Henry and Koski (2010)). While informed traders may not execute their information by short selling a firm's stocks, they may opt to buy put options due to the advantages these offer over short selling (e.g., higher leverage). Indeed, the evidence in this chapter shows that informed trading takes place in the options market prior to SEO announcements.

This chapter also contributes to the literature on the informational role of options in financial markets. While the evidence on the role that informed traders play is mixed, most recent evidence supports the notion that informed traders trade in the options market. For example, Stephan and Whaley (1990) and Chan et al. (2002) argue that options traders are not informed but merely speculate on public information, but Black (1975), Manaster and Rendleman (1982), and Easley et al. (1998) find evidence that informed trading takes place in the options market. The results in this chapter are consistent with the notion that informed trading takes place in the options market.

Chapter 3 also contributes to the literature examining price manipulation prior to SEO issue dates, as evidence on price manipulation prior to the SEO issue dates is mixed. While a number of studies use monthly short-interest data to reject the manipulative trading hypothesis (e.g., Safieddine and Wilhelm (1996), Kim and Shin (2004)), Henry and Koski (2010) use daily short-interest data and find that manipulative trading takes place prior to issue dates. In addition, prior studies only examine short selling for optioned and non-optioned firms (at both the monthly and daily horizons). Henry and Koski (2010) find that short selling is significantly related to the issue discount only for firms without put options. They do not, however, test if the level of put options trading is related to the issue discount. This chapter contributes to this strand of literature by providing evidence that abnormal levels of put option implied volatility are related to higher issue discounts, which implies manipulative trading under the Gerard and Nanda (1993) model, consistent with the recent findings of Henry and Koski (2010), who use short-interest data.

The results in Chapter 3 provide important implications to both issuers and decision makers. Issuers should be wary of price manipulation via options trading and regulators should consider extending the short-sale restrictions of Rule 105 to restrict trading in related securities.

1.4 The Information Content of Options Prior to Changes to the S&P 500 Index

1.4.1 Overview

This study investigates the information content of options prior to S&P 500 Index inclusion and exclusion announcements. I choose to study S&P 500 Index inclusion and exclusion announcements because i) they are unscheduled and therefore (to an extent) unanticipated[2] by the market (as opposed to scheduled events such as earnings announcements), ii) they are not announced by the firm but by the S&P 500 Committee, and, iii) as stated by S&P, they should convey no new information. In addition, with an estimated value of total worldwide indexed assets in excess of $1 trillion (Kappou, Brooks and Ward (2010)) the S&P 500 Index is regarded as the single best indicator of equity markets in the United States. Despite S&P's claim that inclusion to or exclusion from the index conveys no new information, the literature consistently documents a large average announcement-day abnormal return (e.g., 5.9% in Beneish and Whaley (1996) following inclusion announcements). These large abnormal returns clearly provide a strong incentive for investors to acquire information about inclusion and exclusion announcements. Moreover, index funds involved in tracking the S&P 500 Index can also benefit from acquiring information about index change announcements, since these funds must include (exclude) the newly added (deleted) firm in (from) their portfolios. Given the enormous amount of money involved in index tracking, index funds have large incentives to be informed on impending index change announcements.

This study considers the predictive ability of the volatility skew (in addition to other options trading measures) for abnormal returns following index change announcements. I choose the volatility skew, defined as the difference between the volatilities of OTMP options

[2] This is discussed in detail in Chapter 4.

and ATMC options, as a measure of options trading because the literature indicates that the volatility skew can be used as a proxy for jump risk and is predictive of future stock returns (e.g., Xing et al. (2010)) and crashes (Van Buskirk (2011)). As mentioned in the previous subsection, the literature indicates that investors possessing private information may opt to trade in the options market due to the lower costs, higher leverage, and the absence of short-sale restrictions that options offer over stocks (Back (1993), Black (1975), Manaster and Rendleman (1982)). If informed investors with private information on the impending index change announcement choose to trade in the options market, options may contain information that is predictive of the abnormal returns subsequent to these announcements. In particular, since inclusion (exclusion) announcements are positive (negative) events with a sharp increase (decrease) in price immediately afterward, informed investors are likely to purchase ATMCs in favor of OTMPs (OTMPs in favor of ATMCs) prior to the announcement, thus creating a flatter (more pronounced) volatility skew. In turn, this leads to return predictability through the steepness of the volatility skew.

The empirical evidence in Chapter 4 indicates a significant negative relationship between the levels of the volatility skew in the two days preceding the index inclusion announcement and abnormal returns subsequent to the announcement. In contrast, I find no evidence for a relationship between the volatility skew and exclusion announcements. In particular, examination of cross-sectional regressions reveals that the volatility skew has strong predictive power for cumulative abnormal returns on day 0 and 1 immediately after the inclusion announcement. Portfolio sorts provide confirmation for this finding by showing that stocks in the lowest-skew portfolio outperform stocks in the highest-skew portfolio by 1.83% over days 0 and 1 immediately after the inclusion announcement. These results are robust to pseudo-window testing, different measures of options trading (i.e., OTMP options with different deltas, the put–call spread, the options to stock trading volume ratio, and innovations in implied volatilities), and different sub-samples (with different firm sizes, signs of returns, periods, and levels of options trading volume).

The finding that informed trading takes place prior to inclusion but not exclusion announcements is intriguing and is at odds with the findings of Chapter 3 that the volatility skew is predictive of negative events (SEO announcements). As discussed in detail in Chapter 4, these results may plausibly be explained by the fact that the sample size of exclusion announcements is relatively small (81 for exclusions and 326 for inclusions) which may affect the power of the test. In addition, since firms excluded from the index are involved in other significant events around the time of deletion from the index, a large fluctuation in returns of these firms is observed prior to and on the day of exclusion announcements (e.g., the standard deviation of returns for exclusion announcements is more than double that of inclusion announcements). Option traders who are aware of price fluctuations and possible increase in price around exclusion announcements may therefore be reluctant to take positions in put options. It is therefore difficult to disentangle the effect of exclusion announcements from other factors that may affect abnormal returns. Overall, the results in Chapter 4 support the conjecture that information about impending inclusion announcements leaks before the announcements and the notion that informed traders operate in the options market.

1.4.2 Contributions

This study is positioned at the intersection of two different strands of literature. The first strand focuses on index composition changes and the second on the informational role of options. While the S&P Committee clearly states that changes to the index do not reflect opinions about a firm’s future prospects, the literature has observed large abnormal returns following index change announcements. As a result, a considerable number of studies have explored whether these announcements are indeed information-free events. The literature, however, has almost solely focused on explanations for these returns, since these are inconsistent with the efficient market hypothesis. For example, Shleifer (1986) proposes the downward-sloping demand curve (or imperfect substitutes) in which index composition changes are information-free events and demand for newly included stock by large index funds, which track the index by replicating its composition, leads to increased buying pressure. Consequently, the stock price increases subsequent to the inclusion announcement, implying that the demand curve for stock slopes downward. Harris and Gurel (1986) make a similar argument but differ from Shleifer (1986) by suggesting that the effect is temporary and not permanent (the price pressure hypothesis). They find that short-run liquidity constraints lead to price pressure that then reverses in the weeks following the index change. Jain (1987) proposes the information hypothesis, in which the addition of a stock to the S&P 500 index conveys favorable information to the market. Dhillon and Johnson (1991) support the information hypothesis by showing that the bonds and options of newly included firms also increase in price, indicating that inclusions indeed contain information about firms' future performance. Denis, McConnell, Ovtchinnikov and Yun (2003) and Chen, Noronha and Singal (2004) argue that an increase in investor awareness (investor recognition hypothesis) of newly included firms—which leads to closer scrutiny of management, which leads to better performance—is ultimately responsible for the price increase subsequent to the announcement. A common theme of the abovementioned studies is that they offer explanations for the observed abnormal stock returns after index composition changes announcements. No prior study, however, has examined whether these returns can be predicted by measures derived from options trading. Therefore this study makes a unique contribution to the literature by examining the informational role and predictive power of the options volatility skew before S&P 500 Index inclusion and exclusion announcements.

Naturally, this study also contributes to the literature on the informational role of options trading. As mentioned in the previous subsection, evidence is mixed on whether informed investors operate in the options market (Black (1975), Manaster and Rendleman (1982), Easley et al. (1998)) or if these investors merely speculate using publicly available information to trade in the options market (Stephan and Whaley (1990), Chan et al. (2002)). The results in Chapter 4 provide evidence consistent with the notion that informed investors trade in the options market prior to the stock market. It is important to note that since index change announcements are unscheduled and therefore (at least to some degree) unanticipated[3] by the market, any information revealed by options prior to index change announcements indicates that informed trading takes place prior to the announcement. This contrasts markedly with the case of scheduled corporate events, such as earnings announcements, when investors can speculate on the announcement result (Cao et al. (2005)). In the case of unscheduled events such as index inclusion and exclusion announcements, only investors that possess material information will trade in the options market prior to the announcement; therefore, any information revealed by options necessarily indicates informed trading.

My work is also related to previous studies exploring the predictive ability of the options volatility skew but differs in a significant way. Most prior work has used the volatility skew as a proxy for negative jump risk (at either the index or firm level). For example, Bates (1991) shows that OTMP options on the S&P 500 become unusually expensive (and the volatility skew prominent) before negative price jumps and Doran et al. (2007) demonstrate that the volatility skew constructed from options on the S&P 100 Index can predict market crashes but not spikes. Both studies focus on index predictability, whereas this work focuses on the cross-sectional variation in the volatility skew. More recently, Bradshaw, Hutton, Marcus and Tehranian (2010), Van Buskirk (2011), and Jin, Livnat and

[3] This is discussed in footnote 34.

Zhang (2012) have shown that the volatility skew is strongly related to the likelihood of crashes at the firm level. My work differs from theirs because I use the volatility skew as a predictor of extreme unscheduled positive events, since inclusion announcements are positive events by nature, with almost all firms experiencing positive returns and an average abnormal return of 4.59% in my sample. Overall, the results in this study support the hypothesis that informed traders trade in the options market.

1.5 Organization

The remainder of this thesis is organized as follows. Chapter 2 examines the joint cross section of options and bonds. Section 2.1 provides an overview of the chapter. In Section 2.2, I provide background on corporate bonds. In Section 2.3, I survey the related literature and develop the hypothesis. Section 2.4 describes the data and sample characteristics. Section 2.5 reviews the results of the tests on options trading and corporate bond returns. Section 2.6 discusses the results of the tests on the predictability of option prices using changes in bond prices. Section 2.7 presents a discussion on whether the information incorporated into options stems from informed trading or better information processing abilities. Section 2.8 concludes Chapter 2.

Chapter 3 considers the informational role of options around SEOs. Section 3.1 provides an overview of the chapter. Section 3.2 provides the background of SEOs. Section 3.3 surveys the related literature and develops two hypotheses. Section 3.4 describes the data and sample characteristics. Section 3.5 reviews the results of the tests on options trading around SEO announcements and Section 3.6 provides robustness tests for these results. Section 3.7 reviews the results of the tests on options trading around SEO issue dates. Section 3.8 discusses the effectiveness of Rule 105. Section 3.9 concludes Chapter 3.

Chapter 4 explores the information content of options prior to announcements of changes to the S&P 500 Index. Section 4.1 provides an overview of the chapter. Section 4.2 provides a brief background of the S&P 500 Index composition and inclusion criteria. Section 4.3 surveys the related literature and develops the hypothesis. Section 4.4 describes the data and methods used in this study and presents the descriptive statistics. Section 4.5 presents the empirical findings and Section 4.6 discusses the robustness checks. Section 4.7 concludes Chapter 4.

Chapter 5 concludes the thesis.

Chapter 2 – The Joint Cross Section of Options and Bonds

2.1 Introduction

Theoretical and empirical work in finance suggests that stocks and bonds of the same issuing firm should share common risk factors. Therefore, new information about a firm should affect both its stock and bond prices (e.g., Merton (1974) and Easton et al. (2009)). This study examines whether information is incorporated into option prices first and therefore can predict bond returns or vice versa. Specifically, I test the hypotheses that i) the options market contains information which is predictive of bond returns as informed traders prefer to trade in the options market due to the various advantages it offers (e.g., better leverage) and that ii) the corporate bond market contains information which is predictive of option prices as the corporate bond market is characterized by sophisticated and professional institutional investors (e.g., insurance companies and pension funds) which may have a better ability to process information.

A large body of literature explores factors which are associated with future stock prices (e.g., Fama and French (1993))[4] and a number of recent papers examine the prediction

[4] Other factors found predictive of stock returns include: book-to-market (Stattman (1980)), size (Banz (1981)), earnings-to-price (Basu (1977)), cash-flow-to-price (Chan, Hamao, and Lakonishok (1991)), debt-to-equity (Bhandari (1988)), sales-to-price (e.g., Barbee, Mukherji, and Raines (1996)), accruals (Sloan (1996)), investment-to-assets (Titman, Wei and Xie (2004)), net operating assets (Hirshleifer, Kewei, Teoh, and Yinglei (2004)), asset growth (Cooper, Gulen, and Schill (2008)), financial distress (Campbell, Hilscher and Szilagyi (2008)), return-on-assets (Fama and French (2006), Chen, Novy-Marx, and Zhang (2010)), and profitability premium (Novy-Marx (2010)), among others.

of stock prices using measures computed from options trading (e.g., Roll et al. (2010). Options are redundant assets only in a world of complete and competitive markets with no transaction costs and short-sale restrictions (Black and Scholes (1973)). However, in reality, these assumptions of financial markets do not hold. Equity markets have high transaction costs, do not provide continuous liquidity or leverage for trading, and may restrict short selling. The finance literature indicates that informed traders have a number of incentives to trade in options over stocks such as lower transaction costs, better liquidity, more efficient use of leverage for trading, and no short-sale restrictions (e.g., Black (1975) and Chakravarty et al. (2004)). These advantages imply that if traders possess private information about a firm's future performance, they will trade in the options market prior to the stock market. As a result, options will incorporate information prior to stocks and consequently lead stock prices. Recent empirical studies have supported this notion and show that measures of options trading are predictive of stock returns (e.g., Xing et al. (2010) and Ang et al. (2010)).

The corporate bond market presents an interesting ground for testing the informational role of options trading in financial markets. The corporate bond market is much more illiquid relative to the equity market, therefore traders with information will prefer to trade in stocks before bonds which may explain the evidence that stock prices lead bond prices (e.g., Kwan (1996) and Downing et al. (2009)). However, as mentioned above, traders prefer options over stocks due to the various advantages they provide, thus trading in options should logically take place prior to trading in bonds. Bonds are priced based on the risk that a company will default on its future debt obligations (and the current term structure of interest rates). Therefore, if options incorporate news about the firm's future performance prior to bonds, they should lead bond prices.

The corporate bond market is characterized by sophisticated and professional institutional investors such as insurance companies, pension and retirement funds, mutual funds, commercial banks, and foreign investors (Campbell and Taksler (2003)). It is therefore plausible that these sophisticated bond investors have superior information processing ability. In addition, they may have access to private information available to options traders. Thus, if bond investors possess better information processing ability or access to private information and they choose to disseminate this information via bond trading, bond prices will incorporate information prior to options prices.

Using a sample of 25,835 bond-month returns of optioned firms for the period July 2002 to April 2011, I find evidence of a statistically significant negative relation between changes in option (on individual stocks) implied volatility and future corporate bond returns. Specifically, sorting bonds into quintile portfolios based on changes in option implied volatility (in the month previous to measuring bond returns), I find that a strategy of buying the low volatility portfolio and selling the high volatility portfolio yields an average monthly bond excess return of 1.03% which is statistically significant (at the 1% level) and economically meaningful. The profits generated from this strategy are similarly distributed between the low (0.53%) and high (-0.50%) portfolios. Moreover, bond returns across all quintile portfolios vary in a strict monotonic way with changes in implied volatility (returns decrease monotonically from the low to high portfolio). The predictive ability is insensitive to the choice of the number of portfolios used (similar results are observed using 3, 7, 10 and 15 portfolios instead of 5). A further examination of the options' predictive ability indicates that these returns are not compensation for systematic risk, providing statistically significant alphas after controlling for six risk factors known to be priced in the cross-section of bond returns (as in Fama and French (1993) and Gebhardt et al. (2005)).

In addition, changes in option implied volatility exhibit a strong ability to predict bond excess returns in a Fama-Macbeth regressions setting after controlling for five bond-specific factors commonly used in the literature, that is, rating, coupon, offering amount, age and time to maturity (see for example Lin et al. (2011)). I also test a battery of other option-derived measures and document that measures such as the volatility skew, the put-call spread and the ratio of options to stock trading volume (*O/S*) also demonstrate ability to predict bond returns. Results in this study are robust to different sub-sample analysis based on credit rating, period, size, return sign, option type and bond age. Lastly, the predictive ability of options persists up to two months and is non-existent for a holding period of three months.

In the final avenue of inquiry I examine if information is incorporated into bond prices prior to options prices. I find that changes in bond prices are not predictive of options nor are they able to predict stock returns. The findings in this study are consistent with the notion that informed traders operate in the options market and that private information is incorporated into options prior to bonds. Since bond investors are generally sophisticated institutional investors who process information in an efficient manner and the predictive ability of options is relatively long, I conclude that informed trading rather than superior information processing abilities is responsible for the predictive ability of options.

To the best of my knowledge this is the first study to examine the informational role of options and future bond returns. As such, this study contributes to two major strands of the finance literature. First, the analysis is related to the literature on the informational role of options, mainly in equity markets, in which there is ample evidence that options are not redundant assets, and that options play an important informational role in the general financial markets.[5] Specifically, Easley et al. (1998) propose an asymmetric information model in which informed traders may choose to trade in options or equity markets. Easley et al. (1998) use this model to show that option volumes contain information about future stock

[5] The vast literature includes Black (1975), Grossman (1977), Manaster and Rendleman (1982), Diamond and Verrecchia (1987), Jennings and Starks (1986), Bhattacharya (1987), Conrad (1989), Kumar, Sarin and Shastri (1992), Figlewski and Webb (1993), Back (1993), Biais and Hillion (1994), Easley et al. (1998), Chakravarty et al. (2004), Ofek, Richardson and Whitelaw (2004), Cao, Chen and Griffin (2005), Pan and Poteshman (2006), Bali and Hovakimian (2009), Cremers and Weinbaum (2010), Xing et al. (2010), and Ang et al. (2010) among others.

returns. Similarly, Chakravarty et al. (2004), Cao et al. (2005), Pan and Poteshman (2006), and Roll et al. (2010) document that options trading contains information about the future direction of the underlying stock price. Bollen and Whaley (2004) and Gârleanu et al. (2009) suggest that demand side pressure is the driving force of option prices. If end-users of options have an information advantage and choose to trade options, then options will lead underlying stock prices. I contribute to this strand of literature by providing the first study that examines the informational role of options in the corporate bond market. Since bonds play an important role in financing the firm, an examination of the informational role of options in the corporate bond market is warranted. I find that options incorporate information prior to bonds in a way similar to the incorporation of information prior to stocks because informed traders favor the options market over both the equity and bond markets. This arises because of the advantages that the options market offer such as low cost, higher leverage, liquidity and no short-sale restrictions (see e.g., Easley et al. (1998)).

Related but distinct from this research is Cremers, Driessen, Maenhout, and Weinbaum (2008) who examine the contemporaneous but not predictive explanatory power of option implied volatility on credit spreads. Cremers et al. (2008) show that the level of implied volatility can explain the credit spread beyond credit ratings. This study differs from Cremers et al. (2008) in two distinct aspects. First, I focus on expected bond returns as opposed to the contemporaneous credit spread. Second I do not use the level of implied volatility, rather I use innovations in implied volatility and other statistics calculated from implied volatility such as the call-put spread, volatility skew, and volatility innovations. While Cremers et al. (2008) show that the level of implied volatility can explain the credit spread, I show that changes in implied volatility are predictive of bond returns. That is, information about future firm performance is incorporated into options prior to stocks and bonds.

Second, I contribute to the strand of literature on the predictability of returns. This literature is voluminous and the focus of this study is on the new strand of literature on the predictability of returns using measures derived from option implied volatilities. Specifically, a number of recent studies find that option implied volatility, and statistics computed from it, contain important information and can predict stock returns (i.e., the realized-implied volatility spread (Bali and Hovakimian (2009)), the call-put option volatility spread (Bali and Hovakimian (2009), and Cremers and Weinbaum (2010)), the volatility smirk (Xing et al. (2010)), and innovations in implied volatility (Ang et al. (2010)). This study is the first to investigate the predictive power of option implied volatilities on expected bond returns. In particular, these measures capture information which is not captured by option trading volume or the level of implied volatility. The relationship between stocks and bonds of the same issuing firm and the common risk they share (Merton (1974)) implies that these measures should contain important information about bond prices. This research, therefore, provides important evidence on how option implied volatility and other measures derived from it are predictive of bond prices. Apart from the important contribution to the finance literature, this research has a practical implication for institutional investors who are constantly searching for new sources of bond alphas in the corporate bond market.

The remainder of this chapter proceeds as follows. In Section 2.2 I provide background on corporate bonds. In Section 2.3 I survey the related literature and develop the hypothesis. Section 2.4 describes the data and sample characteristics. Section 2.5 reviews results of the tests on options trading and corporate bond returns. Section 2.6 discusses results of the tests on the predictability of option prices using changes in bond prices. Section 2.7 provides discussion on whether the information incorporated into options stems from informed trading or better information processing abilities. Section 2.8 concludes.

2.2 Corporate Bonds – Background

A corporate bond is a contractual promise by the issuing company to pay a series of coupon payments and the bond's face value at a specified maturity date to the bondholders. The corporate bond market is essential for a healthy functioning economy as it is a major external source for companies to raise capital. Once bonds are issued, they are traded (mainly) over-the-counter in secondary markets (non-centralized dealer markets as opposed to stocks in organized exchanges). Their price is then largely dependent on changes in interest rates and the market perception of the company's ability to pay its obligation (likelihood of a default).

In order to evaluate their creditworthiness prior to issuing bonds, companies acquire credit evaluation from one of the credit-rating agencies (e.g., S&P, Moody's, and Fitch). Subsequent to their ratings, bonds are broadly defined as "investment grade" (BBB or higher rating by S&P) or "non-investment grade" (also speculative or "junk" bonds). Table 1 of Appendix A reports that the total issuance of investment-grade bonds is much larger than the total issuance of non-investment grade bonds. In 2009 for instance, the issuance volume of investment grade bonds was more than five times larger than non-investment grade bonds. Credit ratings have implications for both firms and bond prices since regulated financial service institutions such as pension funds, insurance companies, mutual funds and banks, who are the dominant players in this market, are often restricted to invest only in investment grade bonds. As such, transactions in the bond market are enormous with estimated trade size of $2.7 million for institutions (Bessembinder, Maxwell and Venkataraman (2006)). However, these institutions are also restricted in the amount of non-investment grade bonds that they can hold. Thus, changes in bond ratings held by these large institutions require them to rebalance their portfolios resulting in an impact on bond prices (this had a great effect during the 2007-2008 liquidity and credit crunch (see e.g., Brunnermeier (2009))).

Bonds are traded separately from stocks, and companies can issue bonds at different times, and with different terms and payments. Stockholders are entitled to receive residual claims on the company (e.g., dividends) whereas bondholders are only entitled to receiving the fixed promised payments. In case of bankruptcy however, bondholders usually have priority claims over stockholders depending on the agreements detailed in the indenture.

The corporate bond market is an extremely important source of financing for US firms and hence its size. As of 30 June 2010, the outstanding US corporate bond market debt was $7.27 trillion. Table 2 in Appendix A shows that public corporate debt more than doubled in the last decade and that it is among the largest debt markets together with mortgage related and treasury debt.

The total amount of corporate bonds and equity issuance is also significantly different. Table 1 of Appendix A indicates that for the period 1999-2012, the amount of corporate bond issuance is consistently larger than equity issuance which is another indication for the importance of this market. For example, US corporations issued a total of $902 billion in corporate bonds as opposed to only $264 billion in equity (common and preferred) in 2009.

Liquidity also plays an important role in the corporate bond market. The US corporate bond market is significantly less liquid than the equity markets. This stems from the higher trading costs, the non-centralized market which means that price quotations are not disseminated continuously, and the fact that the dominant investors in this market have buy-and-hold strategies, where once bonds are issued they are held to maturity in their portfolios and not traded (Bessembinder and Maxwell (2008)). The lower trading frequency has an impact on bond prices. Chen, Lesmond and Wei (2007) find that more illiquid bonds earn higher yield spreads. Bao, Pan and Wang (2010) show that a bond's illiquidity increases with the bond's age and maturity, but decreases with its issuance size. The corporate bond market is indeed important for a well-functioning economy, as this is where corporations raise most of their capital. This is particularly important at present due to the 2007-2008 liquidity and credit crunch in which credit risk and corporate bond spreads were a dominant force.

2.3 Related Literature and Hypotheses Development

In this section I develop the hypothesis related to this study. I start by examining the theoretical and empirical relationship between stocks and bonds in Subsection 2.3.1. I then turn to discuss the informational role of options for traders with private information (Subsection 2.3.2) and develop the hypotheses (Subsection 2.3.3).

2.3.1 The relationship between stocks and bonds

In order to examine the predictive ability of options in the corporate bond market, I first review the theoretical and empirical relation between stocks and bonds of the same issuing firm documented in the literature. The theoretical background underlying this study is partly based on the seminal work on the structural models of Black and Scholes (1973), and Merton (1974).[6] A firm's stocks and bonds are contingent claims on the firm's underlying assets. Thus, bonds and stocks should share common risk factors. Holding a corporate bond can be viewed as holding a combination of a riskless bond and issuing a put option to the equity holders of the firm at the value of the riskless bond claims. When the volatility of the firm's assets increases, the value of the put option increases. This in turn increases the payoff for equity holders but reduces the payoff for bondholders. The appropriate volatility for use in structural models is the volatility of the firm's assets (debt + equity) and can be inferred from changes in the implied volatility of the firm's traded options (a detailed explanation of this relationship is provided below). The common risk factors that bonds and stocks share, implies that information about the firm's future risk should affect both the bonds and the stocks of the issuing firm. I use this notion to argue that financial contracts (e.g., options) that

[6] Other notable variations of structural models include, among others, Geske (1977), Longstaff and Schwartz (1995), Leland and Toft (1996), Collin-Dufresne, Goldstein and Martin (2001). A detailed review of structural models is presented in Huang and Huang (2003), and Eom, Helwege and Huang (2004).

incorporate new information prior to other assets of the same firm (e.g., bonds and stocks) will have important predictive ability (see Subsection 2.3.3).

The premise of the study is to examine the effect of the information content of options on corporate bonds and vice versa. Prior studies (e.g., Xing et al. (2010), Cremers and Weinbaum (2010), Johnson and So (2011), and Ang et al. (2010)) have shown that various measures of options trading, used as a proxy for news arrival, (for example changes in option implied volatility) can predict future stock returns. However, whether such information can predict future bond returns has not been examined. If information about the firm's future performance is not fully incorporated into stock prices, thus creating stock return predictability, it is plausible to expect that this information should also be predictive of bond returns, given that bonds and stocks should react to the arrival of firm-specific information in a similar way (as in the structural models of Black and Scholes (1973), and Merton (1974)).

A key question that this study relies on is: Why information that affects stocks should also affect bonds? The intuitive answer is that debt is serviced from the firm's cash flow and therefore information which may affect the firm's ability to pay off its future debt obligations is important for bondholders. The theoretical answer to this question relies on the seminal work on structural models of Black and Scholes (1973), and Merton (1974), in which stocks and bonds are contingent claims on the firm's underlying assets and therefore share common risk factors that are affected by information about the firm. Later models and variations of these models are based on a similar notion (see e.g., Huang and Huang (2003)). For the purpose of this research I focus on Merton's (1974) model to demonstrate that firm-specific information should affect both the bonds and stocks of the same issuing firm.

According to the contingent claims approach of Merton (1974)[7], holding a corporate bond can be viewed as holding a combination of a riskless bond with face value (F) and a short position in a put option on the firm's assets (V) (held by the equity holders who have the right to put the assets back to the bondholders in the event of default) with strike price equal to the value of the riskless bond claims. This implies that the value of the bond at time to maturity (T) is equal to:

$$B_T = F - \max[F - V_T, 0] \quad (1)$$

Since the payoff of the riskless bond is fixed, the value of the corporate bond is mainly dependent on the value of the put option. That is, any changes in the volatility of the firm's assets will change the price of the put option and consequently, the price of the corporate bond. When the volatility of the firm's assets increases (decreases), the value of the put option increases (decreases) accordingly. Since equity holders have the long position in the put option and bondholders have the short position in the put option, the increase in value of the put option increases the payoff for equity holders but reduces the payoff for bondholders. Indeed, this relationship may be different in practice as the value of the bond may change due to other factors such as selling pressure by institutional investors or market expectations for a bond downgrade. However, this relationship implies that theoretically both bonds and stocks react to common information. The value of the put option with payoff $\max(F - VT, 0)$ is given by the Black and Scholes (1973) option pricing formula.

$$P(t,T) = Fe^{-r(T-t)}N(-d + \sigma_V\sqrt{T-t}) - VN(-d) \quad (2)$$

with,

[7] The assumptions of the Merton's (1974) model are constant risk-free rate, a single zero-coupon bond liability maturing at time T, no arbitrage, no transaction costs, no taxes, zero bankruptcy costs and enforced protection of priority in bankruptcy, rational wealth maximizing shareholders, allowance of short selling, and assets of the firm follow geometric Brownian motion.

$$d = \frac{ln\frac{V}{F}+\left(r+\frac{1}{2}\sigma_V^2\right)(T-t)}{\sigma_V\sqrt{T-t}} \tag{3}$$

where, $P(t,T)$ is the put option price, *t* is the current time, *T* is the maturity date of the bond and put option, *r* is the risk-free rate, *V* is the current value of the firm, *F* is the face value of the debt, $F(t,T)$ is the current market value of the risk-free debt so that $F(t,T) = Fe^{-r(T-t)}$, σ_V^2 is the instantaneous variance of the return on the firm's assets, and $N(\cdot)$ is the univariate cumulative normal distribution function. The value of a corporate bond is then given by

$$B(t,T) = F(t,T) - P(t,T) = F(t,T)N(d - \sigma_V\sqrt{T-t}) + VN(-d) \tag{4}$$

Since equity can be viewed as a long position in a call option on the firm's assets, the value of the firm (V) and the volatility of $V(\sigma_V)$ can be estimated from

$$nS = VN(d) - Fe^{-r(T-t)}N(d - \sigma_V\sqrt{T-t}) \tag{5}$$

and

$$\sigma_e = \frac{V}{nS}\frac{\partial nS}{\partial V}\sigma_V = \frac{V}{nS}N(d)\sigma_V \tag{6}$$

where *n* is the number of shares outstanding, and *S* is the market price of the stock. σ_V^2 and *V* can be found by simultaneously solving Equations (5) and (6). σ_e can be estimated using historical data.

If at time (*T*) the value of the firm (*V*) is greater than (*F*), the equity holders will make payments to bondholders. On the other hand, if at time (*T*) the value of the firm (*V*) is lower than (*F*), the firm defaults and the bondholders will take control over the firm. That is, in the case of default, bondholders will incur an economic loss equal to the difference between the face value of debt and the value of assets. This implies that the upside for bondholders is limited - their maximum payoff is capped as they receive only fixed payments (in practice they receive only coupons and principal but no dividends). The downside for bondholders however, can become considerable; in case of bankruptcy bondholders can lose a substantial portion of their initial investment.

Since a firm with more volatile equity is more likely to approach the condition for default, the firm's equity volatility affects the bond price. Campbell and Taksler (2003) find that idiosyncratic equity volatility explains as much variation in corporate bond spreads as credit ratings explain. Option implied volatility is forward looking in nature. It contains important information about investors' expectation of future prices, and therefore is generally a better predictor than historical volatility (see for example Christensen and Prabhala (1998)).[8] Hence, I choose option implied volatility as measure of volatility. Equation (4) implies that the volatility of a firm's assets will affect the value of the bond. Volatility of a firm's assets will change with the arrival of news about the market expectation of the firm's future performance. Equation (6) implies that the prices of equities and bonds are linked through σ_V^2 and they should therefore respond to information affecting the asset value. However, they will not respond in exactly the same fashion because equity value increases with increasing asset volatility while bond prices decrease. Therefore, information which is predictive of stock returns should theoretically be important for bondholders. This theoretical relationship is backed by empirical evidence that news which is important for stockholders is important for bondholders (e.g., Easton et al. (2009)).

The conflict of interests between bondholders and shareholders is also pertinent to this research and is well reflected in the seminal work on the theory of the firm and agency costs of Jensen and Meckling (1976), in which bondholders and shareholders have different interests and incentives. Shareholders have the incentive to increase risk in order to increase

[8] For the long term, historical equity volatility may be a better predictor of information.

gains at the expense of bondholders, whereas bondholders' preference is to reduce risk in order to serve debt. The upside for shareholders is theoretically unlimited as they receive residual claims (e.g., dividends) over the firm whereas the upside for bondholders is limited - their maximum payoff is capped as they receive only fixed payments (coupons and principal but no dividends). The downside for bondholders however can become considerable; in a case of bankruptcy, bondholders can lose a substantial portion of their initial investment. This implies an asymmetric payoff for stockholders and bondholders. That is, good news about the firm translates to a higher increase in stock prices than bond prices and bad news about the firm translates to a higher decrease in bond prices than stock prices. Moreover, bad news has a greater effect on bond prices than good news due to the unlimited (limited) downside (upside) of bondholders. In addition, since firms with lower rated bonds are, by definition, closer to financial distress, news that affects stock prices should have a greater effect on lower rather than higher rated bonds (lower rated bonds are more volatile and behave like stocks (Easton et al. (2009))).

The notion that common information about the firm should affect both the bonds and the stocks of the issuing firm, but with an asymmetric payoff for bond and stock holders and greater effect on lower rated bonds than higher rated bonds, is consistent with the recent evidence in Easton et al. (2009). The authors examine whether the well documented role of earnings announcements in equity markets (e.g., Ball and Brown (1968), Beaver (1968), Kothari (2001)), also applies in the corporate bond market. They argue that the theoretical relationship between stocks and bonds implies that news, in the form of earnings announcements, should affect corporate bonds. Easton et al. (2009) show that the nonlinear payoff structure of bonds, in which bonds' payoff can be replicated by taking a long position in the issuing firm's assets and a short position in a call option on those assets (e.g., Black and Scholes (1973) and Merton (1973)), has important implications for the role of earnings news in the corporate bond market. This nonlinear payoff structure implies that the upside to investing in bonds is limited whereas the downside is considerable. An expected value of future cash flows greater than the face value of debt will result in fixed coupon payments to bondholders. However, if stockholders believe that the assets are worth less than the face value of debt, they will default. In this case, bondholders will incur a loss equal to the difference between the value of the firm's assets and the face value of debt. Specifically, Easton et al. (2009) find that earnings announcements have greater effect on higher-risk (lower rating) bonds, and that bad news in earnings announcements have greater impact on bond returns than good news, which is consistent with the nonlinear payoff structure of bonds.

The theoretical work and supporting empirical evidence on the relationship between bonds and stocks, and the effect of news about a firm on bond and stock prices, have important implications for this research. I measure information arrivals about a specific firm using measures of options traded on the same firm. Similar to Easton et al. (2009), these measures of news arrivals and information about the firm's future cash flows are well documented in equity markets but not in the corporate bond market.

If bonds and stocks react jointly to common risk factors, changes in bond and stock (of the same issuing firm) prices should be correlated. The correlation between the stocks and the bonds of the issuing firm depends on whether news about the firm affects the firm's mean return or the firm's return volatility. For instance, Kwan (1996) uses weekly dealer-quote bond returns, to document a positive (negative) relationship between stock and bond returns (yield changes), and concludes that firm-specific information about the firm's mean returns, and not the variance of returns, tends to drive stock and bond prices. Kwan also documents a lead-lag relationship where bond returns are correlated with lagged stock returns of the same firm. These results are consistent with Downing et al. (2009) who use high frequency data (hourly and daily) and find that stock returns lead bond returns in the BBB and lower credit classes, but in contrast to Hotchkiss and Ronen (2002) who find no lead-lag relationship but that stock and bond returns react jointly to common factors.

2.3.2 The informational role of options

There is wide agreement in the literature that informed traders favor the options market and that option prices and volume lead equity prices, and play an important informational role. Black (1975) for example, suggests that when investors have important information, they may choose to trade in options over investing directly in the underlying stock because they can achieve more this way for a given investment. Manaster and Rendleman (1982) propose that informed investors disseminate private information through options trading, and Easley et al. (1998) suggest that markets in which informed traders operate, will lead other markets with lesser informed traders. One such market for informed traders is the options market as it offers advantages over other markets, such as low transaction costs, high leverage, and no short-sale restrictions. Amin and Lee (1997) find that trading volume is predictive of earnings information, and Cao et al. (2005) show that option order imbalance can predict stock response subsequent to take-overs. More recently, in order to examine the informational role of options, Pan and Poteshman (2006) use propriety data to construct put-call ratios from option volume initiated by buyers to open new positions. They find that stocks with low put-call ratios outperform stocks with high ratios by more than 40 basis points on the next day and more than 1% over the next week. However, Pan and Poteshman (2006) show that these results hold only for their propriety measure of option volume which is not observable by market participants, and that the predictive power for stock returns of publicly available option volume is low.[9]

[9] See also Grossman (1977), Diamond and Verrecchia (1987), Jennings and Starks (1986), Bhattacharya (1987), Conrad (1989), Kumar et al. (1992), Figlewski and Webb (1993), Back (1993), Biais and Hillion (1994), Easley et al. (1998), Chakravarty et al. (2004), Ofek et al. (2004) and Cao et al. (2005) among others.

Option implied volatility is considered as a better predictor of future volatility than historical measures (Christensen and Prabhala (1998)) and a number of recent studies show that option implied volatility can predict stock returns. Evidence on the effect of equity volatility on bonds is provided by Campbell and Taksler (2003) who examine the cross-sectional and time-series effect of firm equity volatility on corporate bond spreads. While controlling for various risk and liquidity factors, the authors find that idiosyncratic equity volatility explains as much of the variation in corporate bond spreads as credit ratings do.

Option implied volatility is forward looking in nature, and contains important information about investors' expectation of future prices, and therefore is a better predictor than historical volatility. Bali and Hovakimian (2009) examine the relation between expected returns and the realized-implied volatility spread[10] which can be viewed as a proxy for volatility risk. In addition, they examine the relation between expected returns and the call-put implied volatility spread[11] which can be viewed as a proxy for jump risk. They find that both of these relations are economically and statistically significant with a negative relation for the realized-implied volatility spread, and a positive relation for the call-put implied volatility spread. Specifically, for the period February 1996 – January 2005, they find that a trading strategy that goes long (short) on stocks with the lowest (highest) realized-implied volatility spread produces monthly average returns of between 63 and 73 (59 and 63) basis points for the value-weighted (equal-weighted) portfolios. A trading strategy that goes long (short) on stocks with the highest (lowest) call-put implied volatility spread[12] produces monthly average returns of between 1.05% and 1.14% (1.43% and 1.49%) for the value-weighted (equal-weighted) portfolios.

[10] This is the difference between the historical volatility of a stock and the option implied volatility of that stock.
[11] This is the difference between call and put implied volatilities of the same stock.
[12] To calculate this spread, Bali and Hovakimian (2009) use at-the-money options with absolute values of the natural log of the ratio of the stock to exercise price less than 0.1, and average the implied volatilities across all eligible options.

In a similar vein, Cremers and Weinbaum (2010) study the information contained in put-call parity deviations for expected stock returns. As a measure of deviation, they use the volatility spread, which they calculate as the difference in implied volatility between call and put options on the same underlying stock with the same strike price and expiration date while averaging this spread across all pairs of call and put options. Cremers and Weinbaum (2010) document a statistically and economically significant relation between expected stock returns and deviation from put-call parity for the period January 1996 – December 2005 and with 1-4 week ahead prediction (stronger for the 1-week ahead). In particular, a portfolio that is long stocks with expensive calls (high volatility spread) and short stocks with expensive puts (low volatility spread) produces 50 basis points per week (value-weighted and risk adjusted). The volatility spread prediction power declined from the first half of their sample (70 basis points per week in 1996-2000) to the second half (33 basis points per week in 2001-2005) which the authors interpret as a reduction of mispricing over time.

Xing, Zhang, and Zhao (2010) document significant stock return predictability and information content for the volatility smirk of the individual options, which is defined as the difference between the implied volatilities of out-of-the-money put options and the implied volatilities of at-the-money call options. Since out-of-the-money put options are a natural investment for informed traders with negative news, these options become very expensive (compared to at-the-money call options), and so the volatility smirk turns more pronounced before big negative jumps in stock prices. Xing, Zhang, and Zhao (2010) find that for the period January 1996 – December 2005 stocks with steeper volatility smirks underperform stocks with flatter smirks by 10.90% per year (risk adjusted). Similarily, Bates (1991) shows that out-of-the-money put options on the S&P 500 become unusually expensive (and volatility skew prominent) before negative price jumps.

Lastly, Ang et al. (2010) document significant stock return predictability using changes in option implied volatility (innovations), a measure of news arrival, defined as the first difference in option implied volatilities over the past month. Ang et al. (2010) find that the information content in put and call options is different. An increase in call option volatility over the past month indicates high expected returns, whereas an increase in put option volatility indicates a decrease in future returns. Specifically, for the period January 1996 – September 2008, Ang et al. (2010) find that the difference between the top and bottom portfolios, formed on past changes in call (put) option volatility, produces returns of approximately 1% (60 basis points) per month.

In contrast to equity markets, the evidence on the relationship between option volatilities and bond returns is scarce. The study by Cremers, Driessen, Maenhout, and Weinbaum (2008) is perhaps the only attempt to relate option volatilities to the credit spread of corporate bonds.[13] Using weekly data on 69 US firms for the period January 1996 – September 2002, Cremers et al. (2008) examine the contemporaneous but not predictive explanatory power of option implied volatility[14] on the issuing firm's credit spread. They use at-the-money option implied volatilities as a proxy for volatility risk, and the implied volatility skew as a proxy for jump risk, calculated as the difference between the implied volatility of an out-of-the-money put with strike-to-spot ratio closest to 0.92 and the implied volatility of an at-the-money put, divided by the difference in strike-to-spot ratios. The authors then find that these measures are useful in explaining credit spreads beyond the information contained in historical volatility (i.e., in Campbell and Taksler (2003)).

[13] In the credit default swap market for example, Cao, Yu and Zhong (2010) examine the relation between option implied volatility and credit default swap spreads and find that individual firms' put option-implied volatility dominates historical volatility in explaining the time-series variation in CDS spreads.
[14] The implied volatility of an individual stock is calculated as the average of the call and put option implied volatilities.

2.3.3 Hypotheses development

Theoretically, equity and bonds of a firm and options on the same firm are related (Merton (1974)). Therefore, information about the firm should affect both the stock and bond prices. In addition, as discussed in the previous subsection, options and option volatility contain information which is predictive of stock returns as informed traders prefer the options market over the equity market due to various advantages that the options market offers over the stock market (e.g., leverage). Similarly, due to the same advantages and all else equal, informed traders should prefer the options market over the bond market. Thus, if options incorporate news in advance of stocks, they should do so in advance of bonds.

This hypothesis follows Ang et al. (2010) who document significant stock return predictability using changes (innovations) in option implied volatility (measured as the first difference in volatilities over one month), which is a measure of news arrivals. Ang et al. (2010) provide plausible rational and behavioral explanations for this predictability. The rational explanation is supported by the demand-based option pricing models of Bollen and Whaley (2004) and Gârleanu et al. (2009) in which if traders of options have an information advantage and choose to trade options, then options will lead the underlying stock prices. Based on Bollen and Whaley (2004) subsequent to demand by informed traders, which drives option prices, changes in implied volatility follow. These changes in implied volatility are the result of private information and are not immediately incorporated into the underlying stock price. Therefore, these changes indicate future changes in the underlying stock price. In a similar way, changes in implied volatility should precede changes in corporate bond prices. The behavioral explanation is based on under-reaction to information such as in Hong and Stein (1999). Better informed investors will trade in option markets. Investors in the stock market, who are less sophisticated and informed, do not take into account news from option markets. Therefore, stock prices will be slow to react and incorporate the news from options, hence the options' ability to predict stock returns. However, Ang et al. (2010) state that the behavioral explanation is less likely as it usually applies to longer investment horizon than the one they use (one month).

Since information should affect both bond and stock prices, if information is embedded in changes in option implied volatility prior to stock prices we should observe a similar effect in the bond market.[15] This discussion leads me to hypothesize that if informed traders operate in the options market with private information, and information is incorporated into options prior to stock prices, then in a similar fashion, I should expect that information is embedded in options prior to bond prices. This should apply even if option traders are not informed but merely possess better information processing ability. Specifically, since a larger (smaller) change in option implied volatility may indicate a higher (lower) level of future uncertainty to the firm, we should observe a decreased (increased) future bond price for increased implied volatility.[16] That is, options trading should be predictive of bond prices and formally:

H1a: *Larger (smaller) changes in option implied volatility indicate lower (higher) future bond prices.*

In addition to changes in implied volatility I also use other option trading measures known to predict stock returns. Specifically, I use the volatility skew as in Xing et al. (2010), the put-call spread as in Cremers and Weinbaum (2010), and *O/S* as in Johnson and So (2011).

[15] In the context of this research, it is not necessarily the case that options traders are more sophisticated investors than bond investors who are usually large institutional investors rather they might possess private information not available to institutional investors.

[16] Theoretically, increase in σ_V^2 results in a decrease in the value of the short put position (Merton 1974). That is, an increase in the volatility of the firm benefits equityholders at the expense of bondholders.

I recognize that bond investors are generally sophisticated and professional institutional investors such as insurance companies, pension and retirement funds, mutual funds, commercial banks, and foreign investors (Campbell and Taksler (2003)). It is therefore plausible that these sophisticated bond investors have superior information processing ability. In addition, bond investors may have access to private information. Thus, if bond investors possess better information processing ability (or access to private information) and they choose to disseminate this information via bond trading, bond prices will incorporate information prior to, and lead, option prices.

Indeed, bond investors may choose to trade on their information in the options market and take advantage of the high leverage options offer, in which case, options will lead bond prices. However, there are at least four reasons why bond investors may choose to trade in the bond market prior to the options market. First, bond investors have easier access to bonds than options. This allows them to execute their trades in a faster manner in bonds over options. Second, large transactions may be more easily executed in the bond market than in the options market. Third, due to the large average transaction size in the bond market,[17] bond investors may be able to camouflage their private (or insider) information in a better way in the bond market. Fourth, in a case where bond investors already possess bonds which are about to receive bad news, they will opt to sell these off their portfolios. This is particularly true for investment-grade bonds, since regulated financial service institutions such as pension funds and insurance companies mainly hold investment-grade bonds as they are restricted in the amount of non-investment grade bonds that they are allowed to hold.

Related to this research are a number of recent papers that have examined the predictability of option prices. For example, Ang et al. (2010) document that high stock returns over the past month indicate higher future call option prices. Christoffersen, Goyenko,

[17] For example, Bessembinder et al. (2006) note that the average transaction size for institutions in the corporate bond market is $2.7 million.

Jacobs and Karoui (2011) find illiquidity premia in the equity options market. Specifically, they find that an increase in option illiquidity decreases the current option price and implies higher expected option returns. Cao and Han (2013) find that returns on option prices decrease with an increased idiosyncratic volatility (of the underlying stock). The above mentioned papers indicate that information may be incorporated in stock prices prior to option prices. In a similar way, bond prices may incorporate information prior to option prices.

The above discussion leads me to hypothesize that:

H1b: *Bond prices incorporate information prior to, and lead, option prices.*

Again, note that options are written on the underlying stocks not bonds, that is, bond prices will lead option prices if indeed the theoretical relation between bond and option prices (as discussed above) holds.

2.4 Data and Sample Characteristics

2.4.1 Stocks, options and bonds data

This study spans the period July 2002 to April 2011. Data on stock returns is taken from the Center for Research in Security Prices (CRSP). I obtain options data from the OptionMetrics database. It contains daily closing bid and ask prices, open interest, volume, and implied volatilities for options on individual stocks traded on NYSE, AMEX, and NASDAQ. Options on stocks are American style and implied volatilities are calculated using a binomial tree, taking into account expected discrete dividend payments and the possibility of early exercise. The interest rate used by OptionMetrics is historical LIBOR/Eurodollar rates. OptionMetrics then computes the implied volatility surface from the interpolated implied volatility surface (separately for puts and calls) using a kernel smoothing algorithm. The fitted implied volatilities are reported on a grid of fixed maturities of 30, 60, 90, 180 and 250 days, and fixed option deltas of 0.20, 0.25, …, 0.80 for calls, and -0.8, -0.75, …, -0.20 for puts. One advantage of the volatility surface is that it eliminates the need to choose which strikes or maturities to use in calculating implied call or put volatilities for each stock (Ang et al. (2010)).

The source for bond price, size, and time of transaction is the Trade Reporting and Compliance Engine database (TRACE).[18] Commencing on July 1, 2002, and fully implemented in February 7, 2005, after the SEC's decision to improve corporate bonds transparency, TRACE now covers transactions of all publicly traded OTC corporate bonds.[19] Data on issue- and issuer-specific variables such as coupon rate, maturity, issue amount, provisions, and credit ratings are from the Mergent FISD.

[18] The National Association of Securities Dealers (NASD) now requires dealers to report all over-the- counter (OTC) bond transactions through its TRACE.

[19] See Bessembinder et al. (2006) and Edwards, Harris and Piwowar (2007) for a comprehensive description of TRACE. A SAS program to clean up the TRACE data for some known issues was obtained from Professor William F. Maxwell's website (http://www.cox.smu.edu/web/william-maxwell/).

2.4.2 Sample selection

I follow the data cleaning procedure in Bessembinder, Kahle, Maxwell and Xu (2009) and eliminate all canceled, corrected, and commission trades and retain regular trades. I also exclude bonds which are in foreign currency, perpetual, in bankruptcy, unit deal, fungible, exchangeable, redeemable, convertible, asset backed, putable, coupon frequency different from 2, missing prices, and bonds with less than 15-month of transaction records (as in Lin et al. (2011)).

I compute monthly bond returns by first computing daily prices as the trade-size weighted average of intraday prices. This is consistent with the findings in Bessembinder et al. (2009) that a daily price based on trade-size weighted intraday prices is less noisy than the last price of the day. As in Jostova, Nikolova, Philipov and Stahel (2013), the month-end price is set to be the last available daily price from the last five trading days of the month. I compute monthly returns as:

$$R_{i,t+1} = \frac{\left((P_{i,t+1}+AI_{i,t+1})+C_{i,t+1}\right)-(P_{I,t}+AI_{i,t})}{P_{I,t}+AI_{i,t}} \tag{7}$$

where $P_{i,t+1}$ is the bond's last price in month $t+1$, $AI_{i,t+1}$ is its accrued interest at month-end $t+1$, which is the coupon payment scaled by the ratio of days since the last payment date to the days between last payment and next payment, and $C_{i,t+1}$ is any coupon payment made between month-end t and month-end $t+1$. Bond excess return is then calculated as bond return (as in Equation (7)) minus the risk-free rate.

2.4.3 Descriptive statistics

Table 1 presents summary statistics for the corporate bond sample which contains 25835 bond-month return observations. The mean and median monthly returns are -0.091% and 0.006%, respectively. The mean firm size in the samples (in millions of dollars) is 31669 and the median firm size is 14187 indicating that firms with both options and bonds are large which will eliminate the concern that results are driven by returns of small companies. The mean (median) corporate bond issuance amount is \$3.2 billion (\$2.5 billion), reflecting the sheer size of the corporate bond market. The average (median) transaction amount in the sample is close to \$500,000 (\$25,000) providing an indication that trades in this market are made mainly by large institutions. A close look at the bond characteristics in the sample reveals a mean (median) coupon rate of 7.27 (7.15) with a mean (median) yield of 6.17% (5.58%). Bonds in the sample have an average (median) of 8.9 (5.42) years to maturity and have an average (median) of 9.32 (8.9) years since issuance ('age' of the bond). I also provide information on credit ratings of bonds (*RATING*) in the sample. To calculate the variable *RATING*, I convert the credit rating provided by S&P into a numeric scale where AAA=1…D=22 or, if unavailable, by Moody's where Aaa=1...C=21 (see Table 3 in Appendix A for full description). Ratings 1 through 10 (11 through 22) are investment grade (non-investment grade) corporate bonds. The mean and median *RATING* in the sample are 8.87 and 8, respectively, which translate to about investment grade (BBB+ in S&P or Baa1 in Moody's) corporate bonds.

Table 1 also provides descriptive statistics of options trading measures used in this study. Specifically, I use innovations (first monthly difference - denoted Δ) in the average at-the-money (delta of 0.50 and 30 days to maturity)[20] call and put option implied (*IMPLIED VOLATILITY*) as in Ang et al. (2010), the volatility skew is defined as the difference between the implied volatilities of out-of-the-money (delta of -0.20 and 30 days to maturity) put and at-the-money call options (*SKEW*) as in Xing et al. (2010), the implied volatility put-call

[20] I follow the literature (e.g., Ang et al. (2010)) and use options with 30 days to maturity. Ang et al. (2010) find similar predictive ability of options with 91 days to maturity.

Table 1

Summary Statistics

This table presents descriptive statistics of U.S. corporate bonds and options pooled across the sample for the period July 2002 to April 2011. There are 25835 bond-month observations. *SIZE* is market capitalization in millions of dollars, calculated as number of shares outstanding times share price. *RETURN* is the percentage bond excess return calculated as the difference between bond return and the risk free rate. *ISSUANCE* is the bond issuance amount. *COUPON* is the bond coupon rate. *TRADE SIZE* is the transaction size in thousands of dollars. *YIELD* is the bond's current yield. *RATING* is a numerical representation of the credit rating provided by S&P (AAA=1…D=22) or, if unavailable, by Moody's (Aaa=1...C=21). *TIME TO MATURITY* is the bond time to maturity in years. *AGE* is the time since issuance in years. Options measures are calculated as the monthly first difference (Δ) where *IMPLIED VOLATILITY* is the average at-the-money (delta of 0.50 and 30 days to maturity) call and put option implied volatilities. *CALL VOLATILITY* and *PUT VOLATILITY* are monthly volatility innovations in call and put option implied volatility, respectively. *SKEW* is the difference between implied volatility of out-of-the-money put options with delta of -0.20 and 30 days to maturity and implied volatility of at-the-money call options with delta of 0.50 and 30 days to maturity. *PUT-CALL SPREAD* the implied volatility put-call spread, defined as the difference between the implied volatilities of at-the-money put and at-the-money call options. *O/S* is the ratio of options trading volume to stock trading volume. *CALL VOLUME* and *PUT VOLUME* are the total options trading volume for call and put options, respectively.

	Mean	Min	Q1	Median	Q3	Max	Std
SIZE ($M)	31669	25	5919	14187	34611	279695	48285
RETURN (%)	-0.091	-17.476	-1.843	0.006	1.417	17.484	3.758
ISSUANCE	322285	50000	175000	250000	350000	2500000	277697
COUPON	7.268	3.2	6.625	7.15	7.875	11.875	1.167
TRADE SIZE	496.7	0.25	10	25	100	1665000	10476.7
YIELD (%)	6.17	0.022	4.289	5.584	6.741	714.663	7.776
RATING	8.867	1	6	8	11	21	4.27
TIME TO MATURITY	8.898	0.005	2.205	5.421	15.005	89.997	8.474
AGE	9.321	0.085	6.244	8.899	12.132	24.956	4.332
Δ*IMPLIED VOLATILITY*	-0.004	-1.477	-0.03	-0.003	0.023	1.225	0.086
Δ*CALL IMPLIED VOLATILITY*	-0.004	-1.963	-0.032	-0.003	0.024	1.96	0.092
Δ*PUT IMPLIED VOLATILITY*	-0.004	-1.461	-0.031	-0.003	0.024	1.16	0.089
Δ*SKEW*	0	-1.711	-0.022	-0.001	0.02	2.195	0.075
Δ*O/S*	0	-34.086	-0.039	0	0.038	34.17	0.74
Δ*PUT-CALL SPREAD*	0	-1.492	-0.01	0	0.01	2.156	0.052
CALL VOLUME	6702	0	346	1690	6070	873963	28338
PUT VOLUME	4627	0	220	1133	4042	489722	16056

spread, defined as the difference between the implied volatilities of at-the-money put and at-the-money call options (*PUT-CALL SPREAD*) as in Cremers and Weinbaum (2010), and the ratio of options trading volume to stock trading volume (*O/S*) as in Johnson and So (2011).

Table 2 presents the sample correlations for the main variables. Notably, the variable of interest, bond excess return (*RETURN*), is statistically significantly correlated with 3 of the 4 option measures (I use contemporaneous monthly changes) - *IMPLIED VOLATILITY*, *SKEW*, *PUT-CALL SPREAD*, and with *COUPON* and *TIME TO MATURITY*. *IMPLIED VOLATILITY* is correlated with *SKEW* and *O/S* and *SKEW* is correlated with the *PUT-CALL SPREAD*. In order to eliminate a multicollinearity concern in the regression setting I use a combination of a number of different models.

Table 2

Spearman's Rank Correlation

Sample Period: July 2002 – April 2011

This table presents the Spearman's rank correlations for various variables. *RETURN* is the percentage bond excess return calculated as the difference between bond return and the risk free rate. Options measures are calculated as the monthly first difference where *IMPLIED VOLATILITY* is the average call and put option implied volatility. *SKEW* is the implied volatility skew, defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options. *PUT-CALL SPREAD* the implied volatility put-call spread, defined as the difference between the implied volatilities of at-the-money put and at-the-money call options. *O/S* is the ratio of options trading volume to stock trading volume. *RATING* is a numerical representation of the credit rating provided by S&P (AAA=1…D=22) or, if unavailable, by Moody's (Aaa=1...C=21). *COUPON* is the bond coupon rate. *ISSUANCE* is the bond issuance amount. *AGE* is the time since issuance in years. *TIME TO MATURITY* is the bond time to maturity in years. Correlation values in bold are significant at the 1 % level.

	Δ*IMPLIED VOLATILITY*	Δ*SKEW*	Δ*PUT-CALL SPREAD*	Δ*O/S*	*RATING*	*COUPON*	*ISSUANCE*	*AGE*	*TIME TO MATURITY*
RETURN (%)	**-0.06**	**-0.03**	**-0.02**	-0.01	0.02	**0.02**	0	-0.01	**0.06**
Δ*IMPLIED VOLATILITY*		**-0.02**	0.01	**0.08**	0	-0.01	0	0.01	**-0.02**
Δ*SKEW*			**0.40**	-0.01	0	-0.01	0	0	-0.01
Δ*PUT-CALL SPREAD*				0	0	0	0	0	0
Δ*O/S*					0.01	0	0	0.01	0
RATING						**0.27**	**-0.08**	**0.02**	**0.15**
COUPON							**-0.07**	**0.49**	**0.23**
ISSUANCE								**-0.29**	0
AGE									**0.11**

2.5 Options Trading and Corporate Bond Returns

This section examines the predictive ability of options trading in the corporate bond market and formally tests H1a. I test H1a using both the Fama and MacBeth (1973) methodology and portfolio sorts setting and perform robustness tests to validate the results.

2.5.1 Fama-MacBeth regressions

In order to formally test if options trading is predictive of corporate bond returns (H1a), I estimate the following monthly Fama-MacBeth regressions:

$$R_{i,t+1} – R_{f,t+1} = b_0 + b_1F_{i,t} + b_2X_{i,t} + e_i \tag{8}$$

where $R_{i,t+1}$ is bond's i return as in Equation (7) over month $t+1$ and $R_{f,t+1}$ is the monthly risk free rate (one-month T-bill) over month $t+1$. F_i is a vector of options trading measures observed in month t and includes the four measures described in Subsection 2.4.3 - Δ*IMPLIED VOLATILITY*, Δ*SKEW*, Δ*PUT-CALL SPREAD*, and Δ*O/S*. X_i is a vector of control variables for firm i, observed in month t. Specifically, in order to separate the predictive power of options trading from other potential explanatory variables, I use 5 bond-specific control variables commonly used in the literature (e.g., Lin et al. (2011)) – *RATING*, *COUPON*, *OFFERING*, *AGE* and *TIME TO MATURITY* (all described in Subsection 2.4.3). e_i is the error term.

Following the Fama and MacBeth (1973) methodology, the regression is estimated for all bonds for each month (cross-sectional regressions). I then report the cross-sectional coefficients averaged across the sample (average of the time-series of all coefficients). I run the cross-sectional regressions at a monthly frequency over 105 months from August 2002 to April 2011 (the period where bond data is available from TRACE). In order to account for autocorrelation, I use the Newey and West (1987) correction to compute t-statistics for these regressions.

Table 3 summarizes the results of the regressions from Equation (8). I estimate 10 different models to allow for various combinations of vectors F_i and X_i. I start by estimating univariate regressions with only one option trading measure as the independent variable in Model 1 – Model 4 where the measures are Δ*IMPLIED VOLATILITY*, Δ*SKEW*, Δ*PUT-CALL SPREAD*, and Δ*O/S*, respectively. Model 1 indicates that the coefficient on Δ*IMPLIED VOLATILITY* is negative (-0.04) and statistically highly significant (at the 1% level with t-statistic of -5.35). This suggests that information is incorporated into option prices prior to bond prices. Specifically, when options traders possess private information or simply when they process information better than other traders, they opt to buy options for reasons discussed in Section 2.4. In turn, this demand drives the implied volatility (as in Bollen and Whaley (2004)), resulting in bond return predictability. A larger (smaller) change in option implied volatility may indicate a higher (lower) level of future uncertainty to the firm, hence the negative relationship between changes in implied volatility and expected bond returns. This provides initial support for the hypothesis that an increase (decrease) in option implied volatility should indicate lower (higher) future bond prices.

To provide the economic significance of the average slope coefficients in Table 3, on *ΔIMPLIED VOLATILITY*, I examine the empirical cross-sectional distribution of changes in implied volatility over the full sample. The difference in *ΔIMPLIED VOLATILITY* values between average stocks in the first and fifth quintiles is 0.191 (Table 5). If a firm were to move from the first quintile to the fifth quintile of implied volatilities (holding its other characteristics constant), what would be the change in that firm's expected return? The *ΔIMPLIED VOLATILITY* coefficient of -0.040 in Table 3 represents an economic effect of a

Table 3
Fama-MacBeth Regressions
Sample Period: July 2002 – April 2011

This table presents Fama-MacBeth regressions results from regressing monthly bond excess return on various options measures (all measured as the monthly first difference) and bond characteristics. Bond excess return is calculated as the difference between bond return and the risk free rate. *IMPLIED VOLATILITY* is the average call and put option implied volatility. *SKEW* is the implied volatility skew, defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options. *PUT-CALL SPREAD* is the implied volatility put-call spread, defined as the difference between the implied volatilities of at-the-money put and at-the-money call options. *O/S* is the ratio of options trading volume to stock trading volume. *RATING* is a numerical representation of the credit rating provided by S&P (AAA=1…D=22) or, if unavailable, by Moody's (Aaa=1...C=21). *COUPON* is the bond coupon rate. *OFFERING* is the bond issuance amount. *AGE* is the time since issuance in years. *TIME TO MATURITY* is the bond time to maturity in years. #Bond-month observations=24596. *t*-statistics are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**	**Model 8**	**Model 9**	**Model 10**
Intercept	-0.001	0.000	0.000	0.000	0.000	0.002	0.002	0.003	0.002	0.001
	(-0.31)	(-0.24)	(-0.21)	(-0.21)	(-0.27)	(-0.58)	(-0.65)	(-0.79)	(-0.57)	(-0.4)
Δ*IMPLIED VOLATILITY*	-0.040***				-0.041***	-0.036***				-0.037***
	(-5.35)				(-5.14)	(-5.47)				(-5.21)
Δ*SKEW*		-0.015**			-0.019**		-0.015**			-0.020***
		(-2.16)			(-2.49)		(-2.40)			(-2.68)
Δ*PUT-CALL SPREAD*			-0.025**		-0.008			-0.021*		-0.004
			(-1.99)		(-0.65)			(-1.98)		(-0.37)
Δ*O/S*				0.481**	0.692***				0.472**	0.608***
				(2.24)	(3.64)				(2.34)	(3.15)
RATING						0.001	0.001	0.001	0.001	0.001
						(-0.51)	(-0.45)	(-0.51)	(-0.38)	(-0.79)
COUPON						0.001	0.001	0.001	0.001	0.001
						(-0.85)	(-0.79)	(-0.91)	(-0.66)	(-0.88)
Ln(OFFERING)						0.000	0.000	0.000	0.000	0.000
						(-1.29)	(-1.22)	(-1.24)	(-1.44)	(-1.20)
AGE						0.001	0.001	0.001	0.001	0.001
						(-0.66)	(-0.74)	(-0.98)	(-0.79)	(-0.54)
TIME TO MATURITY						0.001	0.001	0.001	0.001	0.001
						(-0.59)	(-0.65)	(-0.64)	(-0.62)	(-0.56)
R^2	0.025	0.013	0.015	0.007	0.050	0.117	0.111	0.112	0.107	0.140
Adj. R^2	0.020	0.008	0.010	0.002	0.031	0.089	0.083	0.084	0.079	0.099

decrease of -0.040x0.191x100%= -0.764% per month in the average firm's expected return of a firm moving from the first to the fifth quintile of implied volatilities. Economically, these are large effects. For comparison, Ang et al. (2010) present an average of 0.70% return per month for stocks based on changes in option implied volatility in the previous month.

In Models 2 and 3 the coefficients on both Δ*SKEW* and Δ*PUT-CALL SPREAD* are negative (-0.015 and -0.025, respectively) and statistically significant (at the 5% level with t-statistics of -2.16 and -1.99, respectively). Xing et al. (2010) argue that since out-of-the-money put options are a natural investment for informed traders with negative news, these options become very expensive (the volatility skew more pronounced) before big negative jumps in stock prices. Consistent with the results of Model 1, the negative coefficients on Δ*SKEW* and Δ*PUT-CALL SPREAD* indicate that options traders opt to buy both out-of-the-money and at-the-money put options (and not just selling call options) when they possess negative information. The bond return predictability using these measures is a result of a more (less) pronounced volatility skew and larger (smaller) spread due to the demand for put options when traders possess negative (positive) news about the firm. In turn, the news affects both the stock and bond prices of the issuing firm.

Model 4 shows that the coefficient on Δ*O/S* is positive (0.481) and statistically significant (at the 5% level with t-statistic of 2.24) indicating that an increase in options trading volume relative to stock trading volume predicts an increase in future bond prices. While the coefficient on Δ*O/S* is positive, since Δ*O/S* is not constructed using implied volatilities (all other measures are), the direction of prediction (positive/negative) is not necessarily similar to the direction of prediction of measures of implied volatility. In Model 5 I use all four measures. The coefficient on Δ*IMPLIED VOLATILITY* is still statistically highly significant and has the largest t-statistic. The coefficient on Δ*SKEW* is of the same magnitude as in Model 2 and the coefficient on Δ*PUT-CALL SPREAD* now becomes insignificant while the coefficient on Δ*O/S* has a higher t-statistic than in Model 4. While the change in magnitude of the coefficients could be due to correlation, Model 5 still supports the results of the univariate regressions. In Model 6 – Model 9 I introduce control variables and I use each option trading measure (as in Models 1 – 4) with all control variables. In Model 10, I use all option trading measures with all control variables. Adding the control variables does not change the main inference. In all of Models 6 – 10 the coefficient of ΔImplied Volatility still has the highest t-statistic (significant at 1%) followed by Δ*O/S* and Δ*SKEW*, and with Δ*PUT-CALL* being insignificant. The insignificant coefficients on the control variables is consistent with the results in Lin et al. (2011). To summarize, the results of the Fama-MacBeth regressions indicate that options trading and mainly the measure of changes in implied volatility *(*Δ*IMPLIED VOLATILITY*) have strong predictive ability of corporate bond returns.

2.5.2 Fama-MacBeth regressions – sub-sample analysis

In the previous section I documented that options trading is predictive of corporate bond returns. I now test this predictive ability in various sub-samples. Specifically, I rerun Fama-MacBeth regressions as in Model 1 (highest t-statistic) while dividing the sample to two sub-groups based on: 1) *RATING*, where the sample is divided into investment grade and non-investment grade corporate bonds. Investment (non-investment) grade bonds are defined as bonds with credit rating better (worse) than BBB which translates numerically to below (above) 11 (10) in S&P rating. This will test if changes in implied volatility (as a proxy for new information) have greater effect on lower rated bonds as discussed in Subsection 2.3.1. 2) Period, where the sample is divided into July 2002 – December 2006 and January 2007 – April 2011. This will allow me to test the information content of option implied volatility focusing on the period which includes the 2007-2008 liquidity and credit crunch

(Brunnermeier (2009)) that had a substantial effect on bond prices. 3) Firm Size, where the sample is divided into small and big firms based on the median value of market capitalization. This will allow me to test if the predictive ability of options is concentrated in smaller firms with more information asymmetry. 4) Return Sign, where the sample is divided into Negative (below 0 bond excess return) and Positive (above 0 bond excess return) sub-groups so I can test whether the predictive ability is sign specific. 5) Option Type, where the sample is divided into changes in implied volatilities of Call and Put options separately. This analysis will test if call and put options contain different information (as in Ang et al. (2010). 6) Age, where the sample is divided into two samples based on the median bond age in years. Since Age is a proxy for liquidity of bonds (see e.g., Bao, Pan and Wang (2011))[21] which ultimately affects bond prices, I examine the information content of options separately for low and high liquidity bonds.

Table 4 reports results of Fama-MacBeth regressions based on the above sub-samples. For *RATING*, while the coefficient on Δ*IMPLIED VOLATILITY* is smaller in magnitude compared to Model 1, it is still negative and statistically significant (at the 1% level) for both investment and non-investment grade bonds. However the absolute value of the coefficient (and t-statistic) for non-investment grade is higher than for investment grade bonds. This is consistent with the notion that information about the firm should have a greater effect on lower rated bonds due to the asymmetric payoff of bonds in which the upside is limited but the downside may be considerable (see e.g., Easton et al. (2009)).

For the sub-sample period, the coefficient on Δ*IMPLIED VOLATILITY* is higher for the period July 2002 – December 2006 with a highly significant t-statistic (at the 1% level) than for the period January 2007 – April 2011 where the coefficient is only significant at the 5% level.

[21] Older bonds are more likely to be absorbed in portfolios of institutional investors thus trade less frequently and be more illiquid.

Table 4

Fama-MacBeth Regressions - Sub-Samples

Sample Period: July 2002 – April 2011

This table presents Fama-MacBeth regressions results from regressing monthly bond excess return on *IMPLIED VOLATILITY* in various sub-samples. Bond excess return is calculated as the difference between bond return and the risk free rate. Implied Volatility is the monthly first difference of the average call and put option implied volatility. The sub-sample Credit Rating is divided into IG and NIG where IG (NIG) is Investment Grade (Non-Investment Grade) bonds with credit rating better (worse) than BBB (this translates numerically to below 11 or above 10, respectively, in S&P ratings). The sub-sample Period is divided into July 2002 – December 2006 and January 2007 – April 2011. The sub-sample Firm Size is divided into Small and Big firms by the median market capitalization. The sub-sample Return Sign is divided into Negative (below 0 bond excess return) and Positive (above 0 bond excess return). The sub-sample Option Type is divided into implied volatilities of Call and Put options. The sub-sample Age is divided into two samples based on the median bond age in years. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

	Credit Rating		**Period**		**Firm Size**	
	IG	**NIG**	**2002-2006**	**2007-2011**	**Small**	**Big**
Intercept	-0.001	-0.001	-0.002	0.001	-0.001	-0.001
	(-0.47)	(-0.30)	(-1.12)	-0.28	(-0.23)	(-0.44)
Δ*IMPLIED VOLATILITY*	-0.020***	-0.053***	-0.055***	-0.024**	-0.042***	-0.026**
	(-2.96)	(-3.87)	(-5.26)	(-2.57)	(-4.11)	(-2.10)
R^2	0.014	0.059	0.024	0.025	0.038	0.027
Adj. R^2	0.007	0.039	0.021	0.019	0.028	0.017
#Obs.	18756	5386	8950	15643	12297	12296
	Return Sign		**Option Type**		**Age**	
	Negative	**Positive**	**Call**	**Put**	**0-8.9**	**8.9-25**
Intercept	-0.026***	0.024***	-0.001	-0.001	0	-0.001
	(-15.56)	(-12.45)	(-0.32)	(-0.28)	(-0.09)	(-0.72)
Δ*IMPLIED VOLATILITY*	-0.027***	-0.017**	-0.032***	-0.042***	-0.049***	-0.041***
	(-3.48)	(-2.60)	(-4.87)	(-5.15)	(-4.38)	(-4.80)
R^2	0.035	0.031	0.021	0.027	0.081	0.027
Adj. R^2	0.023	0.019	0.016	0.022	0.058	0.019
#Obs.	12180	12413	12297	12296	12297	12296

This suggests that in periods of market turmoil (as in the 2007-2008 liquidity and credit crunch (Brunnermeier (2009)) the overall market uncertainty affects the predictive ability of options trading. This may be due to selling pressures or herding in such periods.

For the sub-sample Firm Size, the coefficient on Δ*IMPLIED VOLATILITY* is higher for small firms than for large firms and is significant at the 1% level as opposed to significance at the 5% level for large firms. This suggests that information asymmetry plays a role in the predictive ability of options for corporate bonds and that information disseminated via options trading on smaller firms contains more information for future bond returns.

For the sub-sample Return Sign, the coefficient on Δ*IMPLIED VOLATILITY* for negative returns is higher (with higher t-statistics) than for positive returns which can be due to the asymmetric payoff of bonds. For the sub-sample Option Type, the coefficients and t-statistics on both call and put options sub-samples are of similar magnitude and sign. This suggests that call and put options contain similar information about future bond returns and is consistent with the notion that one option can be replicated from the other. This is in contrast to the findings in Ang et al. (2010) who find that call (put) options contain positive (negative) information about future stock returns. However, it is important to note that while options and bonds are theoretically related, options are written on the underlying stocks not bonds, hence the possible difference in the information content of options for future stock and bond returns. Lastly, for the sub-sample Age, the coefficient and t-statistics are similar for both sub-samples indicating that the age and liquidity of the bond do not affect the predictive ability of options trading.

2.5.3 Portfolio sorts – raw returns

In the previous section I documented options' strong predictive ability for corporate bond returns. I now turn to examine the portfolio sorts approach to validate these results.

Although portfolio sorts are a simple reflection of how average returns vary across the spectrum of a variable, as Fama and French (2008) note, one shortcoming of regressions is the potential for the influential observation problem which may bias the results. Sorts provide verification for this issue. I construct quintile portfolios as follows. Each month *t* bonds are ranked and sorted into quintile portfolios based on monthly changes (from month *t*-2 to month *t*-1) in *IMPLIED VOLATILITY*, *SKEW*, *PUT-CALL SPREAD*, and *O/S*. Bond excess return is then calculated for each portfolio as the equally-weighted average bond excess return (return minus and the risk-free rate). For each portfolio I also provide portfolio means of *RATING, COUPON, OFFERING, AGE* and *TIME TO MATURITY*. Table 5 presents results of these portfolio sorts.

For portfolios sorted on Δ*IMPLIED VOLATILITY*, the Low (High) portfolio has an average bond excess return of 0.530% (-0.503%). A strategy based on buying the Low portfolio and selling the High portfolio (Low-high) yields an average bond excess return of 1.030% which is statistically significant (t-statistic of 3.1) and is economically meaningful. That is, an investor who purchases all corporate bonds in the Low portfolio and short sells all corporate bonds in the High portfolio and holds this position for a month (rebalancing monthly) will earn an average return in excess of the risk free rate of 1.03% per month. This is a large economic effect and is consistent with the economic significance presented in the previous section (regressions). In addition, returns seem to decrease monotonically across all portfolios but none of the variables *RATING, COUPON, OFFERING, AGE* and *TIME TO MATURITY* seems to change monotonically with returns suggesting that ΔImplied Volatility is unique in predicting returns and does not proxy for bond-specific characteristics. Returns for portfolios sorted on Δ*SKEW* seem to change monotonically as well, however with smaller Low-High portfolio return (0.425%) while returns for Low-High portfolio sorted on Δ*PUT-CALL SPREAD* and Δ*O/S* are even smaller (0.313% and -0.128%, respectively).

Table 5
Portfolio Sorts

This table presents results from portfolio sorts based on measures of options trading. Each month *t* bonds are ranked and sorted into quintile portfolios based on changes from *t*-2 to *t*-1 in *IMPLIED VOLATILITY*, *SKEW*, *PUT-CALL SPREAD*, and *O/S*. Bond excess return is then calculated for each portfolio as the equally-weighted average bond excess return (return minus and the risk-free rate). *IMPLIED VOLATILITY* is the average call and put option implied volatility. *SKEW* is the implied volatility skew, defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options. Put-Call Spread is the implied volatility *PUT-CALL SPREAD*, defined as the difference between the implied volatilities of at-the-money put and at-the-money call options. *O/S* is the ratio of options trading volume to stock trading volume. *RATING* is a numerical representation of the credit rating provided by S&P (AAA=1…D=22) or, if unavailable, by Moody's (Aaa=1...C=21). *COUPON* is the bond coupon rate. *OFFERING* is the bond issuance amount. *AGE* is the time since issuance in years. *TIME TO MATURITY* is the bond time to maturity in years. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

Portfolio	Δ*IMPLIED VOLATILITY*	*RETURN (%)*	*t-stat.*	*RATING*	*COUPON*	*OFFERING*	*AGE*	*TIME TO MATURITY*
Low	-0.100	0.530	8.626***	9.714	7.401	313853	9.483	9.245
2	-0.024	-0.151	-3.307***	8.426	7.219	323065	9.293	8.941
3	-0.003	-0.179	-3.978***	8.176	7.148	329989	8.945	8.636
4	0.017	-0.188	-4.273***	8.252	7.213	328617	9.38	8.603
High	0.091	-0.503	-8.181***	9.817	7.356	316499	9.557	9.078
Low-High		1.030	3.100***					
Portfolio	Δ*SKEW*	*RETURN (%)*	*t-stat.*	*RATING*	*COUPON*	*OFFERING*	*AGE*	*TIME TO MATURITY*
Low	-0.006	0.138	2.287**	10.140	7.371	300182	9.078	9.034
2	-0.007	-0.071	-1.513	8.260	7.232	332508	9.449	8.872
3	-0.003	-0.124	-2.752**	7.731	7.191	335600	9.659	8.799
4	-0.002	-0.148	-3.191***	8.052	7.200	340303	9.410	8.757
High	0.000	-0.287	-4.738***	10.203	7.343	303427	9.062	9.041
Low-High		0.425	2.180**					
Portfolio	Δ*PUT-CALL SPREAD*	*RETURN (%)*	*t-stat.*	*RATING*	*COUPON*	*OFFERING*	*AGE*	*TIME TO MATURITY*
Low	-0.004	0.172	2.824***	10.093	7.369	314531	9.231	9.029
2	-0.005	-0.022	-0.462	8.231	7.228	321655	9.427	9.044
3	-0.003	-0.221	-4.981***	7.812	7.158	331711	9.293	8.617
4	-0.003	-0.278	-6.232***	8.147	7.207	336832	9.378	8.664
High	-0.003	-0.141	-2.298**	10.101	7.374	307304	9.329	9.149
Low-High		0.313	1.470					
Portfolio	Δ*O/S*	*RETURN (%)*	*t-stat.*	*RATING*	*COUPON*	*OFFERING*	*AGE*	*TIME TO MATURITY*
Low	-0.010	-0.214	-3.981***	8.396	7.272	347660	9.463	9.103
2	-0.007	0.033	0.631	8.527	7.208	320828	9.153	8.772
3	-0.005	-0.081	-1.493	9.384	7.222	273537	8.546	8.462
4	0.000	-0.124	-2.309**	8.772	7.248	304110	9.244	8.999
High	0.005	-0.086	-1.595	8.489	7.296	351968	9.586	8.939
Low-High		-0.128	-2.230**					

Overall, results from portfolio sorts support the findings from the Fama-MacBeth regressions that Δ*IMPLIED VOLATILITY* is a strong predictor of future corporate bond returns.

2.5.4 Portfolio sorts – risk-adjusted returns

In the previous subsection I documented that a Low-High portfolio strategy based on Δ*IMPLIED VOLATILITY* yields statistically and economically significant bond excess return. In this section I test whether profits from this strategy compensate for systematic risk. I regress returns of portfolios sorted on Δ*IMPLIED VOLATILITY* on bond and equity risk factors, known to be priced in the cross-section of bond returns (see for example, Fama and French (1989), Fama and French (1993) and Gebhardt et al. (2005)). Specifically, once I calculate bond excess returns of portfolios sorted on Δ*IMPLIED VOLATILITY* (as described in Subsection 2.5.3), I regress these returns on systematic factors and estimate alphas of each portfolio and the Low-High portfolios (and their associated *t*-statistics) for 7 different models using the following time-series regression model:

$$r_{p,t} = \alpha_p + \beta_p F_t + e_{p,t}$$

where $r_{p,t} = R_{p,t} - R_{rf,t}$ is the portfolio excess return over the risk-free rate or the strategy return $r_{p,t} = RP_{Low,t} - R_{High,t}$. F_t is a vector of factors. The coefficients are estimated using OLS. For each model, F is represented by the following factors:

(1) *TERM*

(2) *DEF*

(3) *TERM*, *DEF*

(4) *MKT*, *SMB*, *HML*

(5) *MKT*, *SMB*, *HML*, *MOM*

(6) *TERM*, *DEF*, *MKT*, *SMB*, *HML*

(7) *TERM*, *DEF*, *MKT*, *SMB*, *HML*, *MOM*

where *MKT*, *SMB*, *HML*, and *MOM* are the returns on the market, size, and book-to-market factors of Fama and French (1993), and momentum factor of Carhart (1997), respectively. *TERM* is the difference between the yield of long-term government bonds (average of 20 and 30 years) and the one-month risk-free rate. *DEF* is the difference between the yields of long-term (more than 10 years) investment grade (higher than BBB) corporate bonds and long-term government bonds (average of 20 and 30 years).

Table 6 presents alphas of the 7 models in addition to Model 0 which presents the average raw portfolio returns for easy comparison. Results in Table 6 indicate that while risk-adjusted returns attenuated compared to the Low-High portfolio raw-returns (Model 0), alphas of the Low-High portfolios in all 7 models are statistically highly significant (at the 1% level) and still economically meaningful with monthly returns ranging between 0.47% and 0.49%. Since these returns are observed after controlling for known risk factors, I conclude that profits from the Low-High portfolio strategy (based on portfolios sorted on Δ*IMPLIED VOLATILITY*) are not compensation for systematic risk.

Table 6

Alphas of Bond Portfolios Sorted on ∆Implied Volatility
Sample Period: July 2002 – April 2011

This table shows the estimated alphas of each portfolio and the Low-High portfolios and their associated *t*-statistics for 7 different models. Bond portfolio returns are computed as in Table 5 and based on ∆*IMPLIED VOLATILITY*. I then run time-series regressions of these portfolio excess returns on systematic factors:

$r_{p,t} = \alpha_p + \beta_p F_t + e_{p,t}$,

where $r_{p,t} = R_{p,t} - R_{rf,t}$ is the portfolio excess return over the risk-free rate or the strategy return $r_{p,t} = RP_{Low,t} - R_{High,t}$. F_t is a vector of factors. The coefficients are estimated using OLS. For each model, F is represented by the following factors:

(1) *TERM*
(2) *DEF*
(3) *TERM, DEF*
(4) *MKT, SMB, HML*
(5) *MKT, SMB, HML, MOM*
(6) *TERM, DEF, MKT, SMB, HML*
(7) *TERM, DEF, MKT, SMB, HML, MOM*

where *MKT*, *SMB*, *HML*, and *MOM* are the returns on the market, size, and book-to-market factors of Fama and French (1993), and momentum factor of Carhart (1997), respectively. *TERM* is the difference between the yield of long-term government bonds (average of 20 and 30 years) and the one-month risk-free rate. *DEF* is the difference between the yields of long-term (more than 10 years) investment grade (higher than BBB) corporate bonds and long-term government bonds (average of 20 and 30 years). Model 0 presents the average raw portfolio returns for easy comparison. *** indicates significance at the 1% level.

Model	Low	2	3	4	High	Low-High	*t-stat.*
			Bond portfolios - excess returns				
0	0.530	-0.151	-0.179	-0.188	-0.503	1.030	3.10***
			Bond portfolios - alphas				
1	0.244	-0.007	0.100	-0.260	-0.220	0.470	3.06***
2	0.206	-0.051	0.054	-0.300	-0.266	0.472	3.08***
3	0.150	-0.098	-0.009	-0.354	-0.336	0.485	3.16***
4	0.163	0.002	0.132	-0.312	-0.322	0.485	3.11***
5	0.165	0.005	0.135	-0.310	-0.320	0.485	3.09***
6	0.098	-0.082	0.038	-0.387	-0.393	0.491	3.13***
7	0.099	-0.079	0.037	-0.387	-0.392	0.491	3.12***

2.5.5 Portfolio sorts – robustness check

To explore the robustness of the results from portfolio sorts, I examine if the results are sensitive to the choice of number of portfolios used in the analysis (5 portfolios). I therefore vary the number of portfolios and construct 3, 7, 10 and 15 portfolios based on Δ*IMPLIED VOLATILITY*. I calculate raw-returns for each portfolio and the Low-High portfolio (as in Table 5) along with their alphas as in Model 7 in Table 6 (full model specification with *TERM*, *DEF*, *MKT*, *SMB*, *HML*, *MOM*). Table 7 reports that raw-returns of the Low-High portfolio of these sorts for the 3, 7, 10 and 15 portfolios are 0.67%, 1.33%, 1.88% and 2.45%, respectively (all significant at the 1% level), with alphas of 0.41, 0.60, 0.87 and 0.92, respectively (all significant at the 1% level). This suggests that the results obtained for portfolios sorts are not sensitive to the choice of the number of portfolios used.

Table 7

Portfolio Sorts on ∆Implied Volatility – 3, 7, 10, 15 Portfolios

Sample Period: July 2002 – April 2011

This table presents results from portfolio sorts based on ∆Implied Volatility based on 3, 7, 10 and 15 portfolios. Bond portfolio returns are computed as in Table 5. Low-High portfolio returns and their *t*-statistics (in parentheses) are also presented. Alpha is calculated as in Table 6 Model 7 (full model specification). *** indicates significance at the 1% level.

Portfolio	∆*IMPLIED*	Return (%)	*t*-stat.	Rating	Low-High	Alpha
			3 Portfolios			
1	-0.071	0.291	6.717	9.200	0.671***	0.410***
2	-0.003	-0.204	-5.920	8.187	(3.890)	(4.040)
3	0.063	-0.381	-8.863	9.244		
			7 Portfolios			
1	-0.121	0.709	9.179	9.959	1.331***	0.600***
2	-0.038	-0.050	-0.888	8.761	(3.270)	(3.190)
3	-0.017	-0.138	-2.563	8.361		
4	-0.003	-0.170	-3.195	8.080		
5	0.011	-0.214	-4.097	8.257		
6	0.030	-0.203	-3.709	8.658		
7	0.113	-0.622	-8.010	10.064		
			10 Portfolios			
1	-0.146	0.963	9.712	10.342	1.879***	0.870***
2	-0.053	0.097	1.349	9.086	(3.990)	(3.730)
3	-0.031	-0.122	-1.878	8.500		
4	-0.018	-0.180	-2.802	8.353		
5	-0.007	-0.127	-1.983	8.177		
6	0.002	-0.231	-3.659	8.175		
7	0.011	-0.210	-3.375	8.165		
8	0.024	-0.166	-2.669	8.338		
9	0.044	-0.089	-1.246	9.243		
10	0.139	-0.916	-9.234	10.392		
			15 Portfolios			
1	-0.178	1.160	8.909	10.614	2.446***	0.920***
2	-0.073	0.368	3.893	9.330	(3.040)	(2.680)
3	-0.048	0.061	0.697	9.197		
4	-0.033	-0.168	-2.130	8.557		
5	-0.024	0.031	0.390	8.301		
6	-0.016	-0.316	-4.007	8.419		
7	-0.009	-0.194	-2.537	8.268		
8	-0.003	-0.071	-0.910	7.965		
9	0.003	-0.272	-3.416	8.296		
10	0.009	-0.169	-2.308	7.990		
11	0.017	-0.129	-1.639	8.436		
12	0.026	-0.266	-3.475	8.330		
13	0.039	-0.178	-2.085	9.216		
14	0.062	-0.044	-0.473	9.633		
15	0.173	-1.287	-9.732	10.605		

2.5.6 Long-Term Predictability

In this section I investigate the longer-term predictive power of Δ*IMPLIED VOLATILITY*. Specifically, I repeat the analysis (as in the previous subsections) for holding periods of two and three months. Table 8 presents Fama-MacBeth regressions as in Model 1 in Table 3 and portfolio sorts as in Table 5 (raw returns) and Model 1 in Table 6 (alphas) for holding periods of two and three months (and one month for comparison). Results indicate that the Low-High strategy based on Δ*IMPLIED VOLATILITY* is still profitable for the two-month holding period with average raw-return (alpha) of about 0.75% (0.40) per month which is statistically significant at the 1% level with t-statistic of 3.6 (3.9). The coefficient on Δ*IMPLIED VOLATILITY* from the Fama-MacBeth regression is -0.041 and is statistically significant at the 1% level with t-statistic of -4.5. For the three-month holding period, the coefficient from the Fama-MacBeth regression, and the raw-return and alpha on the Low-High portfolio from portfolio sorts, are all statistically insignificant. This suggests that the predictive ability of Δ*IMPLIED VOLATILITY* persists up to two months but is non-existent beyond that period. Since bond investors are generally large and sophisticated institutional investors, it is unlikely that they do not process new information in an efficient manner. One possible explanation for this long-term predictability is that private information held by informed traders is incorporated into option prices, but then only released to the public (market) at a later stage. This is further discussed in subsequent subsections.

Table 8

Fama-MacBeth Regressions and Portfolio Sorts - Long-Term Predictability

Sample Period: July 2002 – April 2011

This table presents Fama-MacBeth regressions and portfolio sorts for long-term predictability. Bonds excess return is calculated over periods of 2 or 3 months. 1-month estimation is presented for comparison and is taken from Table 3 (regressions) and Tables 5 and 6 (portfolios). Fama-MacBeth regressions are calculated as in Table 3 Model 1. Portfolio sorts are calculated as in Table 5 (raw returns) and Table 6 Model 1 (alphas). *** indicates significance at the 1% level.

Fama-MacBeth Regressions						
	1- month		2- month		3- month	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	-0.001	-0.310	-0.001	-0.470	0.003	-0.540
Δ*IMPLIED VOLATILITY*	-0.040	-5.350***	-0.041	-4.500***	-0.015	-1.200
R^2	0.025		0.021		0.015	
Adj. R^2	0.020		0.016		0.011	

Portfolio Sorts						
	1- month		2- month		3- month	
Portfolio	Return (%)	*t*-stat.	Return (%)	*t*-stat.	Return (%)	*t*-stat.
Low	0.530	8.626***	0.812	9.619	0.889	6.521
2	-0.151	-3.307***	-0.318	-5.167	-0.401	-3.936
3	-0.179	-3.978***	-0.514	-9.036	-0.773	-8.399
4	-0.188	-4.273***	-0.483	-8.196	-0.622	-6.370
High	-0.503	-8.181***	-0.696	-8.380	-0.107	-0.809
Low-High	1.030	3.100***	1.507	3.640***	0.996	0.720
Alpha	0.470	3.060***	0.785	3.910***	0.118	0.480

2.6 Option Prices Predictability

Recall that in hypothesis H1b I argue that if bond investors are informed or have a better information processing ability and they choose to trade on their information in the corporate bond market, then bond prices will incorporate information prior to, and lead, option prices (if bonds and options of the same underlying firm are related and react to common information). In order to test whether bond prices incorporate information prior to option prices, I regress monthly changes of option measures (implied volatility of call and put options, the volatility skew, the put-call spread and the ratio of option to stock trading volume) on monthly changes in bond prices. In addition, I examine if bond prices are predictive of stock returns. If bond prices incorporate information prior to option (or stock) prices, bond prices will lead option (or stock) prices.

I again follow the Fama and MacBeth (1973) methodology as described in Subsection 2.5.1 and report the averaged cross-sectional coefficients across the sample of the following regression:

$$\Delta OM_{i,t+1} = b_0 + b_1 \Delta BP_{i,t} + e_i \tag{9}$$

where ΔOM is a vector of options trading measures observed in month $t+1$ for firm i and includes the measures (as described in Subsection 2.4.3) Δ*IMPLIED VOLATILITY CALL*, Δ*IMPLIED VOLATILITY PUT*, Δ*SKEW*, Δ*PUT-CALL SPREAD*, Δ*O/S* in addition to stock returns (*STOCK RETURN*). ΔBP is the monthly change (first difference) in the bond price of firm i in month t.

Table 9 reports results of these regressions. The coefficients of ΔBP in all six regressions are statistically insignificant. That is, information incorporated into bond prices does not precede the information embedded in option prices.

Table 9

Fama-MacBeth Regressions – Options Predictability

This table presents Fama-MacBeth regressions results from regressing monthly changes in various option measures and stock returns on monthly changes in bond prices (Δ*BP)*. The All Bonds column includes all bonds in the sample and IG Bonds include only investment-grade bonds where investment-grade bonds are bonds with credit rating better than BBB (this translates numerically to below 11 in S&P ratings). *IMPLIED VOLATILITY CALL* is the call option implied volatility. *IMPLIED VOLATILITY PUT* is the put option implied volatility. *SKEW* is the implied volatility skew where implied volatility skew is defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options. *PUT-CALL SPREAD* is the implied volatility put-call spread, defined as the difference between the implied volatilities of at-the-money put and at-the-money call options. *O/S* is the ratio of options trading volume to stock trading volume. *STOCK RETURN* is the monthly stock return of the bond issuing firm. #Bond-month observations=24174. *t*-statistics are in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

	Δ*IMPLIED VOLATILITY CALL*		**Δ*IMPLIED VOLATILITY PUT***		**Δ*SKEW***	
	All Bonds	IG Bonds	All Bonds	IG Bonds	All Bonds	IG Bonds
Intercept	-0.006	-0.006	-0.006	-0.005	0.001	0.001
	(-1.22)	(-1.10)	(-1.06)	(-1.04)	(-0.49)	(0.44)
ΔBP	-0.008	0.006	-0.002	0.002	0.023	0.009
	(-0.26)	(0.18)	(-0.06)	(0.07)	(-0.96)	(0.35)
R^2	0.017	0.011	0.021	0.011	0.015	0.015
Adj. R^2	0.012	0.004	0.016	0.004	0.010	0.008
	Δ*PUT-CALL SPREAD*		**Δ*O/S***		***STOCK RETURN***	
	All Bonds	IG Bonds	All Bonds	IG Bonds	All Bonds	IG Bonds
Intercept	0.001	0.000	0.000	0.000	0.000	0.000
	(-0.76)	(0.41)	(-0.44)	(0.38)	(-0.24)	(0.01)
Δ*BP*	0.006	-0.003	0.000	0.000	-0.006	-0.002
	(-0.31)	(-0.17)	(-0.08)	(0.08)	(-0.60)	(-0.22)
R^2	0.016	0.016	0.008	0.006	0.018	0.011
Adj. R^2	0.011	0.009	0.003	-0.001	0.013	0.004

This is in contrast to the findings in Ang et al. (2010) who find that stock prices contain important information for future option prices. However, it is important to note that since options are written on the underlying stock, the relationship between stocks and options is more direct as opposed to the theoretical relationship between options and bonds. Thus, these results cannot be directly compared to the results in Ang et al. (2010). In addition, I find that bond prices do not incorporate information prior to stock prices (last regression in Table 9). The results are in contrast to the findings in Kwan (1996) who documents correlation between bond returns and lagged stock returns but are consistent with Hotchkiss and Ronen (2002) who find no lead-lag relationship between bonds and stocks but that stock and bond returns react jointly to common factors. I further examine if investment-grade corporate bonds incorporate information prior to option and stock prices. Investment-grade bonds are generally issued by large and established companies with lower risk of default (by definition). In addition, investment-grade bonds are often held by institutions that are considered large and sophisticated but also regulated and restricted in the amount of non-investment grade bonds that they are allowed to hold in their portfolios (e.g., pension funds and insurance companies). Thus, one could expect that if these institutions possess better information processing ability or private information, they will disseminate this information via investment-grade corporate bonds. I repeat the regressions as in Equation (9) only for the investment-grade corporate bonds in the sample. Table 9 reports results of these regressions. Specifically, the coefficients of ΔBP in all six regressions are again statistically insignificant. That is, information incorporated into investment-grade corporate bond prices does not precede the information embedded in option and stock prices.

Results in this section do not support hypothesis H1b. That is, I find no evidence that bond prices incorporate information prior to option and stock prices for both the full sample and the investment-grade sub-sample. This does not necessarily indicate that option traders are more sophisticated investors than bond traders. In the next section I further discuss these results and answer the question why information is incorporated into option prices prior to bond prices but not vice versa.

2.7 Discussion: Bond Returns Predictability – Superior Information Processing Ability or Informed Trading?

I now turn to discuss if traders are likely to possess superior information processing ability or if they are merely informed. In Section 2.5 I documented that options trading has a strong predictive power of bond returns and that this predictability lasts up to two months. In Section 2.6 I found that bonds do not incorporate information prior to option prices. However, the findings that bonds do not incorporate information prior to options do not necessarily indicate that bond traders are not informed or do not possess the ability to process information in an efficient matter. This is because bond traders with either private information or better information processing ability may choose to trade, and therefore disseminate their information, in the options market if they can achieve a higher payoff in options trading (as in Easley et al. (1998)).

A key question is then where does the information which is predictive of bond returns come from? Since bond investors are generally large and sophisticated institutional investors, it is unlikely that they do not possess the ability and resources to process information in an efficient manner. The relatively long persistence of bond return predictability coupled with the fact that bond investors generally process information in an efficient manner, may point to the fact that the information incorporated into options prior to bond prices stems from informed trading rather than from investors with superior information processing ability.

2.8 Conclusions

Theoretical and empirical work imply that information about the firm should affect both the firm's stocks and bonds (e.g., Merton (1974), Easton et al. (2009)). Research on the informational role of options suggests that options offer various advantages over stocks such as lower transaction costs, continuous liquidity, high leverage for trading, and no short-sale restrictions (Black (1975), Back (1993), Chakravarty et al. (2004)). In turn, these advantages imply that options incorporate information from informed traders prior to stocks and therefore lead the stock market (Easley et al. (1998)). In a similar fashion, I hypothesize that information incorporated into option prices should lead bond prices. The empirical findings support this hypothesis. Specifically, Fama-MacBeth regressions reveal a strong negative relation between changes in implied volatility and future bond excess returns. In addition, a strategy based on buying (selling) the lowest (highest) portfolio of bonds sorted on past month's changes in option implied volatility, generates average monthly bond excess returns of about 1% and risk-adjusted alpha of 0.5 both statistically and economically highly significant. The results are robust to various sub-samples and the choice of number of portfolios in the sorting procedure. The predictive ability persists up to two months. In contrast, I find no evidence that bond prices incorporate information prior to option and stock prices. Since bond investors are generally sophisticated institutional investors who process information in an efficient manner and the predictive ability of options is relatively long, I conclude that informed trading rather than superior information processing abilities is responsible for the predictive ability of options. This is consistent with prior research supporting the notion that informed traders operate in the options market and that private information is incorporated into options prior to other assets.

Chapter 3 – The Information Content of Option Implied Volatility around Seasoned Equity Offerings

3.1 Introduction

This study examines the informational role of options around seasoned equity offerings (SEOs). Specifically, I investigate options trading around i) the SEO announcement date, and ii) the SEO issue date. SEO announcements and issue dates contain important information about the firm and therefore provide profitable opportunities for traders with private information. While prior research has focused on the information content of short sales around SEOs (e.g., Gerard and Nanda (1993), Safieddine and Wilhelm (1996), Corwin (2003) and Henry and Koski (2010)), I focus on the information incorporated into options trading around SEOs. This is because i) with regards to SEO announcements (negative events), traders with information about the approaching announcement can choose to either short sell the firm's stock or buy put options, and ii) with regards to SEO issue discounts, investors can manipulate the offer price and profit at the expense of the issuer (Gerard and Nanda (1993)) by short selling the firm's stock or by purchasing put options.

The literature indicates that informed traders have a number of incentives to trade in options over stocks and to prefer put options over short positions. These incentives stem from the lower transaction costs, better liquidity, more efficient use of leverage for trading, and no short-sale restrictions that options offer over stocks (see e.g., Black (1975), Manaster and Rendleman (1982), Cox and Rubinstein (1985) and Chakravarty et al. (2004)). These advantages suggest that if traders possess private information about SEO announcements, they may choose to execute this information via the options market. In turn, option prices will incorporate information from informed traders prior to stocks (Easley et al. (1998)). Since SEO announcements are associated with economically and statistically significant negative average abnormal returns of more than 2% (e.g., Myers and Majluf (1984)) over a short period of 1-3 days, it is likely that investors have a strong incentive to acquire information about these announcements. My first research question examines if investors are informed about SEO announcements and whether they disseminate this information via options trading.

The literature on SEOs indicates that short selling activities around issue dates can be informative or manipulative. Informed investors with negative news can profit by short selling prior to issuance and subsequently cover their positions at the lower offer price (see for example, Henry and Koski (2010)). Manipulative traders can short sell to push prices downward after SEO announcements and prior to issuance and cover their positions at a lower price following SEO issuance (e.g., Gerard and Nanda (1993), Safieddine and Wilhelm (1996), Kim and Shin (2004) and Henry and Koski (2010)). In April 1997 the Securities and Exchange Commission (SEC) adopted Rule 105 (formerly Rule 10b-21 since 1988) to prohibit short sellers from purchasing shares in an SEO in order to cover their short positions if the positions were established during the five business days preceding the offer date. If Rule 105 is binding, traders can either short sell six days prior to the issue date, or circumvent the restriction of Rule 105 by using other securities such as options on the underlying stock during the short-sale restriction period and closer to the issue date. While the literature has focused on short selling around issue dates, my second research question examines options trading around issue dates since options can act as an alternative to short selling (Cox and Rubinstein (1985)). Specifically, I test if trading is informed or manipulative around issue dates by using the Gerard and Nanda (1993) model.[22] According to their model, manipulative (informed) trading is predicted to lower (increase) market informativeness and increase (decrease) the issue discount (a detailed explanation of the model is provided in the next section).

Using a sample of 412 SEOs of firms with options trading over the period January 1996 to December 2011, I find evidence for a statistically significant negative relation between options trading and SEO announcement cumulative abnormal returns (CARs). Specifically, I document that higher demand for out-of-the-money put options relative to at-the-money call options (as reflected by the volatility skew) in the two days preceding the announcement is strongly associated with SEO announcement *CAR* on days (0,1). Sorting CARs (0,1) into quintile portfolios based on levels of the volatility skew prior to SEO announcements, I find that the difference between the low and high portfolios is -1.93% which is both statistically and economically highly significant. Cross-sectional regressions support these results. To further confirm these results I test whether the volatility skew has a predictive power around pseudo *CAR* windows but find no evidence for such predictive power indicating that options trading is abnormally high only around events with material information. In addition, I use a number of alternative measures of the volatility skew and find that informed investors prefer deeper out-of-the-money put options prior to SEO announcements (as these options provide a greater profit relative to at-the-money put options).

For the issue discount, I find that put option implied volatilities are associated with larger issue discounts. Specifically, regressing levels of the issue discount on levels of put option implied volatilities prior to the issue date while controlling for various factors known

[22] In Gerard and Nanda (1993), manipulative short sellers trade against their private information in order to manipulate the offering price. Since manipulative traders received a private signal, they are also informed. As in Henry and Koski (2010), I use the term "informed traders" to describe trading by informed traders who trade consistent with their private information, and "manipulative traders" to describe trading by informed traders who trade against their private information in order to manipulate the offering price.

to influence the issue discount,[23] yields positive and statistically highly significant coefficients in models with various levels of put options moneyness. Further investigation reveals that abnormal levels of put option implied volatility are also associated with larger issue discounts. This is consistent with manipulative trading under the Gerard and Nanda (1993) model. That is, traders try to manipulate the offer price downward by purchasing put options.[24] They subsequently buy stocks at the discounted offer price to cover their positions. This result is in contrast to studies which use monthly short-interest data and reject the manipulative hypothesis (e.g., Safieddine and Wilhelm (1996), Kim and Shin (2004)) but consistent with recent evidence by Henry and Koski (2010) who use daily short-interest data and find that manipulative trading takes place prior to issue dates.

This study contributes to the finance literature in at least two important ways. First, to the best of my knowledge, this is the first study that documents that informed traders trade on their private information about impending SEO announcements and that they disseminate this information in the options market in the period prior to the announcements. These findings are in contrast to recent evidence of no informed trading via short selling prior to SEO announcements (Henry and Koski (2010)). While informed traders may not execute their information by short selling the firm's stocks, they elect to buy put options due to the advantages they offer over short selling (e.g., higher leverage). As such, this study also contribute to the literature on the informational role of options trading. While a number of studies argue that options traders are not informed and merely speculate on public information (e.g., Stephan and Whaley (1990), Chan et al. (2002)), the results are consistent with the notion that informed investors trade their information in the options market (e.g.,

[23] The choice of variables is influenced by the findings of Altinkilic and Hansen (2003) and Corwin (2003).

[24] In a similar way that short sellers can manipulate the offer price by establishing short positions, options traders can establish an explicit short position using a constant equity exposure through either a put-call-parity based replication of the underlying equity or through a dynamic strategy involving options and borrowing or lending (Safieddine and Wilhelm (1996)). Figlewski and Webb (1993) provide evidence for options as a direct substitute for short selling.

Black (1975), Manaster and Rendleman (1982) and Easley et al. (1998)). It is important to note that unlike scheduled corporate events such as earnings announcements where investors may speculate on the announcement result (e.g., Cao et al. (2005)), SEO announcements are unscheduled and therefore (at least to some extent) unanticipated by the market, which implies that any information revealed by options trading prior to the announcement points to insider information.

Second, I contribute to the literature examining price manipulation prior to the issue date. Evidence on price manipulation prior to the SEO issue dates is mixed. While studies using monthly short-interest data reject the manipulative hypothesis (e.g., Safieddine and Wilhelm (1996), Kim and Shin (2004)), Henry and Koski (2010) use daily short-interest data and find that manipulative trading takes place prior to issue dates. In addition, prior studies only examine short selling for optioned and non-optioned firms (both at the monthly and daily horizons). Henry and Koski (2010) find that short selling is significantly related to the issue discount only for firms without put options. They do not, however, test if the level of put options trading is related to the issue discount. Therefore, the results in this study contribute to the literature by providing evidence that abnormal levels of put option implied volatility is related to higher issue discounts which implies manipulative trading under the Gerard and Nanda (1993) model.

The remainder of this chapter proceeds as follows. Section 3.2 provides explanation of SEO. In Section 3.3 I survey the related literature and develop two hypotheses. Section 3.4 describes the data and sample characteristics. Section 3.5 reviews results of the tests on options trading around SEO announcements and Section 3.6 provides robustness tests for these results. Section 3.7 reviews results of the tests on options trading around SEO issue dates. Section 3.8 discusses the effectiveness of rule 105. Section 3.9 concludes.

3.2 Seasoned Equity Offerings – Background

A Seasoned Equity Offering (SEO) is the process of issuing equity in order to raise capital when the issuing firm is beyond its initial public offering (IPO) stage. Generally, any issuance of shares by a company subsequent to its IPO is referred to as an SEO (also known as follow-on offering or secondary offering). While the main reason for an IPO is to go public and sell shares to a larger number of investors (see for example Ibbotson and Ritter (1995)), the main reason for an SEO is to raise funds for capital expenditures and new investment projects (Eckbo (2008)). Eckbo (2008) notes that other reasons for an SEO include refinancing or replacing of existing or maturing securities, modifying a firm's capital structure, exploiting private information about securities' intrinsic value and periods when financing costs are historically low, financing mergers and acquisitions, facilitating asset restructuring such as spin-offs and carve-outs, shifting wealth and risk bearing among classes of securities, improving the liquidity of existing securities, creating more diffuse voting rights and ownership, strengthening takeover defences and facilitating blockholder sales, privatizations, demutualizations and reorganizations.

Both IPOs and SEOs are generally underwritten by investment banks in order to issue shares. According to the records of IPOs and SEOs in SDC Platinum, the underwriting method (also called flotation method) for IPOs is usually firm commitment while for SEOs, various underwriting method such as best efforts, issue rights, equity offerings, shelf-registration and private placements in addition to firm commitment are used.[25] Another important difference between IPOs and SEOs is in the degree of information asymmetry. In

[25] In the firm commitment method the underwriter buys shares from the issuing firm and guarantees the sale of a specific number of shares to investors. In the best efforts method the underwriter does not guarantee the sale of a specific number of shares rather the promise to sell as much of the issue as possible. Rights offer grant the existing shareholders the right to purchase a new equity issued at a fixed price. In the shelf-registration method the issuer is allowed to file a single document the permits the issuance of multiple securities. In the private placement method the issuer sells the issue to a single investor or a group of investors, bypassing the firm's shareholders.

an IPO the existing shareholders possess non-public information (as the company is not yet public). However, in an SEO, information such as the market closing price prior to the offer is readily available; this creates a higher degree of information asymmetry for IPOs (Ibbotson and Ritter (1995)). In addition, SEOs have a larger market than IPOs. For example, in 2006 the volume of IPOs was only $256.4 billion compared to $317.2 billion of SEO issuance (Bortolotti, Megginson and Smart (2008)).

Generally, the timeline of an SEO can be divided into three stages – before the announcement of an SEO, after the announcement of an SEO but before the issue date, and after the issue date. Following the approval of its board of directors for an SEO, the issuing firm will choose one or more underwriters who will lead the issuance of shares and advise the firm on the price, timing, issuing size and the legal requirements of the offering. The leading underwriters then usually choose other investment banks to form a syndicate and conduct a due diligence of the firm in order to meet the SEC requirements for filing an SEO. The firm then issues a prospectus and registers the offering at the SEC (Geddes (2003)). Once the firm has registered the offering, the managers of the firm and the underwriters will meet with potential investors (a process known as a "road show") in order to collect bid information and set the offer price for the future issuance (the book building process). The underwriters then negotiate the offer price with the issuing firm and usually sign an underwriting agreement to purchase the shares at a fixed price within 24 hours of the start of the offering (Eckbo (2008)). On the issue date, the underwriters confirm investors' orders and allocate issues accordingly. After the issuance underwriters often commit to provide analyst coverage for the shares for a period after the offering in order to enhance investor interest in the firm and improve liquidity. The lead underwriters also usually commit to be active market makers in the stock following the offering. In a case where the offering is oversold, the lead underwriters can buy shares either from the secondary market or from the issuers to meet the order. If the price in the secondary market drops below the offer price, lead underwriters can buy shares in the secondary market. This will support the price in the secondary market and prevent the need to add more shares into the secondary market. The next sections review the relevant literature on SEOs for this research – the literature on SEO announcement effects and the literature on SEO issue date effects.

3.3 Related Literature and Hypotheses Development

This section discusses the relevant literature and develops the two testable hypotheses pertinent to this study. As Chemmanur, Hu and Huang (2010) point out, the literature on SEOs is broadly divided into studies on the announcement effect of SEOs (e.g., Myers and Majluf (1984), Giammarino and Lewis (1988) and Asquith and Mullins (1986)), the literature on SEO discounts (e.g., Gerard and Nanda (1993), Safieddine and Wilhelm (1996) and Corwin (2003)) and the literature on long-term performance following SEOs (e.g., Loughran and Ritter (1995) and Carlson, Fisher and Giammarino (2006)). The first goal of this study is to examine the informational role of options prior to SEO announcements. I start by describing the negative announcement effect following SEO announcements and the possible explanations for this effect. I then discuss the informational role of options for traders with private information and develop the first hypothesis. The second goal of this study is to explore the role of options around the issue date. Rule 105 prohibits short selling five days prior to an SEO in order to prevent price manipulations. It does not however, restrict transactions in the options market. Thus, traders can opt to buy put options which are a substitute for short-selling and profit from, or manipulate, the offer price.

3.3.1 SEO announcement effects and the informational role of options

The literature on SEOs documents that SEO announcements are associated with negative abnormal return of about 2-3%. For example, Masulis and Korwar (1986) document an average return of -2.2% following SEO announcements, while Hansen and Crutchley (1990) document -3.65%, Korajczyk, Lucas and McDonald (1991) -2.26%, Bayless and Chaplinsky (1996) -2.5%, Altinkilic and Hansen (2003) -2.23%, and more recently Henry and Koski (2010) find an average abnormal return of -2.3% following SEO announcements. The strong evidence for negative market reaction to announcements of security offerings indicates that these corporate events convey important information to the market but also a degree of information asymmetry between the issuer and the market (Eckbo (2008)).

The literature on SEOs explores the information content of security offering announcements and provides a number of explanations for the negative market reaction. Specifically, the literature points at the information signaling hypothesis (e.g., Leland and Pyle (1977) and Miller and Rock (1985)) as the dominant explanation for the market's negative reaction to SEO announcements (Elliott, Prevost and Rao (2009)) and examines models developed under this hypothesis (also called adverse selection models). Miller and Rock (1985) present an asymmetric information model in which unexpected financing (e.g., SEOs) signals lower current cash flow to market participants. As a result, the market reacts negatively to companies' SEO announcements. Myers and Majluf (1984) argue that managers issue new equity when they think their firm is overvalued relative to their private information of the true intrinsic value. Investors learning about the firm's intention to issue new equity (via SEO announcement) interpret it as conveying management's opinion that the firm is overvalued. As a result, investors will then bid the price of the stock down (i.e., negative market reaction to SEO announcement). Some of the more recent literature examines other aspects of information asymmetry and its effect on announcement returns. For example, Lee and Masulis (2009) argue that when investors first hear about the firm's intention to issue equity, they are more likely to greatly discount their valuation of the firm if the firm has poor quality accounting information (increased information asymmetry) because they take into account the greater agency adverse selection risk that investing in such a firm involves. As a result, they hypothesize, and empirically confirm, that issuers with worse accounting information quality have more negative announcement returns relative to issuers with better accounting information quality. Jeon and Ligon (2011) examine the effect of co-managers on information asymmetry and announcement returns. They find that the number of co-managers does not affect information asymmetry while co-manager characteristics do. Specifically, Jeon and Ligon (2011) show that issues including highly reputable co-managers have higher announcement returns, but experience lower underpricing, probability of offering cancellation, and offer delays and that having commercial banks as co-managers is positively correlated with announcement returns, but negatively correlated with underpricing and offer delays.

While the information signaling hypothesis remains the dominant explanation for the market reaction to SEO announcements, other hypotheses have been explored in the literature. For example, the wealth transfer hypothesis based on the Galai and Masulis (1976) framework posits that the reduction of leverage and financial distress risks (due to new equity issuance) has an effect on bondholders at the expense of equity holders resulting in wealth redistribution (an increased supply of shares). The price-pressure hypothesis posits that the firm is faced with a downward sloping demand curve for its stock and so increasing supply of the number of shares decreases the price of the outstanding equity (see Asquith and Mullins (1986) and Kalay and Shimrat (1987)). Although the literature provides a number of possible explanations for the market reaction, and regardless of whether managers convey important information in SEO announcements or not, the evidence remains the same – a sharp decline in price following SEO announcements. The large decrease in share price provides a strong incentive for traders to acquire information about impending SEO announcements. I now turn to discuss how and where informed investors possessing material information about SEO announcements would trade on their private information. Specifically, for reasons discussed below, I show that informed traders would prefer to trade in the options market over other markets.

Whether investors possess, and make use of, information about SEO announcements, and whether they disseminate this information via options trading, is an empirical question this section investigates. Since returns from SEO announcements are on average negative, informed traders can either short-sell stocks or buy (sell) put (call) options in order to profit from their private information. If informed traders are unable to short-sell a specific stock, they can choose the options market as their preferred trading venue. In such case, options will contain information which is incremental to the information embedded in stocks (short-interest) prior to the announcement. In addition, prior literature suggests that informed traders have a number of incentives to trade in the options market such as lower transaction costs, continuous liquidity, high leverage for trading, and no short-sale restrictions Back (1993); Black (1975); Chakravarty et al. (2004); Manaster and Rendleman (1982). In turn, these advantages imply that options incorporate information from informed traders prior to stocks and therefore lead the stock market (Easley et al. (1998)).

Black (1975) suggests that when investors have important information, they may choose to trade in options over investing directly in the underlying stock because they can achieve a higher profit for a given investment this way (e.g., due to higher leverage). Manaster and Rendleman (1982) propose that informed investors disseminate private information through options trading, and Easley et al. (1998) suggest that markets in which informed traders operate, will lead other markets with lesser informed traders. Amin and Lee (1997) find that trading volume is predictive of earnings information. Cao et al. (2005) show that option order imbalance can predict stock response subsequent to take-overs. Chern, Tandon, Yu and Webb (2008) document that abnormal returns subsequent to stock split announcements are significantly lower for optioned than non-optioned stocks because a large part of information regarding the split has been pre-empted by options trading in the period preceding the announcements.

Pan and Poteshman (2006), Roll et al. (2010), and Johnson and So (2011) show that options trading volume is related to future stock returns, suggesting that informed trading prevails in the options market. In addition the literature also documents that option implied volatility, and statistics computed from it such as the realized-implied volatility spread Bali and Hovakimian (2009), the call-put option volatility spread Cremers and Weinbaum (2010), the volatility smirk Xing et al. (2010), and innovations in implied volatility Ang et al. (2010) are predictive of stock returns. To summarize, the literature indicates that informed traders operate in the options market as it offers advantages such as higher leverage and lower transaction costs over the stock market, and as a result, options prices incorporate information from informed traders prior to stock prices. Thus, information extracted from options prices is a useful predictor of stock returns.

In this study, I use the volatility skew, defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options. This measure proxies for the information content of options before SEO announcements as prior studies indicate that the volatility skew has the ability to predict negative events at the index (Bates (1991); Doran, Peterson and Tarrant (2007)) and at the firm (Van Buskirk (2011)) levels. Bates (1991) for example, documents that out-of-the-money put options on the S&P 500 become unusually expensive (and the volatility skew more pronounced) before negative price jumps (e.g., before the 1987 stock market crash). Doran et al. (2007) demonstrate that the volatility skew constructed from options on the S&P 100 Index can predict market crashes but not spikes. Van Buskirk (2011) shows that a steep volatility skew can predict crashes around earnings announcements at the firm level.

In this study, I examine the ability of the volatility skew to predict abnormal returns from SEO announcements - events which are associated with significant negative returns (-2.3% over days (0,1) in this study). The rationale is consistent with the demand-based option pricing models of Bollen and Whaley (2004) and Gârleanu et al. (2009) who show that changes in implied volatilities are driven by net buying pressure. Thus, if informed traders operate in the options market, their demand for options will drive option prices and subsequently affect option implied volatilities. Since these changes in implied volatility are a result of private information which is yet to be fully incorporated into the underlying stock price, these changes may be related to future changes in the underlying stock price. In a similar way, the volatility skew should become more pronounced before SEO announcements, as informed traders opt to buy put options[26] (or write call options) on the underlying stock before the announcement (negative news). The demand for out-of-the-money put OTMP options increases their implied volatilities relative to ATMC options and deepens the volatility skew before the announcement resulting in returns predictability of SEO announcements. I therefore use the volatility skew to gauge the information incorporated into options prices prior to SEO announcements.

If options traders possess private information about SEO announcements, then:

H1: *The volatility skew will be negatively related to abnormal returns following SEO announcements.*

[26] Informed traders can also write call options which should be, under certain conditions, similar to buying put options. However, this is less likely than buying put options as writing call options is a more 'passive strategy' for informed traders. That is, informed traders who write the call options will have to have high enough demand for these options from uninformed traders. It is not necessarily the case that there will be high demand for buying call options by traders without private information about the approaching announcement and so informed traders are better off buying put options. For robustness, I also examine call options in addition to put options in the analysis.

3.3.2 Issue date effects

3.3.2.1 Rule 105

Adopted by the SEC in 1988, Rule 105[27] (then known as Rule 10b-21) prohibits short-sellers from purchasing shares in an SEO in order to cover their short positions if the positions were established during the five business days preceding the offer date. Rule 105 was then amended in October 2007 to include a restriction on purchasing shares regardless of whether the shares are used to cover an open short position (established during the five business days preceding the offer date). The intention of Rule 105 was to prevent manipulative short selling that can affect prices and ultimately lower the issuer's offer proceeds. Manipulative short-sellers, who push the share price down, could profit at the expense of the issuer by repurchasing the shares at the fixed and discounted price on the offer date. Some evidence for such manipulative trading strategies prior to the adoption of Rule 105 in 1988 can be found in Barclay and Litzenberger (1988) and Lease, Masulis and Page (1991). As a result, the literature has focused on the effectiveness of Rule 105 (i.e., if levels of discounts changed after its introduction) and examination of manipulative trading by investigating the relationship between pre-issue short selling and the pricing of SEOs (e.g., Gerard and Nanda (1993), Safieddine and Wilhelm (1996), Corwin (2003), Altinkilic and Hansen (2003), Kim and Shin (2004) and Henry and Koski (2010)).

3.3.2.2 Manipulative informed trading – the Gerard and Nanda (1993) model

In order to explain SEO underpricing, Gerard and Nanda (1993) present a model (in the spirit of Kyle (1985)) of the relationship between manipulative short selling prior to SEOs and the offering price. In their model, the SEO price is discounted from the share price the day before the offering, which is consistent with evidence from the literature. The SEO price

[27] The final rule can be found in the SEC's website (http://www.sec.gov/rules/final/2007/34-56206.pdf).

is conditional on order flow so manipulative traders can use their trades to impact the net order flow which ultimately affects the issue discount. Given the model parameterization, informed traders cannot absorb the whole issue offer implying that the issuer must set the offer price such that uninformed traders have zero expected profits (otherwise they would not participate). Under these conditions, Gerard and Nanda show that the equilibrium SEO issue price, P_Q^*, will be (Proposition I, p. 220):

$$P_Q^* = E[\tilde{V}|Q] + \frac{Cov[\tilde{\alpha}_U, \tilde{V}|Q]}{E[\tilde{\alpha}_U|Q]} \tag{1}$$

where $\tilde{\alpha}_U$ is the number of new shares allocated to uninformed bidders, $\tilde{V}$ is the end of period value of the stock, and Q is secondary market net order flow. The term $Cov[\tilde{\alpha}_U, \tilde{V}|Q]$ is negative – uninformed traders tend to get more shares in deals with lower fundamental values (the winner's curse problem). Since $P_Q^* \leq E[\tilde{V}|Q]$, the SEO offer price will be set at a discount to $E[\tilde{V}|Q]$, the equilibrium price without an SEO. Secondary market order flow, Q, affects the equilibrium offer price through its impact on the equilibrium price without an SEO and the impact on the second term, the issue discount. As trading becomes more informative, the offer price discount decreases. In contrast, manipulative trading increases the discount by reducing the informativeness of the secondary market net order flow. Gerard and Nanda show that traders may sell before the offering to conceal their information even if they have positive information. This strategy may be profitable if they can recover secondary market losses by buying at a sufficiently reduced price in the offering. That is, manipulative short selling may be profitable because of the impact of secondary market trading on the discount.

3.3.2.3 Manipulative informed trading and put options trading

One of the implications of the Gerard and Nanda (1993) model is that manipulative trading worsens the winner's curse problem (uninformed traders tend to get more shares in deals with lower fundamental values) and increases the issue discount by reducing the informativeness of the secondary market net order flow. That is, Gerard and Nanda's model predicts that informed short selling makes market prices more efficient, implying smaller issue discounts, while manipulative short selling makes market prices less efficient implying larger issue discounts.

While studies using monthly short-interest data reject the manipulative trading hypothesis (e.g., Safieddine and Wilhelm (1996), Corwin (2003), Kim and Shin (2004)), more recently, Henry and Koski (2010) use daily short-interest data and find evidence that supports the manipulative trading hypothesis. Specifically, Henry and Koski show that, as predicted by the model of Gerard and Nanda (1993), higher levels of pre-issue short selling are significantly related to larger issue discounts for non-shelf-registered offerings.

Safieddine and Wilhelm (1996) point out that if options and stocks are linked by arbitrage, then put options can be a substitute for direct short selling. Thus, manipulative traders can use put options instead of short selling to influence the offer price. Importantly, Cox and Rubinstein (1985) argue that put options may be preferred over short positions as the use of leverage is more efficient (less net equity is required than shorting the stock directly), commissions on options tend to be lower than on share transactions, and finally, they can be used to circumvent short-sale restrictions. Since Rule 105 restricts short selling but not put option transactions, manipulative traders can use put options to influence the offer price. In addition, the literature indicates that the information in put options trading is more informative than the information in short sales before important negative events (Hao, Lee and Piqueira (2013)).

If manipulative trading in put options (as a substitute for short selling) prior to SEOs makes market prices less efficient and issue discounts larger as predicted by the model of Gerard and Nanda (1993), then:

H2: *Higher demand for put options is associated with larger issue discounts.*

3.4 Data and Sample Characteristics

3.4.1 Options and stocks data

This study spans the period 1996 to 2011. Data on stock returns and volume is taken from the Center for Research in Security Prices (CRSP). I obtain options data from the OptionMetrics database. It contains daily closing bid and ask prices, open interest, volume, and implied volatilities for options on individual stocks traded on NYSE, AMEX, and NASDAQ. Options on stocks are American style and implied volatilities are calculated using a binomial tree, taking into account expected discrete dividend payments and the possibility of early exercise. The interest rate used by OptionMetrics is sourced from historical LIBOR/Eurodollar rates. OptionMetrics then computes the implied volatility surface from the interpolated implied volatility surface separately for puts and calls using a kernel smoothing algorithm. The fitted implied volatilities are reported on a grid of fixed maturities of 30, 60, 90, 180 and 250 days, and fixed option deltas of 0.20, 0.25, …, 0.80 for calls, and -0.8, -0.75, …, -0.20 for puts. One advantage of the volatility surface is that it eliminates the need to choose which strikes or maturities to use in calculating implied call or put volatilities for each stock Ang et al. (2010).

3.4.2 SEOs data

Data on SEOs is obtained from the Securities Data Corporation (SDC) Platinum database for all U.S. Public Common Stock firm commitment offerings that were issued between January 1, 1996, and December 31, 2011. I exclude IPOs, rights offerings, unit issues, closed-end funds, REITs, spinoffs, simultaneous international offerings, private placements, non-U.S. (foreign issues) offerings, depositary issues, shelf registration issues and pure secondary offerings (but include mixed offerings of both primary and secondary shares). These screenings result in 1976 SEOs. I then merge the SEO data with the options data. The combined datasets yield a sample of 412 SEOs of optioned firms.

3.4.3 Sample characteristics

Table 1 provides summary statistics of firm and offering characteristics for the SEOs sample. Generally, statistics are consistent with previous literature (e.g., Henry and Koski (2010). Notably, the average discount, defined as the percentage difference between the SEO offering price and the closing price the day before the offering, is -2.72% (-3.63% in Henry and Koski (2010)) and the number of days between the announcement and the issue dates is 53 (29.5 in Henry and Koski (2010)).[28] Table 2 presents option and stock trading activity around various trading windows relative to SEO announcement (AD) and issue (ID) dates: (-50,-6), (-5,-1), (0), (1,5), (6,50). Noticeable is the high abnormal return on AD(0) of -1.2% (-2.3% over days 0,1) which is consistent with previous studies (e.g., Henry and Koski (2010)). On average, there is higher trading volume of both stocks and options prior to the announcement and issue dates (days -5,-1) compared to an earlier period (days -50,-6).[29] Open interest on calls (puts) seems to decrease (increase) before the issue date.

In addition, both the ratio of put relative to call options trading volume (*PCR*) and the ratio of options relative to stock trading volume (*O/S*) increase before the announcement date (days -5,-1) relative to the benchmark period (days -50,-6). Taken together, table 2 provides initial evidence for abnormal trading as measured by *O/S* (as in Roll et al. (2010)) prior to the announcement date. In addition, high put options trading volume is observed prior to the issue date, possibly due to the short-sale restrictions five days prior to the issue day (Rule 105).

[28] These differences may be due to the different samples used (optioned firms only versus optioned and non-optioned firms).
[29] There might be some overlap as the period ID(-50,-6) may include the announcement day (AD). However, since there are on average 53 days between the ID and the AD the effect should be negligible.

Table 1
Summary statistics
Sample Period: 1996 – 2011

This table presents descriptive statistics of firm and offering characteristics for the SEOs sample for the period 1996 to 2011. SIZE is the logged market capitalization in millions of dollars. MB is the price-to-book ratio. Shares Offered is the number of shares offered in the issue in millions. Offer Price is the share price for the equity offer. Offer Proceeds is the total dollar amount of the offer. Gross Spread is the gross underwriter spread on the deal. Pre-Issue Date Closing Price is the closing stock price one day before the issue date. Issue Date Closing Price is the closing stock price on the issue date. Days AD-ID is the number of days between the announcement date and issue date. Discount is the percentage difference between the SEO offering price and the closing price the day before the offering.

	Mean	Min	Q1	Median	Q3	Max	Std
SIZE	6.48	3.90	5.83	6.33	7.00	9.89	0.97
MB	7.99	0.36	2.37	3.79	6.36	1177.60	61.48
Shares Offered (mil.)	6.31	0.25	2.62	3.65	6.00	156.25	11.05
Offer Price ($)	29.79	2.00	18.00	26.25	36.00	295.00	21.69
Offer Proceeds ($ mil.)	156.35	2.06	63.63	95.00	160.50	4176.98	272.36
Relative Offer Size (%)	19.21	0.56	11.41	15.67	22.97	318.51	19.59
Gross Spread (%)	7.43	0.12	3.70	5.33	8.46	86.14	7.72
Shares Outstanding (mil.)	39.24	5.86	15.17	23.75	40.67	586.90	54.96
Pre-Issue Date Closing Price	30.56	2.05	18.57	26.54	37.00	311.68	22.33
Issue Date Closing Price	30.61	1.98	18.27	26.80	36.50	302.62	22.15
Days AD-ID	58.12	6.00	21.00	28.00	43.00	1665.00	140.41
Discount (%)	-2.72	-34.55	-4.20	-1.92	-0.39	179.35	9.85
N=412							

Table 2
Options and Stocks Trading Activity around SEO
Sample Period: 1996 – 2011

This table presents options and stocks trading activity around SEOs announcement (AD) and issue (ID) dates. The figures are the cross-sectional averages over various trading windows. *ABRET* is the average daily percentage abnormal return, defined as the difference between the firm's actual return and the return from the CRSP value-weighted return index (VWRETD). *STOCKVOL* is the stock trading volume in '000. *OPTVOL_C* and *OPTVOL_P* are the total options trading volume for call and put, respectively. *O/S* is the ratio of total options trading volume (call and put) to total stock trading volume. *OPENINT_C* and *OPENINT_P* are the total open interest for call and put, respectively. *PCR* is the ratio of put to call options trading volume. *IVC* and *IVP* are implied volatilities of at-the-money call (delta=0.50) and put (delta=-0.50) options, respectively. *OTP* is implied volatility of out-of-the-money put options (delta=-0.25). *SKEW* is the implied volatility skew, defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options.

	AD (-50,-6)	AD (-5,-1)	AD (0)	AD (1,5)	AD (6,50)	ID (-50,-6)	ID (-5,-1)	ID (0)	ID (1,5)	ID (6,50)
ABRET(%)	0.4	0.287	-1.256	-0.12	0.07	0.230	-0.317	0.463	0.181	0.012
STOCKVOL	624	672	685	770	686	529	583	299	716	550
OPTVOL_C	781	692	832	530	537	442	518	779	393	404
OPTVOL_P	523	392	413	359	316	263	352	552	209	212
O/S	0.084	0.088	0.082	0.073	0.073	0.001	0.001	0.000	0.000	0.001
OPENINT_C	7696	7607	6012	6081	6755	5778	5621	4566	4622	5092
OPENINT_P	4942	5075	4022	4088	4557	3705	3955	3346	3195	3443
PCR	0.587	1.151	0.864	1.237	0.549	0.623	1.441	0.704	0.862	0.545
IVC	0.63	0.617	0.659	0.653	0.648	0.630	0.634	0.665	0.657	0.657
IVP	0.642	0.633	0.671	0.665	0.66	0.644	0.645	0.672	0.667	0.668
OTP	0.687	0.677	0.709	0.703	0.698	0.685	0.683	0.704	0.701	0.706
SKEW	0.057	0.06	0.05	0.05	0.049	0.055	0.050	0.039	0.044	0.048

Table 3 presents the sample correlations for the main variables. The variable of interest for H1 – *SKEW* over days (-2,-1), is negatively (and significantly at the 1% level) correlated with the cumulative abnormal returns over days 0 and 1 (*CAR*(0,1)), providing initial support for H1 and evidence for its predictive ability. *CAR*(0,1) is also significantly correlated with historical stock returns skewness (*HSKEW*), and idiosyncratic volatility (*IDIOV*), indicating that firms with higher information asymmetry experience higher abnormal returns following SEO announcement. In order to eliminate any concerns of multicolinearity in the regression setting, I test a number of different models (in addition to portfolio sorts) that include different combinations of variables.

Table 3
Spearman's Rank Correlation
Sample Period: 1996 – 2011

This table presents the Spearman's rank correlations for the variables. *CAR*(0,1) is the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return from the CRSP value-weighted return index (VWRETD). *SKEW* is the average of *SKEW* over the two days prior to the announcement (trading days -2,-1), where *SKEW* is the difference between the implied volatilities of out-of-the-money put and at-the-money call options. *HSKEW* is the skewness of stock returns over the period (-30,-1). *ΔHSKEW* is the change in *HSKEW* from (-60,-31) to (-30,-1). *IDIOV* is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. *TURN* is the ratio of stock's volume over the period (-2,-1) and the number of shares outstanding. *SIZE* is the logged firm market capitalization. *MB* is the price-to-book ratio. *ILLIQ* is the illiquidity factor of Amihud (2002), which is the ratio of absolute stock returns to trading volume over the period (-2,-1). *PCR* is the ratio of the average put and call options trading volume. *VOLPR* is the volatility premium, defined as the ratio of the average at-the-money call implied volatility and the stock's realized volatility. *O/S* is the ratio of total options trading volume (call and put) to total stock trading volume over the period (-2,-1). *ΔIVC* and *ΔIVP* are changes in implied volatilities over the period (-2,-1) in at-the-money call and put options, respectively. Correlation values in bold are significant at the 5 % level.

	SKEW	*HSKEW*	*IDIOV*	*TURN*	*SIZE*	*MB*	*ILLIQ*	*PCR*	*VOLPR*	*O/S*	*ΔIVC*	*ΔIVP*
CAR(0,1)	**-0.15**	**0.12**	**-0.21**	-0.09	0.03	-0.09	0.03	0.07	0.03	-0.02	0.06	0.00
SKEW		-0.08	-0.05	0.06	0.01	**0.11**	**-0.14**	**0.14**	-0.03	-0.04	**-0.25**	**0.11**
HSKEW			**0.17**	-0.01	**-0.13**	-0.11	0.07	-0.06	**0.11**	0.06	-0.03	-0.04
IDIOV				0.39	-0.29	-0.18	0.09	-0.01	**-0.03**	**0.25**	-0.04	-0.03
TURN					-0.05	-0.09	**-0.34**	**0.18**	**-0.16**	**0.36**	0.00	0.01
SIZE						0.03	**-0.40**	**0.25**	0.01	0.09	0.07	-0.04
MB							**-0.12**	0.06	-0.10	**-0.18**	-0.05	-0.04
ILLIQ								**-0.31**	0.00	**-0.11**	0.01	0.07
PCR									-0.05	**0.17**	0.01	**0.13**
VOLPR										0.04	-0.02	0.00
O/S											-0.01	0.06
ΔIVC												**0.06**

3.5 Options Trading around SEO Announcements

3.5.1 Cross-sectional regressions

In order to formally test if informed traders disseminate information about future SEO announcements via options trading (H1), I estimate the following cross-sectional regression:

$$CAR(0,1)_i = b_0 + b_1 SKEW_i + b_2^{'} X_i + \varepsilon_i \tag{2}$$

where $CAR(0,1)_i$ is firm *i*'s cumulative abnormal return over days 0 to 1, where day 0 is the announcement day and abnormal returns are calculated as the difference between the firm's actual return and the return from the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. I construct the options measure for informed trading – *SKEW*, as the difference between the implied volatilities of out-of-the-money put options with delta of -0.20 (*VOLOTMP*),[30] and at-the-money call options with delta of 0.50 (*VOLATMC*)[31] both with maturity of 30 days:

$$SKEW_{i,t} = VOLOTMP_{i,t} - VOLATMC_{i,t} \tag{3}$$

I calculate the average *SKEW* for firm *i*, as defined in Equation (3), over the two days preceding the announcement (trading days -2, -1). I use trading days (-2,-1) as Skinner (1997) notes that the information advantage and potential trading profit of informed trading should be greatest immediately before the event. Results (unreported) are similar for alternative trading windows such as (-3,-1), (-4,-1), (-5,-1) and with one day gap between *CAR*(0,1) and the trading period – the window (-3,-2). Also, results are similar when I measure *CAR* over

[30] For robustness I test SKEW with deltas other than -0.20 in the next section.
[31] This measure resembles the measure used in Xing et al. (2010)

days (-1,1) or on day (0). X_i is a vector of control variables for firm *i*, observed in the window (-2, -1) unless otherwise stated. Specifically, in order to separate the predictive power of *SKEW* from other potential explanatory variables, I use 16 control variables: 7 from the equity market and 9 from the options market. The first equity market control variable is the run-up return leading up to the announcement, $CAR(-2,-1)_i$, which is firm *i*'s cumulative abnormal returns over days (-2,-1). If *SKEW* contains information which is incorporated into options prior to stocks, or has any incremental information over stocks, I would expect the coefficient of *SKEW* to be statistically significant. The second control variable is historical stock return skewness (*HSKEW*) measured over the period (-30,-1). I include this as a control variable as Barberis and Huang (2008) show that a more positively skewed stock should earn lower returns.[32]

The third control variable is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model (*IDIOVOL*) as Ang, Hodrick, Xing and Zhang (2006) show that this measure is predictive of stock returns. The fourth variable is stock turnover (*TURNOVER*) which is the ratio of stock volume and the number of shares outstanding, as Lee and Swaminathan (2000) show that liquidity is related to future stock returns. The fifth variable is *LOGSIZE* which is the natural log of market capitalization in millions of dollars measured at December of the previous year, defined as stock's price times shares outstanding, as Banz (1981) and Fama and French (1993) among others show that larger firms earn lower subsequent returns. The sixth control variable is the book-to-market (*BM*) ratio which is the ratio of book value, defined as the book value of common equity plus balance-sheet deferred taxes for the firm's latest fiscal year ending in the prior calendar year, to market capitalization. Fama and French (1993)

[32] Note that SKEW is computed from option implied volatilities and represents the skewness under the risk-neutral probability while HSKEW is computed under the real probability.

show that value stocks (high *BM*) outperform growth stocks (low *BM*). The final equity market control variable is the illiquidity factor (*ILLIQ*) of Amihud (2002), which is the ratio of absolute stock returns to trading volume, as Amihud (2002) finds that illiquidity is related to future stock returns.

The first options market control variable is the ratio of the average put to call options trading volume (hereafter *PCR*). This measure is an approximation of the proprietary data *PCR* measure used in Pan and Poteshman (2006) who show that high *PCR* indicates low future returns. In addition to *PCR* I also examine options trading volume and open interest separately for put and call options (*OPTVOL_C*, *OPTVOL_P*, *OPENINT_C*, and *OPENINT_P*, which are the second, third, fourth and fifth options market control variables, respectively). The sixth control variable is the volatility premium (*VOLPREMIUM*), defined as the ratio of the average at-the-money call implied volatility and the stock's realized volatility. Bali and Hovakimian (2009) show that the realized-implied volatility spread is predictive of expected stock returns. The seventh control variable is *O/S* which is the ratio of total options trading volume to stock trading volume. Roll et al. (2010) show that the *O/S* ratio is strongly related to stock returns and Johnson and So (2011) indicate that firms with low *O/S* outperform firms with high *O/S*. The eighth and ninth control variables are changes in implied volatilities in at-the-money call (*ΔIVC*) and put (*ΔIVP*) options, respectively as Ang et al. (2010) show that *ΔIVC* (*ΔIVP*) indicates higher (lower) expected stock returns.

Table 4 summarizes the results of the regressions from Equation (2). I start by estimating a univariate regression with only *SKEW* as the independent variable (Model 1) and the results are reported in Column 1. The coefficient on *SKEW* is negative (-0.12) and statistically highly significant. This suggests that informed investors significantly increase their demand for OTMP (bet on price decline) relative to ATMC options immediately before SEO announcements. In turn, this demand deepens the volatility *SKEW* resulting in larger

Table 4
***CAR*(0,1) Predictability of SEO Announcements using *SKEW* in Cross-Sectional Regressions**
Sample Period: 1996 – 2011

This table presents results from cross-sectional regressions where the dependent variable is *CAR*(0,1), defined as the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return from the CRSP value-weighted return index (VWRETD). The variables of interest is *SKEW* which is the average of *SKEW* over the two days prior to the announcement (trading days -2,-1), where *SKEW* is the difference between the implied volatilities of out-of-the-money put and at-the-money call options. The control variables defined as follows. *CAR*(-2,-1) is the stock returns pre-announcement run-up, defined as the cumulative abnormal returns over the period (-2,-1). *HSKEW* is the skewness of stock returns over the period (-30,-1). *IDIOVOL* is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. *TURNOVER* is the ratio of stock's volume over the period (-2,-1) and the number of shares outstanding. *LOGSIZE* is the logged firm market capitalization. *MB* is the price-to-book ratio. *ILLIQ* is the illiquidity factor of Amihud (2002), which is the ratio of absolute stock returns to trading volume over the period (-2,-1). *PCR* is the ratio of the average put and call options trading volume. *VOLPREM* is the volatility premium, defined as the ratio of the average at-the-money call implied volatility and the stock's realized volatility. *OPTVOL_C* and *OPTVOL_P* are the total call and put options trading volume over the period (-2,-1), respectively. *OPENINT_C* and *OPENINT_P* are the total call and put open interest over the period (-2,-1), respectively. *O/S* is the ratio of total options trading volume (call and put) to total stock trading volume over the period (-2,-1). *ΔIVC* and *ΔIVP* are changes in implied volatilities over the period (-2,-1) in at-the-money call and put options, respectively. Model 1 includes only the variable of interest, *SKEW*. Model 2 includes the equity market control variables. Model 3 includes all options market control variables. Model 4 includes all control variables from both equity and options markets. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

	Model 1		Model 2		Model 3		Model 4	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	-0.023	-6.09***	0.007	0.16	-0.021	-4.85***	0.048	0.83
SKEW	-0.119	-3.20***	-0.105	-2.63***	-0.142	-3.41***	-0.147	-3.20***
CAR(-2,-1)			-0.077	-1.31			-0.059	-0.90
HSKEW			0.019	4.85***			0.016	3.96***
IDIOVOL			-1.012	-5.08***			-0.960	-4.57***
TURNOVER('000)			-0.030	-0.29			-0.030	-0.34
LOGSIZE			0.000	0.03			-0.002	-0.36
MB('000)			-0.050	-1.15			-0.052	-0.99
ILLIQ			-52200	-0.37			-27141	-1.19
PCR					0.001	0.85	0.001	0.93
VOLPREM('000)					-0.005	-0.66	-0.005	-1.08
OPTVOL_C('000)					-0.005	-2.08**	-0.005	-1.10
OPTVOL_P('000)					0.015	2.43**	0.013	2.12**
OPENINT_C('000)					0.000	-0.03	0.000	-0.24
OPENINT_P('000)					0.000	-0.15	0.000	-0.27
O/S					0.167	0.25	0.293	0.44
ΔIVC					0.064	-0.06	-0.040	-0.78
ΔIVP					-0.003	-0.53	0.028	-0.51
Adj.R^2	0.022		0.119		0.030		0.108	

levels of *SKEW* before the announcement.[33] The higher the demand for OTMP relative to ATMC options, the higher the abnormal returns subsequent to the SEO announcement. This is consistent with Bollen and Whaley (2004) and the equilibrium model of Gârleanu et al. (2009) who show that end-user demand is positively related to options moneyness measured by their implied volatilities. Thus, an investor with information about a future SEO announcement, which implies negative news and decline in price, can choose to buy OTMP options (or write call options as discussed in footnote 24) before the announcement in the view of a price decline immediately after the announcement. Investors with similar information possessing ATMC options will opt to sell these securities. This demand creates higher OTMP implied volatility relative to ATMC implied volatility thus making the volatility *SKEW* more pronounced resulting in abnormal returns prediction by *SKEW*.

I then turn to estimate 3 multivariate regressions to gauge the incremental information content in *SKEW* over the information embedded in the stock price and other firm and options characteristics prior to the announcement. The results of the 3 multivariate regressions are presented in Table 4. Model 2 contains the 7 equity market variables, Model 3 contains the 9 options market variables, and Model 4 includes all 16 control variables described above. In all 3 models with the various control variables the coefficient of *SKEW* remains negative and statistically highly significant (at the 1% level). Stock returns prior to the announcement (*CAR* (-2,-1)) however, is statistically insignificant in Models 2 and 4 indicating that the information from informed investors about the approaching announcement is incorporated into options but not into stock prices as reflected by the demand for OTMP relative to ATMC (higher levels of *SKEW*).

I now turn to examine the coefficients in Model 4 which includes all control variables. In addition to *SKEW*, the variables *HSKEW*, *IDIOVOL* and *OPTVOL_P* are also statistically

[33] As I show in the next section, the increase in implied volatility (high demand) of for put options is not necessarily accompanied by higher trading volume.

significant. The positive coefficient on *HSKEW* is consistent with Xing et al. (2010) but in contrast to Barberis and Huang (2008) who show that a more positively skewed stock should earn lower returns. *IDIOVOL* has a negative coefficient indicating that stocks with low idiosyncratic volatility in the month before the announcement experience higher abnormal returns following SEO announcements which is consistent with the findings in Ang et al. (2006). While *OPTVOL_P* has a significant positive coefficient, *OPTVOL_C* is insignificant indicating that it is higher put and not call options trading volume which is related to abnormal returns. Thus, it is the higher demand for put options (bet on decline in price) and not the selling of call options which drives the shape of the volatility skew.

Overall, results in Table 4 show that in the immediate period preceding the announcement, informed investors disseminate information into options, but not stocks, by choosing to trade on their information by buying OTMP options. In turn, the demand for these OTMP options drives up their implied volatilities making the volatility *SKEW* more pronounced. These findings clearly support H1 that the volatility skew is related to, and predictive of, the abnormal returns subsequent to SEO announcements.

3.6 Robustness Tests

Results in the previous section indicate a strong relation between *SKEW* and abnormal returns following SEO announcements as predicted by H1. I now examine if these results hold under various robustness tests. First, I observe the relation between *SKEW* and abnormal returns from SEO announcements using the portfolio sorts approach. Second, I test the prediction of *SKEW* around pseudo *CAR* windows. Third, I look at alternative measures of *SKEW*.

3.6.1 Portfolio sorts

Although portfolio sorts are a simple reflection of how average returns vary across the spectrum of *SKEW*, as Fama and French (2008) note, one shortcoming of regressions is the potential of influential observation problem which may bias the results. Sorts provide verification for this issue. To construct quintile portfolios, I rank all firms' *CAR*(0,1) based on *SKEW*(-2,-1). Table 5 presents results of the portfolio sorts. The Low (High) portfolio has an average *SKEW* of -0.0327 (0.1736) and average *CAR*(0,1) of -2.28% (-4.21%) with *t*-statistic of -3.65 (-6.26). The higher (lower) negative *CAR*(0,1)s are concentrated in the higher (lower) *SKEW* portfolios. The *CAR*(0,1) difference between the High and Low portfolios is -1.93% and a two-sample t-test yields a t-statistic of -2.10. These results are consistent with the findings from the cross-sectional regressions in the previous section that show that higher (lower) *SKEW* is related to higher (lower) negative *CAR*(0,1).

Table 5 also presents means of SIZE, *MB*, OPTVOL, *PCR*, *ΔIVC*, *ΔIVP* and *O/S* for each portfolio. Noticeably, the lowest option trading volume is in the extreme portfolios (Low and High), indicating that higher implied volatilities increase by demand and are not necessarily accompanied by higher trading volume. In addition, none of these variables seems to change monotonically across portfolios. To summarize, the results from the portfolio sorts

Table 5
Portfolio Sorts on *SKEW*
Sample Period: 1996 – 2011

This table presents results from portfolio sorts based on the average *SKEW* two days before the announcement (trading days -2,-1), where *SKEW* is the difference between the implied volatilities of out-of-the-money put and at-the-money call options. *CAR*(0,1) is the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return from the CRSP value-weighted return index (VWRETD). *SIZE* is market capitalization in millions of dollars at December of the previous year, defined as stock's price times shares outstanding. *MB* is the price-to-book ratio. *OPTVOL* is the average total put and call options trading volume. *PCR* is the ratio of the average put to call options trading volume. *ΔIVC* and *ΔIVP* are the changes in implied volatilities over the week before the announcement in at-the money call and put options, respectively. *O/S* is the percentage ratio of total options trading volume (call and put) to total stock trading volume over the period (-2,-1). The t-statistics for High-Low is from a two-sample t-test. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Portfolio	*SKEW*	*CAR*(0,1)	*t-stat.*	*SIZE*	*MB*	*OPTVOL*	*PCR*	*ΔIVC*	*ΔIVP*	*O/S*
Low	-0.033	-0.023	-3.65***	13.36	0.31	904.16	0.62	0.72	0.68	0.10
2	0.019	-0.022	-2.79***	13.76	0.31	2684.52	1.26	0.62	0.62	0.09
3	0.047	-0.021	-2.74***	13.78	0.32	2972.88	0.43	0.60	0.62	0.08
4	0.086	-0.043	-6.90***	13.69	0.42	1888.71	1.19	0.56	0.59	0.08
High	0.174	-0.042	-6.26***	13.42	0.44	1012.94	1.23	0.59	0.64	0.11
High-Low		-0.019	-2.10**							

support the findings from the regression analysis that *SKEW* is highly related to, and is an important predictive measure of, abnormal returns subsequent to SEO announcements.

3.6.2 Predictive power of *SKEW* around pseudo *CAR* windows

Results in previous sections indicate that *SKEW* is strongly related to abnormal returns following SEO announcements (*CAR*(0,1)). However, it is plausible that *SKEW* is not uniquely related to these abnormal returns. That is, *SKEW* might have a general predictive ability for different (random) return periods around SEO announcements. In order to separate the predictive ability of *SKEW* for abnormal returns following an SEO announcement (*CAR*(0,1)) from other CARs which are not around SEO announcements, I again run multivariate cross-sectional regressions, as in Equation (1), with control variables (as in Model 4) on six random pseudo *CAR* windows. Specifically, I run six regressions where the dependent variable is *CAR* for the randomly chosen windows: (-15,-14), (-12,-11), (-10,-9), (-8,-7), (-5,-4) and (-2,-1) and the variable of interest *SKEW*, is measured over the preceding two-day windows: (-17,-16), (-14,-13), (-12,-11), (-10,-9), (-7,-6) and (-4,-3), respectively.

Table 6 reports results of these six regressions and for comparison, I also include the results of the regression for *CAR*(0,1) from Model 4, Table 4, in which the coefficient of *SKEW* was statistically highly significant. For brevity, I only report coefficients and *t*-statistics of *SKEW* and not the control variables. The results reported in Table 6 show that the coefficients of *SKEW* are statistically insignificant for all pseudo *CAR* windows. The results also show that the *t*-statistics do not increase in magnitude as the *CAR* approaches the (0,1) window, indicating that information is only incorporated into *SKEW* prior to the news from the SEO announcement. This is consistent with prior research which shows that informed traders initiate a greater amount of short positions immediately before bad news (e.g., Amin and Lee (1997) among others). Overall, results in Table 6 indicate that *SKEW* is strongly

Table 6
Multivariate Cross-Sectional Regressions with Control Variables for Predictability Power of *SKEW* for Pseudo *CAR* Periods
Sample Period: 1996 - 2011

This table presents results from multivariate cross-sectional regressions where the dependent variable is a two-day window *CAR*, defined as the cumulative abnormal returns for the two days, where abnormal returns are calculated as the difference between the firm's actual return and the return from the CRSP value-weighted return index (VWRETD). The independent variables in each regression are *SKEW* which is the average of *SKEW* over the two days prior to the predicted two-day *CAR*, where *SKEW* is the difference between the implied volatilities of out-of-the-money put and at-the-money call options. The control variables are the variables from model 4 and include: *HSKEW*, *IDIOVOL*, *CAR* of the five trading days prior to the predicted period, *TURNOVER*, *LOGSIZE*, *MB*, *ILLIQ*, *PCR*, *VOLPREMIUM*, *OPTVOL_C*, *OPTVOL_P*, *OPENINT_C*, *OPENINT_P*, *O/S*, *ΔIVC*, *ΔIVP*. *** indicates significance at the 1% level.

Predicted Period Window	Predicting Period Window	Coefficient of *SKEW*	*t*-statistics of *SKEW*	*f*-statistics of model	Adj.R^2
CAR(-15,-14)	(-17,-16)	-0.073	-1.16	1.72	0.039
CAR(-12,-11)	(-14,-13)	0.018	0.34	1.57	0.030
CAR(-10,-9)	(-12,-11)	0.023	0.44	0.57	-0.024
CAR(-8,-7)	(-10,-9)	0.011	0.23	0.60	-0.022
CAR(-5,-4)	(-7,-6)	0.026	0.69	1.20	0.011
CAR(-2,-1)	(-4,-3)	-0.010	-0.27	0.87	-0.007
CAR(0,1)	(-2,-1)	-0.147	-3.20***	3.34	0.109

related to abnormal returns from SEO announcements but not related to CARs around pseudo windows.

3.6.3 Alternative measures of options trading

So far I have documented that *SKEW* is strongly related to abnormal returns from SEO announcements. In this section I test whether this relationship holds for alternative measures of options trading and *SKEW*. In particular, it is possible to construct the volatility skew, defined as the difference between the volatilities of OTMP and ATMC, using different moneyness (deltas) levels of OTMP options. While the choice of deep-out-of-the-money put options (with delta=-0.20) resembles the volatility skew in Xing et al. (2010), other deltas for *SKEW* are also used in the literature. Yan (2011) for example, defines the volatility skew as the difference between volatilities of put options with delta of -0.50 and call options with delta of 0.50. Using this measure as a proxy for jump risk, Yan (2011) documents a negative predictive relation between the slope of the volatility skew and stock returns. To the extent that the predictive ability of abnormal returns subsequent to SEO announcements by *SKEW* is sensitive to the choice of moneyness, I consider the measure of volatility skew used in Yan (2011) in addition to other measures. Specifically, I examine *SKEW*(-0.25), *SKEW*(-0.30), *SKEW*(-0.35), and *PUT-CALL* as measures of *SKEW* in which the deltas of the OTMP options are: -0.25, -0.30, -0.35, and -0.50, respectively. In addition, other measures of options trading which are predictive of stock returns have been documented in the literature. In particular, Roll et al. (2010) show that the *O/S* ratio is strongly related to stock returns and Johnson and So (2011) find that firms with low *O/S* outperform firms with high *O/S*. Since the *O/S* has the ability to predict stock returns, I use it as an alternative measure for *SKEW*. Lastly I examine innovations in call and put implied volatilities as an alternative measure for *SKEW* as Ang et al. (2010) show that *ΔIVC* (*ΔIVP*) indicate higher (lower) expected stock returns. I then use these measures and repeat the analysis of the multivariate regressions in Equation (1).

Table 7 provides results of these regressions. The coefficients of *SKEW*(-0.25), *SKEW*(-0.30) and *SKEW*(-0.35) are all negative and statistically highly significant (1% level) and of a similar magnitude to the *SKEW* used in Model 4 (with delta=-0.20). Interestingly, the coefficient on *PUT-CALL* is much lower in magnitude, and not significant at the 5% level (but significant at the 10% level) and the coefficients on *O/S*, *ΔIVC*, and *ΔIVP* are all statistically insignificant. Overall, these results indicate that informed investors demand deeper OTMP over ATMP options prior to SEO announcements in order to increase their profit from the upcoming announcement and subsequent sharp decline in price (OTMP options can provide higher returns than ATMP in case of a sharp price decline as in SEO announcements).

Table 7

Predictability of Alternative Measures of *SKEW* in Multivariate Cross-Sectional Regressions

Sample Period: 1996 – 2011

This table presents results from multivariate cross-sectional regressions for different measures of *SKEW* where the dependent variable is *CAR*(0,1), defined as the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return from the CRSP value-weighted return index (VWRETD). The independent variables are *SKEW*(-0.25), *SKEW*(-0.30), *SKEW*(-0.35), *PUT-CALL*, which are the averages over the two days prior to the inclusion announcement in the difference between the implied volatilities of out-of-the-money put options with deltas of -0.25, -0.30, -0.35, and -0.50, respectively, and at-the-money call options (call options with delta=0.50). O/S is the options to stock trading volume ratio, *ΔIVC* and *ΔIVP* are the first difference over the two days before the announcement in implied volatilities of call and put options, respectively. The other control variables are the variables from Model 4 in Table 4. *t*-statistics are in parenthesis. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

	SKEW(-0.25)		*SKEW*(-0.30)		*SKEW*(-0.35)		*PUT-CALL*		*O/S*		*ΔIVC*		*ΔIVP*	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	0.04	0.76	0.04	0.74	0.04	0.65	0.02	0.39	0.02	0.43	0.02	0.42	0.02	0.40
SKEW	-0.14	-3.01***	-0.15	-3.04***	-0.16	-3.03***	-0.11	-1.80*	-0.66	-0.51	-0.01	-0.27	-0.05	-0.99
CAR(-2,-1)	-0.07	-1.17	-0.07	-1.14	-0.07	-1.14	-0.08	-1.33	-0.09	-1.51	-0.10	-1.52	-0.09	-1.52
HSKEW	0.02	4.04***	0.02	4.03***	0.02	3.96***	0.02	4.09***	0.02	4.28***	0.02	4.27***	0.02	4.30***
IDIOVOL	-0.92	-4.39***	-0.91	-4.33***	-0.89	-4.25***	-0.88	-4.17***	-0.90	-4.25***	-0.91	-4.28***	-0.91	-4.28***
TURNOVER('000)	0.00	-1.05	0.00	-1.04	0.00	-1.02	0.00	-0.95	0.00	-0.87	0.00	-0.79	0.00	-0.71
LOGSIZE	0.00	-0.58	0.00	-0.59	0.00	-0.52	0.00	-0.33	0.00	-0.38	0.00	-0.38	0.00	-0.36
MB('000)	0.00	-0.98	0.00	-0.98	0.00	-0.99	0.00	-0.96	0.00	-0.85	0.00	-0.85	0.00	-0.82
ILLIQ	-29785	-1.32	-30149	-1.34	-29068	-1.29	-22450	-1.00	-19025	-0.84	-18355	-0.80	-17893	-0.79
PCR('000)	0.00	0.94	0.00	0.91	0.00	0.85	0.00	0.74	0.00	0.72	0.00	0.73	0.00	0.73
VOLPREM('000)	0.00	-1.09	0.00	-1.08	0.00	-1.05	0.00	-0.94	0.00	-0.81	0.00	-0.80	0.00	-0.86
OPTVOL('000)	0.00	1.31	0.00	1.29	0.00	1.30	0.00	1.34	0.00	1.41	0.00	1.36	0.00	1.23
OPENINT_C('000)	0.00	-0.30	0.00	-0.35	0.00	-0.37	0.00	-0.28	0.00	-0.17	0.00	-0.26	0.00	-0.36
OPENINT('000)	0.00	0.02	0.00	0.07	0.00	0.08	0.00	-0.01	0.00	-0.11	0.00	-0.03	0.00	0.08
Adj.R^2	0.11		0.11		0.11		0.09		0.08		0.08		0.08	

3.7 Options Trading around Issue Dates

3.7.1 Issue discount and options trading

In order to test the manipulative trading hypothesis I examine if higher levels (higher demand) of put option implied volatility are associated with higher issue discounts (H2), I run regressions of SEO issue discounts on a measure of put option implied volatility and various firm and offering characteristics as control variables. Specifically, I estimate the following cross-sectional regression:

$$DISCOUNT_i = b_0 + b_1\, PUTIV_i + b_2{}' X_i + \varepsilon_i \qquad (3)$$

where $DISCOUNT_i$ is firm i's issue discount, defined as the percentage difference between the SEO offering price and the closing price the day before the offering multiplied by negative one. I follow the literature (e.g., Safieddine and Wilhelm (1996)) and apply the volume-based correction procedure to account for offerings that occur after the close of trading on the SDC reported offer date (Lease et al. (1991)). I correct the offer date and set it to the day following the SDC reported offer date, if trading volume on the day following the SDC offer date is more than twice the trading volume on the SDC offer date. The procedure results in a total of 284 corrections. I also require that there are at least five trading days between the announcement and issue dates to eliminate the effect of options trading around the announcement day.

$PUTIV_i$ is the variable of interest and is defined as the firm i's average put option implied volatility over the five trading days preceding the issue date (the short-sale restriction period). It is important to note that all firms in the sample have short selling activities in the month of the issue date (however data on short interest are only available from 2003). This ensures that results are not driven by short-sale restrictions. As per H2, I expect the coefficient on this variable (*PUTIV*) to be significantly positive if manipulative trading takes place before the issue date. Since investors may require different levels of options moneyness, I examine $PUTIV_i$ with five different deltas: -0.20, -0.25, -0.30, -0.35 and -0.50. X_i is a vector of control variables known to influence the issue discount and is motivated by the findings in Altinkilic and Hansen (2003) and Corwin (2003). Specifically, I control for levels of information asymmetry (higher levels imply higher discounts) by including the logarithm of the firm's market capitalization the day before the offering (*LOGSIZE*) and the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. To capture price-pressure effects which are related to the ability of the market to absorb the new shares, I include the number of shares offered in the SEO divided by the number of shares outstanding prior to the offering (*RELOFRSIZE*). To capture the information incorporated into the stock price prior to the issue I include *CARPOS* (*CARNEG*) which is the cumulative abnormal return over the five days preceding the offering if it is positive (negative), and zero otherwise. *LOGPRICE* is the natural log of price the day before the issue and captures underwriter pricing effects (as in Lee, Lochhead, Ritter and Zhao (1996)). *MB* is the price-to-book ratio to capture the relationship between this ratio and the issue discount (as in Jones and Lamont (2002)). To capture the clustering of pricing at even quarters (as in Molina (2005)) I include *OFPRCLUSTER*, which is the offer price cluster - a dummy variable equal to one if the decimal portion of the offer price is 0.00, 0.25, 0.50, or 0.75. I also include EXCHANGE which is a dummy variable that takes the value of 1 for NYSE/AMEX or 0 for NASDQ to capture the differences across these markets.

Table 8 reports results of the regression in Equation (3) across five models where the variable of interest, $PUTIV_{i,}$ has delta of: -0.20, -0.25, -0.30, -0.35 and -0.50 in Models 1 – 5, respectively. $PUTIV_i$ is positive and statistically highly significant in all five Models. This is consistent with hypothesis H2 – under the Gerard and Nanda (1993) model, manipulative trading takes place in the put options market which is a substitute for short selling. This result is consistent with the recent finding of Henry and Koski (2010) that short selling originates from traders who try to manipulate the offer price downward.

I further investigate if abnormal trading in put options is related to the issue discount. To do so, I rerun the regressions in Equation (3) with *ABPUTIV* which is the abnormal put option implied volatility and is calculated as the average put option implied volatility over the five trading days pre-issue divided by the average put option implied volatility over the benchmark period (days -50,-30) with deltas of -0.20, -0.25, -0.30, -0.35 and -0.50 in Models 1 - 5, respectively, and all control variables discussed above. Table 9 reports results of these regressions. The significant coefficients on *ABPUTIV* indicate that abnormal put option implied volatility is also associated with the issue discount, again supporting the manipulation trading hypothesis (H2).

Table 8

Regressions of SEO Discount on Pre-Issue Put Option Implied Volatility

Sample Period: 1996 – 2011

This table presents results from cross-sectional regressions where the dependent variable is the SEO discount, defined as the percentage difference between the SEO offering price and the closing price the day before the offering multiply by negative one. The variable of interest is *PUTIV* which is the average put option implied volatility over the five trading days pre-issue with put options deltas of -0.20, -0.25, -0.30, -0.35 and -0.50 in Model 1, Model 2, Model 3, Model 4 and Model 5, respectively. The control variables defined as follows. *LOGSIZE* is the logged firm market capitalization. *IDIOVOL* is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. *RELOFRSIZE* is the number of shares offered in the SEO divided by the number of shares outstanding prior to the offering. *CARPOS* (*CARNEG*) is the cumulative abnormal return over the five days preceding the offering if it is positive (negative), and zero otherwise. *LOGPRICE* is the logged price the day before the issue. *MB* is the price-to-book ratio. *OFPRCLUSTER* is the offer price cluster - a dummy variable equal to one if the decimal portion of the offer price is 0.00, 0.25, 0.50, or 0.75. *EXCHANGE* is a dummy variable that takes the value of 1 for NYSE/AMEX or 0 for NASDQ. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

	(Δ=-0.20) Model 1		(Δ=-0.25) Model 2		(Δ=-0.30) Model 3		(Δ=-0.35) Model 4		(Δ=-0.50) Model 5	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	3.100	0.88	3.180	0.90	3.080	0.87	3.040	0.86	1.920	0.54
PUTIV	6.680	5.89***	6.650	5.85***	6.730	5.90***	6.790	5.92***	7.830	6.54***
LOGSIZE	-0.150	-0.54	-0.150	-0.52	-0.130	-0.46	-0.120	-0.43	-0.030	-0.12
IDIOVOL	-42.730	-2.68***	-42.990	-2.68***	-43.720	-2.72***	-44.18	-2.75***	-51.060	-3.18***
RELOFRSIZE	0	-1.05	0	-1.06	0	-1.06	0	-1.06	0	-1.09
CARPOS	-12.380	-3.00***	-12.400	-3.00***	-12.490	-3.02***	-12.540	-3.04***	-13.460	-3.28***
CARNEG	0.380	0.10	0.570	0.15	0.770	0.20	0.900	0.24	2.130	0.57
LOGPRICE	-0.560	-1.36	-0.580	-1.42	-0.610	-1.48	-0.620	-1.53	-0.730	-1.81
MB	0.020	7.38***	0.020	7.36***	0.020	7.34***	0.020	7.33***	0.020	7.27***
OFPRCLUSTER	1.480	2.88***	1.490	2.91***	1.500	2.93***	1.500	2.93***	1.510	2.98***
EXCHANGE	-0.130	-0.25	-0.110	-0.21	-0.090	-0.17	-0.080	-0.15	-0.040	-0.08
Adj.R^2	0.250		0.250		0.250		0.250		0.270	

Table 9

Regressions of SEO Discount on Pre-Issue Abnormal Put Option Implied Volatility

Sample Period: 1996 – 2011

This table presents results from cross-sectional regressions where the dependent variable is the SEO discount, defined as the percentage difference between the SEO offering price and the closing price the day before the offering multiply by negative one. The variable of interest is *ABPUTIV* which is the abnormal put option implied volatility and is calculated as the average put option implied volatility over the five trading days pre-issue divided by the average put option implied volatility over the benchmark period (days -50,-30) with put options deltas of -0.20, -0.25, -0.30, -0.35 and -0.50 in Model 1, Model 2, Model 3, Model 4 and Model 5, respectively. The control variables defined as follows. *LOGSIZE* is the logged firm market capitalization. *IDIOVOL* is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. *RELOFRSIZE* is the number of shares offered in the SEO divided by the number of shares outstanding prior to the offering. *CARPOS* (*CARNEG*) is the cumulative abnormal return over the five days preceding the offering if it is positive (negative), and zero otherwise. *LOGPRICE* is the logged price the day before the issue. MB is the price-to-book ratio. *OFPRCLUSTER* is the offer price cluster - a dummy variable equal to one if the decimal portion of the offer price is 0.00, 0.25, 0.50, or 0.75. *EXCHANGE* is a dummy variable that takes the value of 1 for NYSE/AMEX or 0 for NASDQ. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

	(Δ=-0.20) Model 1		(Δ=-0.25) Model 2		(Δ=-0.30) Model 3		(Δ=-0.35) Model 4		(Δ=-0.50) Model 5	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	3.100	1.02	3.080	1.01	3.020	0.99	3.000	0.98	3.000	0.98
ABPUTIV	1.950	2.33**	1.940	2.29**	1.840	2.12**	1.700	1.93*	2.110	2.23**
LOGSIZE	0.160	0.67	0.170	0.68	0.170	0.69	0.170	0.69	0.180	0.72
IDIOVOL	31.810	2.83***	31.560	2.81***	31.470	2.79***	31.700	2.81***	32.330	2.88***
RELOFRSIZE	0	-1.13	0	-1.14	0	-1.14	0	-1.13	0	-1.15
CARPOS	-6.700	-1.90*	-6.710	-1.90**	-6.760	-1.92*	-6.790	-1.92**	-6.960	-1.98**
CARNEG	-4.330	-1.29	-4.360	-1.30	-4.410	-1.31	-4.460	-1.33	-4.250	-1.26
LOGPRICE	-1.520	-4.32***	-1.520	-4.32***	-1.520	-4.30***	-1.510	-4.28***	-1.540	-4.36***
MB	0.020	9.21***	0.020	9.20***	0.020	9.19***	0.020	9.17***	0.020	9.11***
OFPRCLUSTER	1.830	3.95***	1.840	3.96***	1.830	3.95***	1.820	3.92***	1.830	3.95***
EXCHANGE	-0.210	-0.48	-0.210	-0.46	-0.200	-0.44	-0.200	-0.44	-0.250	-0.57
Adj.R^2	0.330		0.330		0.330		0.330		0.330	

Since informed traders can also write call options which should be, under certain conditions, similar to buying put options and short selling stocks, I repeat the analysis, as in Equation (3), for call option implied volatility (*CALLIV*), abnormal call option implied volatility (*ABCALLIV*), the volatility skew (*SKEW*), the call-put spread (*CALL-PUT*), in addition to the ratio of options to stock trading volume (*O/S*). Table 10 reports results for this analysis for each of these option measures in Models 1 – 5, respectively. While the coefficient on *CALLIV* is statistically significant, the coefficient on *ABCALLIV* is statistically insignificant indicating that there is no abnormal demand for call options in order to manipulate the offer price and that put and call options contain different information. In particular, it is easier for traders to replicate a short position by buying put options than writing call options. The higher demand for put options relative to call options is also reflected in the significant coefficient on *SKEW* which is positive, that is, higher demand for out-of-the-money put options relative to at-the-money call options indicates higher issue discount, and the significant coefficient on *CALL-PUT* which is negative, that is, higher demand for at-the-money call options relative to at-the-money put options indicates lower issue discount. Lastly, it seems that the ratio of options to stock trading volume is unrelated to the issue discount possibly due to activities in both the stock and option markets.

Table 10

Regressions of SEO Discount on Options Trading Measures

Sample Period: 1996 – 2011

This table presents results from cross-sectional regressions where the dependent variable is the SEO discount, defined as the percentage difference between the SEO offering price and the closing price the day before the offering multiply by negative one. The variables of interest are *CALLIV* which is the average at-the-money call option implied volatility over the five trading days pre-issue (Model 1), *ABCALLIV* (Model 2) is the abnormal call option implied volatility and is calculated as the average at-the-money call option implied volatility over the five trading days pre-issue divided by the average at-the-money call option implied volatility over the benchmark period (days -50,-30), *SKEW* is the volatility skew defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options (Model 3), *CALL- PUT* is the difference between the implied volatilities of at-the-money call and at-the-money put options (Model 4), *O/S* is the ratio of option to stock trading volume (Model 5). The control variables defined as follows. *LOGSIZE* is the logged firm market capitalization. *IDIOVOL* is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. *RELOFRSIZE* is the number of shares offered in the SEO divided by the number of shares outstanding prior to the offering. *CARPOS* (*CARNEG*) is the cumulative abnormal return over the five days preceding the offering if it is positive (negative), and zero otherwise. *LOGPRICE* is the logged price the day before the issue. *MB* is the price-to-book ratio. *OFPRCLUSTER* is the offer price cluster - a dummy variable equal to one if the decimal portion of the offer price is 0.00, 0.25, 0.50, or 0.75. *EXCHANGE* is a dummy variable that takes the value of 1 for NYSE/AMEX or 0 for NASDQ. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

	Model 1		Model 2		Model 3		Model 4		Model 5	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	2.580	0.72	2.809	0.92	7.830	2.17**	7.770	2.19**	7.899	2.16**
CALLIV	6.697	5.30***								
ABCALLIV			1.200	1.33						
SKEW					5.271	2.13**				
CALL-PUT							-16.069	-4.09***		
O/S									116.031	0.88
LOGSIZE	-0.045	-0.16	0.185	0.75	-0.337	-1.14	-0.300	-1.04	-0.284	-0.96
IDIOVOL	-41.959	-2.52**	32.640	2.89***	14.268	1.09	16.161	1.25	14.991	1.14
RELOFRSIZE	-0.001	-1.12	-0.001	-1.16	-0.001	-0.73	-0.001	-0.59	-0.001	-0.91
CARPOS	-12.569	-3.01	-6.914	-1.95	-9.551	-2.24**	-10.520	-2.50**	-9.783	-2.28
CARNEG	1.534	0.4	-4.418	-1.31	-4.316	-1.11	-3.920	-1.03	-3.284	-0.85
LOGPRICE	-0.754	-1.84	-1.526	-4.30***	-0.623	-1.45	-0.737	-1.77	-0.817	-1.91*
MB	0.024	7.29***	0.024	9.20***	0.024	7.05***	0.023	6.79***	0.024	6.99***
OFPRCLUSTER	1.582	3.06***	1.833	3.92***	1.613	3.02***	1.594	3.04***	1.702	3.18***
EXCHANGE	-0.101	-0.19	-0.220	-0.49	-0.547	-1.02	-0.549	-1.04	-0.536	-0.99
Adj.R^2	0.240		0.325		0.191		0.217		0.183	

3.8 Discussion – Effectiveness of Rule 105

Rule 105 prohibits short-sellers from purchasing shares in an SEO in order to cover their short positions if the positions were established during the five business days preceding the offer date and since October 2007 it prohibits any share purchasing regardless of whether the shares are used to cover an open short position. As discussed in Subsection 3.2.2 the intention of the Rule was to eliminate manipulative trading. While most previous studies (e.g., Safieddine and Wilhelm (1996), Corwin (2003), Kim and Shin (2004)) reject the manipulative trading hypothesis using monthly short-interest data, more recently, Henry and Koski (2010) use daily short-interest data and find evidence that supports the manipulative trading hypothesis. The evidence in this study supports the manipulative trading hypothesis by showing that, consistent with the Gerard and Nanda (1993) model, higher demand for put options is associated with higher levels of the issue discount. The results in this study suggest that Rule 105 should be extended to restrict other related securities and not only short-sale activities.

3.9 Conclusions

The literature on seasoned equity offerings (SEOs) indicates that announcements of SEOs are associated with economically and statistically significant negative average abnormal returns of more than 2% in addition to an issue discount of about 3%. This study examines the informational role of options around SEO announcement and issue dates. I develop two hypotheses in order to test whether i) investors receive information about impending SEO announcements, and ii) manipulative trading takes place prior to SEO issuance. The results in this study support the first hypothesis and show that traders are informed about SEO announcements. Specifically, higher demand for out-of-the-money put options relative to at-the-money call options is strongly associated with abnormal returns from SEO announcements. Higher demand for out-of-the-money put options predicts higher negative abnormal returns following SEO announcements. The results are robust to a battery of alternative methods (cross-sectional regressions and portfolio sorts) and option trading measures. In addition, results indicate that informed investors demand deeper out-of-the-money over at-the-money put options prior to SEO announcements in order to increase their return from the upcoming announcement and subsequent sharp decline in price. These results are in contrast to prior studies which find no evidence for informed trading prior to SEO announcements using data on short-selling activities as a proxy for informed trading (e.g., Henry and Koski (2010)). The evidence of informed trading prior to SEO announcements is consistent with the notion that informed traders operate in the options market.

Around issue dates, I find that higher demand for put options is significantly related to larger issue discounts. Specifically, higher levels of put option implied volatility prior to issue dates are positively correlated with higher levels of issue discounts. These results are consistent with manipulative trading under the Gerard and Nanda (1993) model and with prior studies which find evidence for manipulative trading using data on short selling activities prior to issue dates (e.g., Henry and Koski (2010)). That is, manipulative trading takes place in the put options market, which is a substitute for short selling, in order to manipulate, and subsequently profit from, a higher issue discount.

Lastly, the results in this study have implications for both issuers and decision makers. Issuers should be wary of price manipulation via options trading and regulators should consider extending the short-sale restrictions of Rule 105 to restrict trading in related securities.

Chapter 4 – The Information Content of Options Prior to Changes to the S&P 500 Index

4.1 Introduction

This study investigates whether options trading contains information which is predictive of the abnormal returns from S&P 500 Index inclusion and exclusion announcements. Specifically, the predictive ability of the volatility skew (in addition to other options trading measures) is considered as the literature indicates that the options volatility skew can be used as a proxy for jump risk and is predictive of future stock returns (e.g., Xing et al. (2010) and crashes Van Buskirk (2011)). I choose to study S&P 500 Index inclusion and exclusion announcements because i) they are unscheduled and therefore to some extent unanticipated by the market,[34] ii) they are not announced by the firm but by the S&P 500 Committee, and iii) they should convey no new information. With an estimated value of total worldwide indexed assets in excess of $1 trillion (Kappou et al. (2010)) and a large average announcement-day abnormal return (4.59% for inclusion, -4.53 for exclusion

[34] While investors may speculate as to which firm might be included or excluded from the index, S&P does not reveal which firms are candidates for inclusion or exclusion from the index thus the included and excluded firms are not known with certainty. Indeed anecdotal evidence indicates that some investors heavily speculate on firms which might be included or excluded from the index, however, investors can only know which firm will end up included in, or excluded from the index with certainty if they possess private material information. Thus, these announcements are, at least to some extent, unanticipated by the market.

announcements), there is a clear incentive for investors to acquire information about these announcements.

When S&P announces a new addition to (deletion from) the S&P 500 Index, index funds that track the index (also known as "trackers") must add (sell) the newly index-included (excluded) firm to (from) their portfolios. However, in order to mitigate tracking error, some index funds buy (sell) the included (excluded) firm only on the effective day of inclusion (exclusion) to (from) the index which usually occurs a few days after[35] the announcement.[36] As a result, buying or selling firms immediately after the announcement and before the effective day provides a profitable trading strategy to investors not involved in index tracking. By contrast, index funds that choose to buy (sell) the added (excluded) firm at a higher (lower) price on the effective day of inclusion (exclusion), pay a premium relative to investors not involved in index tracking. Considering the large abnormal returns from these announcements and the amount of funds involved in indexing, acquiring information about index change announcements can clearly benefit index funds and other investors not involved in index tracking.

In this study I examine whether the options volatility skew, defined as the difference between the volatilities of out-of-the-money put (OTMP) and at-the-money call (ATMC) options, contains information which is predictive of the abnormal stock returns subsequent to index change announcements. A key question in financial economics is how information (private and public) diffuses across markets and how quickly it is reflected in security prices. A large body of literature indicates that investors possessing private information may opt to

[35] This time varies between one day and less than one month with an average of 6.5 days in the sample of this study.

[36] There is a trade-off between buying (selling) firms following the inclusion (exclusion) announcement and the tracking error. Fund managers who add (sell) the included (excluded) firm following the announcement and before the effective day will have higher tracking error but a better purchasing (selling) price while managers who add (sell) the included (excluded) firm on the effective day will have lower tracking error but worse purchasing (selling) price. The decision to trade strategically around announcement and effective dates depends on the fund characteristics (Green and Jame (2011)).

trade in the options market due to the lower costs, higher leverage and an absence of short-sale restrictions that options offer over stocks (Back (1993), Black (1975) and Manaster and Rendleman (1982)). If informed investors with private information on the impending index change announcement choose to trade in the options market, options may contain information which is predictive of the abnormal returns subsequent to these announcements. In particular, since inclusion (exclusion) announcements are positive (negative) events with a sharp increase (decrease) in price immediately after the announcement, informed investors are likely to purchase ATMC in favor of OTMP (purchase OTMP in favor of ATMC) prior to the announcement, thus creating a flatter (more pronounced) volatility skew. In turn, this creates returns predictability by the steepness of the volatility skew.

I adopt a standard event study methodology in order to gauge the predictive ability of the volatility skew for abnormal returns following inclusion and exclusion announcements. Using a comprehensive sample of 326 inclusion and 81 exclusion announcements[37] of optioned firms spanning the period 1996 to 2010, I find a significant negative relationship between levels of the volatility skew in the two days preceding the index inclusion announcement and abnormal returns subsequent to the announcement. In contrast I find no evidence for a relationship between the volatility skew and returns following exclusion announcements. Cross-sectional regressions reveal that levels of the volatility skew have a strong predictive power for cumulative abnormal returns on days 0 and 1 immediately after inclusion announcements. Portfolio sorts provide confirmation for this finding by showing that stocks in the lowest skew portfolio outperform stocks in the highest skew portfolio by 1.83% over days 0 and 1 immediately after the announcement. I also examine whether the volatility skew has a predictive power for abnormal stock returns for pseudo two-day-

[37] The discrepancy between the number of inclusions and exclusions is due to the filtering rule I apply to the sample which is discussed in Section 4.4 (for example, I exclude firms deleted from the index due to mergers and acquisitions) and is consistent with prior research (e.g., Chen et al. (2004)).

windows before and after the announcement, but find insignificant relationships from these regressions, indicating that the information is gradually incorporated into the volatility skew and reaches maximum efficiency closer to the announcement day. I also examine different measures of options trading (i.e., OTMP options with different deltas, the put-call spread, the options to stock trading volume ratio, and innovations in implied volatilities) and find that the results are robust to these different measures. Finally, I find that the predictive ability of the volatility skew is robust to different sub-samples (firm size, sign of returns, period, and level of options trading volume).

As discussed in Subsection 1.4.1, the finding that informed trading takes place prior to inclusion but not exclusion announcements is intriguing and is at odds with the findings of Chapter 3 that the volatility skew is predictive of negative events (SEO announcements). This may plausibly be explained by the fact that the sample size of exclusion announcements is relatively small (81 for exclusions and 326 for inclusions). This is because many of the firms are excluded from the index due to mergers and acquisitions, bankruptcy or other significant corporate events. As a result, the small sample may affect the power of the test. In addition, since firms excluded from the index are involved in other significant events around the time of deletion from the index, a large fluctuation in the stock prices of these firms is observed. For example, the average one-day return in the sample two days before the exclusion announcement is -2.3%, 1.4% on the following day and then -4.53% on the announcement day. The large fluctuation in returns on exclusion announcement days is reflected by the high standard deviation of returns which is more than double that of inclusion announcements. Option traders who are aware of price fluctuations and possible increase in price around exclusion announcements may therefore be reluctant to take positions in put options. It is therefore difficult to disentangle the effect of exclusion announcements from other factors that may affect abnormal returns.

This study is positioned at the intersection of two different strands of literature. The first strand focuses on index composition changes and the second focuses on the informational role of options. Although S&P clearly states that changes to the index do not reflect opinions about the firm's future prospects, the empirically observed abnormal returns have sparked a debate on whether these announcements are indeed information-free events, and a number of theories explaining these returns have emerged. In a seminal paper, Shleifer (1986) proposes the Downward-Sloping Demand Curve (or Imperfect Substitutes) in which index composition changes are information-free events and demand for newly included stock by large index funds, which track the index by replicating its composition, leads to increased buying pressure. Consequently, the stock price increases subsequent to the inclusion announcement, implying that the demand curve for stock slope downwards. Harris and Gurel (1986) make a similar argument but differ from Shleifer (1986) as they suggest that the effect is temporary and not permanent (the Price Pressure Hypothesis). They find that short-run liquidity constraints lead to price pressure which then reverses in the weeks following the index change. Jain (1987) proposes the Information Hypothesis in which addition of a stock to the S&P 500 index convey favorable information to the market. Dhillon and Johnson (1991) support the information hypothesis by showing that the bonds and options of the newly-included firm also increase in price indicating that the inclusions indeed contain information about the firm's future performance. Denis et al. (2003) and Chen et al. (2004) argue that an increase in investor awareness (Investor Recognition Hypothesis) to newly included firms whereby closer scrutiny of management which leads to better performance, is ultimately responsible for the price increase subsequent to the announcement. A common theme of the above mentioned studies is that they offer explanations for the observed abnormal stock returns after index composition changes announcements. No prior study, however, has examined whether these returns can be predicted. To the best of my knowledge this is the first study to examine the informational role and predictive power of the options volatility skew before S&P 500 Index inclusion and exclusion announcements.

This study also contributes to the literature on the informational role of options trading. Evidence is mixed on whether informed investors operate in the options market (Black (1975), Manaster and Rendleman (1982), and Easley et al. (1998)) or if these investors merely speculate using publicly available information to trade in the options market (Chan et al. (2002) and Stephan and Whaley (1990)). The empirical results in this study are consistent with the notion that informed traders trade in the options market prior to the stock market. It is important to note that any information revealed by options trading prior to index change announcements, necessarily points at informed trading as the culprit as only investors who possess material information will trade in the options market prior to the announcements which are unscheduled and therefore (at least to some extent) unanticipated[38] by the market. This contrasts markedly with the case of scheduled corporate events such as earnings announcements where investors may speculate on the announcement result (Cao et al. (2005)).

Lastly, this study is also related to previous studies exploring the predictive ability of the options volatility skew. However, this study differs from prior research in a significant way. Most prior work has used the volatility skew as a proxy for negative jump risk (at either the index or firm levels). For example, Bates (1991) shows that out-of-the-money put options on the S&P 500 become unusually expensive (and the volatility skew prominent) before negative price jumps, and Doran et al. (2007) demonstrate that the volatility skew constructed from options on the S&P 100 Index can predict market crashes but not spikes. Both studies focus on index predictability while this study focuses on the cross-sectional variation in the volatility skew. A number of recent studies show that the volatility skew is strongly related to

[38] This is discussed in footnote 34.

the likelihood of crashes at the firm level (Bradshaw et al. (2010), Van Buskirk (2011) and Jin et al. (2012)). My work differs from theirs as I use the volatility skew as a predictor of extreme unscheduled positive events as inclusion announcements are positive events by nature with almost all firms experiencing positive returns. Overall, results in this study support the hypothesis that informed traders trade in the options market.

The remainder of this chapter proceeds as follows. Section 4.2 provides a brief background of the S&P 500 Index composition and inclusion criteria. Section 4.3 surveys the related literature and develops the hypothesis. Section 4.4 describes the data and methods used in this study and presents the descriptive statistics. Section 4.5 presents the empirical findings and Section 4.6 discusses the robustness checks. Section 4.7 concludes.

4.2 The S&P 500 Index – Background

The S&P 500 Index is regarded as the single best measure of the U.S. equities market. It includes 500 leading companies and covers about 75% of the U.S. equities market in terms of market capitalization, and has a total index assets value of over US$ 1.3 trillion. First published in 1957, the Index is maintained by the S&P 500 Index Committee, a group of economists and index analysts who ensures that the Index is consistently representative of the U.S. equities market. The Committee follows a set of publically available criteria for determining Index inclusions and exclusions, while clearly stating that any decision for inclusion or exclusion is solely based upon public information. The Committee also states that "…Inclusion of a security within an index is not a recommendation by S&P Dow Jones Indices to buy, sell, or hold such security, nor is it considered to be investment advice" (S&P 2012, p. 27). The criteria for addition to the Index are revised from time to time but generally include the following: market capitalization of US$ 4 billion or more, adequate liquidity and reasonable price, a minimum of 250,000 traded shares, public float of at least 50% of the stock, sector representation, and positive reported earnings in 4 consecutive quarters. At each monthly meeting, the S&P Index Committee follows the guidelines for inclusion or exclusion from the index and identifies the list of eligible candidates. This list is kept confidential and the firms to be included to or excluded from the index are only announced once the choice has been finalized by the Committee stating that "S&P Dow Jones Indices considers information about changes to its U.S. indices and related matters to be potentially market moving and material. Therefore, all Index Committee discussions are confidential" (S&P 2012, p.21). Until October 1989, announcements of addition to, and deletions from the S&P 500 Index and the actual changes to the index occurred on the same day. S&P changed the announcement date to occur five days prior to the effective date, after October 1989.[39]

[39] Source: Standard & Poor's (www.standardandpoors.com).

4.3 Related Literature and Hypothesis Development

4.3.1 Announcement effects of S&P 500 Index inclusions and exclusions

It is well documented in the literature that announcements for inclusion to (exclusion from) the S&P 500 Index are followed by large positive (negative) abnormal returns (e.g., 2.79% in Shleifer (1986) and 5.9% in Beneish and Whaley (1996)). This is at odds with S&P's claim that inclusion to (exclusion from) the Index is an information-free event, making these abnormal returns inconsistent with the efficient market hypothesis. As a result, a number of hypotheses aiming at explaining the observed abnormal returns have emerged.

The Price Pressure Hypothesis: Harris and Gurel (1986) examine the stock price response of firms added to the S&P 500 Index for the period 1976 to 1988 and document an average return of 3% with a large increase in volume following the announcement. In addition, they find that the increase in price is temporary and reverses after two weeks. Their results support the notion that these announcements are information-free events and the Price Pressure Hypothesis in which investors who accommodate demand shifts should be compensated for the transaction costs and portfolio risks that they take when agreeing to immediately buy or sell stocks which they otherwise would not trade. These liquidity suppliers should then be compensated for the additional risk that they bear when price reverses fully to its full-information level.

The Downward-Sloping Demand Curve (or Imperfect Substitutes) Hypothesis: Shleifer (1986) documents abnormal returns of 2.79% following inclusion announcements, and a positive correlation of abnormal returns with newly-added stocks purchased by index funds, but no correlation with bond ratings and concludes that the demand curve for stocks is downward-sloping. Results in Shleifer (1986) support the Downward-Sloping Demand Curve (or Imperfect Substitutes) Hypothesis in which the shape of the demand curve slopes downward not only in the short-term but also in the long-term. That is, in contrast to the Price

Pressure Hypothesis, no price reversal should be observed and the increase (decrease) in price following inclusion (exclusion) announcements should be permanent. In a similar vein, Lynch and Mendenhall (1997) examine abnormal returns subsequent to index changes announcements pre- and post-1989, the year S&P started announcing the included firm one week prior to the effective index inclusion. For the period post-1989 they find permanent price shift following index changes announcements and conclude that the permanent price shifts indicate that demand curves for stocks are downward-sloping.

The Information Hypothesis: Jain (1987) finds evidence supportive of the Information Hypothesis in which addition of a stock to the S&P 500 index conveys favorable information to the market. When a stock is included in the index, important information is revealed by S&P who closely track companies before they announce their inclusion, and so the information revealed has a permanent effect on prices but a temporary effect on volume. Dhillon and Johnson (1991) support the Information Hypothesis by showing that the bonds and options of the newly-included firm also increase in price indicating that inclusions of companies to the index indeed contain information about the firm's future performance. Denis et al. (2003) find that analysts' earnings per share forecasts significantly increase compare to benchmark companies for firms newly included in the S&P 500 Index, and that these firms experience significant improvements in realized earnings after index inclusion. They conclude that inclusion to the S&P 500 Index is not an information-free event. Cai (2007) investigates the effect of inclusion to the index by examining industry and size matched firms for firms newly included to the S&P 500 Index and finds positive price reaction, but not volume reaction, for the matching firms. In addition, Cai (2007) finds a negative relation between the matching firm price reaction and the newly added firm's weight in its industry and concludes that index inclusions contain important information for the added firm and its industry, consistent with the Information Hypothesis. More recently, Gygax and Otchere (2010) examine the effect of index composition changes on incumbents in the S&P 500 Index. They find that incumbents in the index realize negative excess returns when S&P revises the composition of the index, however, with a smaller magnitude for firms in the same industry as the included firm due to industry-level information and momentum effects. They conclude that changes to the index are not information-free events.

The Investor Recognition Hypothesis: Chen et al. (2004) find support for Merton's (1987) Investor Recognition Hypothesis in which investors are only aware of a subset of all stocks (e.g., S&P 500 stocks) and therefore can only hold stocks that they know of. These investors are therefore not fully diversified and demand a premium for the non-systematic risk that they bear. Chen et al. (2004) document an asymmetric price response to S&P 500 Index inclusions. They find permanent price increase for newly added firms but no permanent price decrease for deleted firms. They conclude that it is changes in investor awareness of the included companies that creates the asymmetric price effect.

The Liquidity Cost Hypothesis: Edmister, Graham and Pirie (1996) document permanent increase in both stock price and trading volume attributed to permanently increased liquidity, and decrease in trading costs following inclusion announcements which is consistent with the Liquidity Cost Hypothesis (LCH). Under the LCH, and following the findings in Mikkelson and Partch (1985) and Amihud and Mendelson (1986) that the increase in the stock's liquidity results in an increased price (due to lower transaction costs), an inclusion of a firm to the S&P 500 Index should be followed by a permanent increase in the stock's liquidity due to its new exposure to index funds that track the index. As a result, a permanent increase in prices should also be observed. Erwin and Miller (1998), Hegde and McDermott (2003) and Becker-Blease and Paul (2006) also find evidence in support for the LCH.

4.3.2 Informational role of options

Whether investors possess information about index inclusion announcements, and whether they disseminate this information via stock or options trading, are empirical questions I aim to answer in this study. If informed traders choose the options market as their preferred trading venue, options will contain information which is incremental to the information embedded in stocks prior to the announcement. Prior literature suggests that informed traders have a number of incentives to trade in options over stocks such as lower transaction costs, continuous liquidity, high leverage for trading, and no short-sale restrictions (Back (1993), Black (1975) and Manaster and Rendleman (1982) and Chakravarty et al. (2004)). In turn, these advantages imply that options incorporate information from informed traders prior to stocks and therefore lead the stock market (Easley et al. (1998)).

Black (1975) suggests that when investors have important information, they may choose to trade in options over investing directly in the underlying stock because they can achieve a higher profit for a given investment this way. Manaster and Rendleman (1982) propose that informed investors disseminate private information through options trading, and Easley et al. (1998) suggest that markets in which informed traders operate, will lead other markets with lesser informed traders. Amin and Lee (1997) find that trading volume is predictive of earnings information. Cao et al. (2005) show that option order imbalance can predict stock response subsequent to take-overs. Chern et al. (2008) document that abnormal returns subsequent to stock split announcements are significantly lower for optioned than non-optioned stocks because a large part of information regarding the split has been pre-empted by options trading in the period preceding the announcements.

Pan and Poteshman (2006), Roll et al. (2010), and Johnson and So (2011) show that options trading volume is related to future stock returns, suggesting that informed trading prevails in the options market. In addition the literature also documents that option implied volatility, and statistics computed from it such as the realized-implied volatility spread Bali and Hovakimian (2009), the call-put option volatility spread Cremers and Weinbaum (2010), the volatility smirk Xing et al. (2010), and innovations in implied volatility Ang et al. (2010) are predictive of stock returns. To summarize, the literature indicates that informed traders operate in the options market as it offers advantages such as higher leverage and lower transaction costs over the stock market, and as a result, options prices incorporate information from informed traders prior to stock prices. Thus, information extracted from option prices is a useful predictor of stock returns.

Prior studies have also examined the ability of the volatility skew (as a proxy for jump risk) to predict negative events both at the index (Bates (1991); Doran et al. (2007)) and at the firm (Van Buskirk (2011)) levels. Bates (1991) for example, documents that out-of-the-money put options on the S&P 500 become unusually expensive (and the volatility skew more pronounced) before negative price jumps (e.g., before the 1987 stock market crash). Doran et al. (2007) demonstrate that the volatility skew constructed from options on the S&P 100 Index can predict market crashes but not spikes. Van Buskirk (2011) shows that a steep volatility skew can predict crashes around earnings announcements at the firm level.

In this study, I examine the ability of the volatility skew (other measures are considered for robustness of results) to predict abnormal returns from inclusion and exclusion announcements. The rationale is consistent with the demand-based option pricing model of Bollen and Whaley (2004) who show that changes in implied volatilities are driven by net buying pressure. Thus, if informed traders operate in the options market prior to the stock market, their demand for options will drive options prices and subsequently change the option implied volatility. Since these changes in implied volatility are a result of private information which is yet to be fully incorporated into the underlying stock price, these changes are likely to indicate future changes in the underlying stock price. In a similar vein, I argue that the volatility skew becomes flatter (more pronounced) before S&P 500 Index inclusion (exclusion) announcements, as informed traders neglect OTMP options in favor of ATMC options (prefer OTMP over ATMC) on the underlying soon-to-be-included (excluded) stock before the inclusion (exclusion) announcement.[40] The demand for ATMC (OTMP) options increases their implied volatilities relative to OTMP (ATMC) options and flattens (deepens) the volatility skew before the inclusion (exclusion) announcement, resulting in return predictability by the volatility skew. I therefore use the volatility skew to gauge the information incorporated into options prices prior to inclusion and exclusion announcements.

The notion that informed traders prefer to trade in options prior to stocks, indicates that if information about index change announcements leaks prior to the announcement, it is likely be reflected in the volatility skew. Based on the above discussion I hypothesize that:

H1: *The volatility skew predicts abnormal returns from S&P 500 Index change announcements.*

[40] As discussed, the advantages of buying ATMC options are the higher potential profit due to higher leverage, but also the ability to camouflage the transactions in these highly liquid derivatives.

4.4 Data and Summary Statistics

I obtain the data for this study from four sources. The S&P 500 index inclusions and exclusions data for the period 1996-2000 are obtained from Chen et al. (2004)[41] and I hand collect the index inclusions and exclusions data for the period 2001 to 2010 from the Standard and Poor's website. I obtain stock returns from the Center for Research in Security Prices (CRSP), financial information from Compustat and options data from OptionMetrics. This study spans the period 1996 to 2010.

I apply the following filtering rule to the sample. In order to capture the effect of the announcements, I only include those announcements which were not caused by other significant contemporaneous events (e.g., mergers and acquisitions). This ensures that the observed abnormal returns are solely due to the announcements and not due to other contemporaneous effects which may contaminate the results. I then merge the S&P 500 Index data with the data from CRSP, Compustat, and OptionMetrics and retain only firms with options data available for at least 20 days before and 20 days after the announcement. Since all S&P 500 Index change announcements occur after hours I set the first trading day immediately after the announcement as event day 0. Table 1 describes the sample selection criteria, indicating a final sample of 326 inclusions and 81 exclusions (the discrepancy between the number of inclusions and exclusions is due to the filtering rule I apply to the sample).

The OptionMetrics database contains daily closing bid and ask prices, open interest, volume, and implied volatilities for options on individual stocks traded on NYSE, AMEX, and NASDAQ. Options on stocks are American style and implied volatilities are calculated using a binomial tree, taking into account expected discrete dividend payments and the

[41] I thank Chen, Noronha, and Singal for making their sample available on the Journal of Finance website.

Table 1
Sample Selection Criteria
Sample Period: 1996 – 2010

This table provides the sample selection procedure for the S&P 500 Index addition and deletion announcements sample. The data for the period 1996-2000 is from Chen, Noronha, and Singal (2004) and the data for the period 2001-2010 is hand collected from the S&P website.

	Number of Inclusions
Initial Sample	1169
Less:	
Mergers and Acquisition	44
Spin-Offs	60
IPO	1
Change of share class	1
Same permno	32
Duplicate firms	7
No stock returns data	29
No options data available for the window (-20,20)	588
Final Sample:	
Additions	326
Deletions	81

possibility of early exercise. The interest rate used by OptionMetrics is historical LIBOR/Eurodollar rates. The implied volatility surface is then computed from the interpolated implied volatility surface separately for puts and calls using a kernel smoothing algorithm. The fitted implied volatilities are reported on a grid of fixed maturities of 30, 60, 90, 180 and 250 days, and fixed option deltas of 0.20, 0.25, …, 0.80 for calls, and -0.8, -0.75, …, -0.20 for puts. One advantage of the volatility surface is that it eliminates the need to choose which strikes or maturities to use in calculating implied call or put volatilities for each stock (Ang et al. (2010)).

I use the difference between the implied volatilities of out-of-the-money put options with delta of -0.20 (*VOLOTMP*), and at-the-money call options with delta of 0.50 (*VOLATMC*) both with maturity of 30 days, to construct the measure of volatility skew.[42]

$$SKEW_{i,t} = VOLOTMP_{i,t} - VOLATMC_{i,t} \tag{1}$$

The average volatility skew is then computed over trading days (-2,-1) relative to the announcement day (0), as Skinner (1997) notes that the information advantage and potential trading profit of informed trading should be greatest immediately before the event. Results (unreported) are insensitive to the choice of trading windows – they similar for alternative trading windows such as (-5,-1).

Table 2 provides the descriptive statistics of the sample for firms added and deleted from the index. The table shows that the average firm size in the sample of firms added to (deleted from) the index is $8.73 ($7.38) billion with an average book-to-market of about 0.30 (1.15). Noticeably from Table 2 is the large abnormal return on event day 0 (announcement day), defined as the difference between the firm's actual return and the return

[42] This measure resembles the measure used in Xing et al. (2010)

Table 2

Summary statistics

Sample Period: 1996 – 2010

This table presents the descriptive statistics of the main variables for the S&P 500 Index additions and deletions sample for the period 1996 to 2010. *ABRET* is the percentage abnormal return, defined as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. *SIZE* is market capitalization in millions of dollars at December of the previous year, defined as stock's price times shares outstanding, and book-to-market (*BM*) ratio which is the ratio of book value, defined as the value of common equity plus balance-sheet deferred taxes for the firm's latest fiscal year ending in prior calendar year, divided by market capitalization. *TURNOVER* is the firm turnover defined as trading volume divided by the number of shares outstanding. *HSKEW* is the skewness of stock returns over the period (-30,-1). *IDIOVOL* is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. *STOCKVOL* is the stock trading volume. *OPTVOL* is the average total options trading volume (call and put). *OPENINT* is the average total open interest (call and put). *IVC* is the average implied volatility of at-the-money call and put options. *O/S* is the ratio of total options trading volume (call and put) to total stock trading volume. *PUT-CALL* is the difference between the implied volatilities of at-the-money put and call options. *SKEW* is the average implied volatility skew, defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options.

	Mean	Min	Q1	Median	Q3	Max	Std
				Additions *N*=326			
ABRET(%)	4.59	-14.06	1.96	4.08	6.36	28.86	4.32
SIZE	8.73	6.92	8.34	8.64	9.01	11.94	0.60
BM	0.29	0.00	0.10	0.21	0.40	1.90	0.28
TURNOVER	47.84	0.69	17.53	28.12	54.51	330.47	53.10
HSKEW	0.34	-4.07	-0.21	0.23	0.79	4.90	1.04
IDIOVOL	0.03	0.01	0.02	0.02	0.03	0.09	0.01
STOCKVOL	8224187	101700	2452500	4521642	10312200	79743704	9992696
OPTVOL	4391	0	374	1212	3635	120405	10699
OPENINT	32723	37	2923	10682	30722	496187	62524
IV	0.48	0.16	0.32	0.44	0.58	1.44	0.21
O/S	0.14	0.00	0.00	0.05	0.12	9.45	0.55
PUT-CALL	0.01	-0.11	-0.01	0.01	0.02	0.48	0.04
SKEW	0.05	-0.11	0.01	0.04	0.07	0.61	0.07
				Deletions *N*=81			
ABRET(%)	-4.53	-33.70	-7.99	-4.64	-2.21	38.06	9.71
SIZE	7.38	5.26	6.62	7.24	7.87	11.55	1.22
BM	1.15	0.06	0.50	0.88	1.32	6.79	1.02
TURNOVER	39.87	3.82	15.22	24.61	41.57	357.40	51.70
HSKEW	0.11	-1.74	-0.38	0.05	0.58	2.35	0.90
IDIOVOL	0.05	0.00	0.02	0.03	0.06	0.18	0.04
STOCKVOL	16813395	208500	918300	2807599	7287100	690826563	78739948
OPTVOL	1692	0	52	176	1078	26973	4230
OPENINT	37558	75	1033	6275	36662	536026	81564
IV	0.74	0.20	0.41	0.60	1.01	1.90	0.42
O/S	0.04	0.00	0.00	0.02	0.04	0.40	0.06
PUT-CALL	0.01	-0.58	-0.02	0.00	0.05	0.52	0.12
SKEW	0.04	-0.58	-0.01	0.03	0.10	0.55	0.14

estimated from the market model in the period (-250,-30), which is 4.59% (-4.53%) for firms added to (deleted from) the index which is consistent with previous literature.[43] Table 3 reports the cross-sectional averages for the underlying stock and option measures in the sample for 7 different event windows surrounding the announcement: (-20, -1), (-10, -6), (-5, -1), (0), (1, 5), (6, 10) and (11, 20). Noticeable from Table 3, is the reverse in abnormal returns following the announcement day. For additions (deletions), there is, on average, a positive (negative) abnormal return on the announcement date, which is then reversed and becomes negative (positive) for the period (6, 20). This return reversal is consistent with Harris and Gurel (1986) and Beneish and Whaley (1996) and points at a temporary but not permanent change in price.

Table 3 also shows that for additions, both the stock and options (for both put and call) trading volume increase in the period leading to the announcement (-5, -1) compared to an earlier period (trading days -20, -11) and then sharply increase (more than double) on the announcement day. For deletions, both the stock and call options trading volume increase but not the put options trading volume. The increase in trading volume is attributed more to call options as indicated by the ratio of put to call trading volume (*PCR*). The level of *SKEW* increases in the lead-up to the announcement (trading days -5, -1) by 14% for additions and 7% for deletions compared to the period (-20, -10). Overall, Table 3 provides initial evidence for higher trading volume in options in the week before the announcement compared to an earlier period, mainly for inclusion announcements.

[43] Depending on period, returns vary from 2.27% for the period 1976-1980 (Shleifer (1986)) to 5.67% for the period 1993-2000 (Elliott, Ness, Walker and Wan (2006)).

Table 3

Options Trading around S&P 500 Index Addition and Deletion Announcements

Sample Period: 1996 – 2010

This table presents cross-sectional averages for various variables around S&P 500 Index addition and deletion announcements for the period 1996 to 2010. *ABRET* is the percentage abnormal return, defined as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. *STOCKVOL* is the stock trading volume. *OPTVOL_C* and *OPTVOL_P* are the total options trading volume for call and put, respectively. *OPENINT_C* and *OPENINT_P* are the total open interest for call and put, respectively. PCR is the ratio of the average put and call options trading volume. *IVC* and *IVP* are the averages implied volatilities of at-the-money call and put options, respectively. *OTP* is the average implied volatility of out-of-the-money put options. *SKEW* is the average implied volatility skew, defined as the difference between the implied volatilities of out-of-the-money put and at-the-money call options. *O/S* is the ratio of total options trading volume (call and put) to total stock trading volume. *PUT-CALL* is the difference between the implied volatilities of at-the-money put and call options.

Period	(-20,-11)	(-10,-6)	(-5,-1)	0	(1,5)	(6,10)	(11,20)
				Additions			
ABRET(%)	-0.001	0.101	0.227	4.590	0.096	-0.101	-0.046
STOCKVOL	2092169	2215124	2276306	8224187	6396430	3616036	2710060
OPTVOL_C	2342	2498	2469	5889	3516	3483	2397
OPTVOL_P	1564	1866	1662	2894	2094	1703	1594
OPENINT_C	35911	38211	37413	38578	40405	41061	40024
OPENINT_P	24980	26511	26322	26867	28031	28136	27826
PCR	0.744	0.839	0.735	0.628	0.628	0.867	0.752
IVC	0.453	0.457	0.451	0.471	0.469	0.465	0.466
IVP	0.463	0.469	0.465	0.479	0.480	0.479	0.478
OTP	0.503	0.513	0.508	0.519	0.523	0.522	0.523
SKEW	0.050	0.056	0.057	0.048	0.053	0.057	0.057
O/S	0.127	0.128	0.125	0.140	0.101	0.145	0.111
PUT-CALL	0.009	0.012	0.014	0.008	0.011	0.014	0.012
				Deletions			
ABRET(%)	-0.240	-0.444	-0.473	-4.529	0.386	0.427	0.578
STOCKVOL	4401243	5153342	4811191	16813395	9657102	8227648	5285222
OPTVOL_C	1091	1238	1223	1944	1286	1425	1187
OPTVOL_P	836	798	795	1441	801	810	597
OPENINT_C	47280	45846	47566	48679	48746	49226	51978
OPENINT_P	27257	26293	26599	26437	26219	25411	25758
PCR	0.987	1.668	1.559	1.566	0.907	0.769	0.552
IVC	0.653	0.675	0.689	0.733	0.742	0.747	0.715
IVP	0.654	0.673	0.701	0.742	0.742	0.750	0.732
OTP	0.706	0.729	0.746	0.775	0.776	0.783	0.770
SKEW	0.053	0.054	0.057	0.041	0.034	0.036	0.055
O/S	0.047	0.046	0.045	0.040	0.030	0.034	0.039
PUT-CALL	0.001	-0.002	0.012	0.009	0.000	0.003	0.017

4.5 Volatility Skew and Abnormal Returns from Announcements of Changes to the S&P 500 Index

In order to examine the relationship between abnormal returns subsequent to S&P 500 Index inclusion and exclusion announcements and variations in *SKEW* I first examine this relationship in a cross-sectional regression setting and then sort abnormal returns based on *SKEW* into quintiles (portfolio approach). While cross-sectional regressions allow me to examine this relationship while controlling for the potential effect of other explanatory variables, portfolio sorts provide evidence on how abnormal returns vary across the spectrum of *SKEW* without imposing a linear relationship between the variables and the potential of influential observations in the regressions (Fama and French (2008)).

4.5.1 Cross-sectional regressions

In order to formally test if the volatility skew incorporates information about future changes to the S&P 500 index, I estimate the following cross-sectional regression:

$$CAR(0,1)_i = b_0 + b_1 SKEW_i + b_2' X_i + \varepsilon_i \qquad (2)$$

where $CAR(0,1)_i$ is firm *i*'s cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. $SKEW_i$ is the average volatility skew for firm *i*, as defined in Equation (1), over the two days preceding the announcement (trading days -2, -1). X_i is a vector of control variables for firm *i*, observed in the window (-2, -1) unless otherwise stated. Specifically, in order to separate the predictive power of *SKEW* from other potential explanatory variables, I use 11 control variables: 7 from the equity market and 4 from the options market. The first equity market control variable is the run-up return leading to the announcement, *CAR*$(-2,-1)_i$, which is firm *i*'s cumulative abnormal returns over days (-2,-1). If *SKEW* contains information which is incorporated into options prior to stocks, or has any incremental information over the information contained stock prices, I would expect the coefficient of *SKEW* to be statistically significant (positive for additions and negative for deletions). The second control variable is historical stock returns skewness (*HSKEW*) measured over the period (-30,-1). I include this as a control variable as Barberis and Huang (2008) show that a more positively skewed stock should earn lower returns.[44]

The third control variable is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model (*IDIOVOL*) as Ang et al. (2006) show that this measure is predictive of stock returns. The fourth variable is stock turnover (*TURNOVER*) which is the ratio of stock's volume and the number of shares outstanding, as Lee and Swaminathan (2000) show that liquidity is related to future stock returns. The fifth variable is *LOGSIZE* which is the logged market capitalization in millions of dollars at December of the previous year, defined as stock's price times shares outstanding, as Banz (1981) and Fama and French (1993) among others show that larger firms earn lower subsequent returns. The sixth control variable is book-to-market (*BM*) ratio which is the ratio of book value, defined as the value of common equity plus balance-sheet deferred taxes for the firm's latest fiscal year ending in prior calendar year, to market capitalization. Fama and French (1993) show that value stocks (high *BM*) outperform growth stocks (low *BM*). The final equity market control variable is the illiquidity factor (*ILLIQ*) of Amihud (2002), which is the ratio of absolute stock returns to trading volume, as Amihud (2002) finds that illiquidity is related to future stock returns.

[44] SKEW is computed from option implied volatilities and represents the skewness under the risk-neutral probability while HSKEW is computed under the real probability.

The first options market control variable is the ratio of the average put to call options trading volume (hereafter *PCR*). This measure is an approximation of the proprietary data *PCR* measure used in Pan and Poteshman (2006) who show that high *PCR* indicates low future returns. The second control variable is the volatility premium (*VOLPREMIUM*), defined as the ratio of the average at-the-money call implied volatility and the stock's realized volatility. Bali and Hovakimian (2009) show that the realized-implied volatility spread is predictive of expected stock returns. Lastly, I include options trading volume and open interest (*OPTVOL* and *OPENINT)* of call and put options.

Table 4 summarizes the results of the regression from Equation (2). I first run a univariate regression with only *SKEW* as the independent variable (Model 1) and the results are reported in Column 1 for additions and Column 2 for deletions. For additions, *SKEW* has a strong predictive power of *CAR*(0,1) with a coefficient of -0.11 and is statistically highly significant (at the 1% level). The negative coefficient indicates that over the two days preceding the inclusion announcement, investors significantly increase the demand for ATMC relative to OTMP options resulting in a smaller *SKEW* before the announcement. The higher the demand for ATMC relative to OTMP, the higher the abnormal returns subsequent to the inclusion announcement. This is consistent with Bollen and Whaley (2004) and the equilibrium model of Gârleanu et al. (2009) who show that end-user demand is positively related to options moneyness measured by their implied volatilities. Thus, an investor with information about the future inclusion announcement may choose to buy the liquid ATMC options before the announcement in the view of a price increase immediately after the announcement. This demand creates higher ATMC implied volatility relative to OTMP implied volatility resulting in abnormal returns prediction. For deletions, the coefficient on *SKEW* is statistically insignificant indicating no predictive ability of *SKEW* for deletion announcements.

Table 4

***CAR*(0,1) Predictability using *SKEW* in Cross-Sectional Regressions**

Sample Period: 1996 – 2010

This table presents results from cross-sectional regressions where the dependent variable is *CAR*(0,1), defined as the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. The variables of interest is *SKEW* which is the average of the volatility skew over trading days (-2,-1), where the volatility skew is the difference between the implied volatilities of out-of-the-money put and at-the-money call options. The control variables defined as follows. *CAR*(-2,-1) is the stock returns pre-announcement run-up, defined as the cumulative abnormal returns over the period (-2,-1). *HSKEW* is the skewness of stock returns over the period (-30,-1). *IDIOVOL* is the stock's idiosyncratic volatility over the period (-30,-1), measured as the standard deviation of residuals from estimating the market model. *TURNOVER* is the ratio of stock's volume over the period (-2,-1) and the number of shares outstanding. *LOGSIZE* is the logged firm market capitalization. *BM* is the book-to-market ratio. *ILLIQ* is the illiquidity factor of Amihud (2002), which is the ratio of absolute stock returns to trading volume over the period (-2,-1). *PCR* ('000) is the ratio of the average put and call options trading volume. *VOLPREM* ('000) is the volatility premium, defined as the ratio of the average at-the-money call implied volatility and the stock's realized volatility. *OPTVOL* ('000) is the total call and put options trading volume over the period (-2,-1), respectively. *OPENINT* ('000) is the total call and put open interest over the period (-2,-1), respectively. *** and ** indicate significance at 1% and 5% levels, respectively.

	Additions - Model 1		Deletions - Model 1		Additions - Model 2		Deletions - Model 2		Additions - Model 3		Deletions - Model 3		Additions - Model 4		Deletions - Model 4	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	0.048	16.5***	-0.042	-3.4***	-0.017	-0.4	-0.033	-0.4	0.048	13.5***	-0.051	-3.6***	-0.013	-0.3	-0.039	-0.5
SKEW	-0.110	-3.2***	-0.158	-1.3	-0.170	-4.9***	-0.070	-0.7	-0.127	-3.5***	-0.146	-1.3	-0.189	-5.1***	-0.101	-1.2
CAR(-2,-1)					0.051	3.2***	0.137	3.7***					0.043	2.6**	0.076	2.3
HSKEW					0.016	5.4***	0.004	0.3					0.016	5.4***	0.007	0.7
IDIOVOL					1.330	6.3***	-0.333	-0.8					1.401	6.5***	-0.732	-2.4
TURNOVER					0.000	-1.3	-0.001	-1.2					0.000	-1.8	0.000	0.2
LOGSIZE					0.003	0.6	0.006	0.6					0.002	0.4	0.004	0.4
BM					0.002	0.3	-0.020	-1.6					0.003	0.3	-0.010	-1.0
ILLIQ					122290	1.1	-227575	-2.1**					131901	1.0	-77160	-0.8
PCR									-0.001	-1.1	-0.006	-1.1	0.000	-0.5	-0.006	-0.9
VOLPREM									0.000	-1.8	0. .000	0.0	0.000	-2.4**	0.000	-0.2
OPTVOL									0.000	1.2	0. .000	-3.1***	0.000	1.0	0.000	-3.0
OPENINT									0.000	-0.6	0. .000	4.3***	0.000	-0.1	0.000	3.9
Adj.R^2	0.027		0.01		0.274		0.217		0.035		0.197		0.281		0.338	

Next, I run 3 multivariate regressions to gauge the incremental information content in *SKEW* over the information embedded in the stock price and other firm and options characteristics prior to the announcement. Model 2 contains the 7 equity market variables, Model 3 contains the 4 options market variables, and Model 4 includes all 11 control variables. For additions, in all 3 models the coefficient of *SKEW* remains negative and statistically highly significant (at the 1% level). The significance of the *SKEW* coefficient shows that some investors possess private information regarding the approaching announcement. These informed investors prefer to trade in the options market and more specifically in the liquid ATMC options relative to the illiquid OTMP options and by doing so, disseminate information to options but not to stock prices. For deletions, the coefficient of *SKEW* remains statistically insignificant.

I now take a closer look at the coefficients of the control variables in Model 4. Most notable is the significant coefficients on *CAR*(-2,-1), *HSKEW, IDIOVOL* and *VOLPREM*. The positive coefficient on *CAR*(-2,-1) indicates that some of the information about the future inclusion announcement is incorporated into the firm's stock price in addition to its option prices. If index funds possess information about impending inclusion announcements they may opt to buy the stock of the soon-to-be-included firm in which case information will be incorporated into stock prices. The positive coefficient on *HSKEW* shows that a more positively skewed stock earns higher returns which is consistent with Xing et al. (2010) but in contrast to Barberis and Huang (2008). *IDIOVOL* has a positive coefficient indicating that stocks with high idiosyncratic volatility in the month before the announcement experience higher abnormal returns which is in contrast with Ang et al. (2006). *VOLPREMIU* has a negative coefficient indicating that firms with higher realized-implied volatility spread (a proxy for volatility risk) earn lower returns which is consistent with Bali and Hovakimian (2009). Overall, the results of Model 4 indicate that in the two days preceding the inclusion but not exclusion announcement, informed investors disseminate information into options by choosing to trade on their information in ATMC options, thus creating higher demand for these options, and higher implied volatility as a result. These findings clearly support the hypothesis that the volatility skew is predictive of the abnormal returns subsequent to inclusion, but not exclusion, announcements.

Many prior studies have focused on, inclusion to, but not exclusion from the S&P 500 Index. This is because a firm may be excluded from the index for a number of reasons such as mergers and acquisitions or bankruptcy. This is reflected by the sharp fluctuations in returns prior to exclusion announcements. For example, the average one-day return in the sample two days before the exclusion announcement is -2.3%, 1.4% on the following day and then -4.53% on the announcement day. Moreover, the standard deviation of returns for exclusion announcements is more than double that of inclusion announcements. Thus, option traders may be reluctant to trade when uncertainty is higher (compared to inclusion announcements). It is therefore difficult to disentangle the effect of exclusion announcements from other factors that may affect abnormal return. In addition, the small sample size (326 for inclusions, 81 for exclusions) may affect the power of the test and bias the results. It is thus plausible that the results obtained for exclusion announcements are distorted due to the small sample size and fluctuations in stock and option prices in the period preceding the announcement which may include financial turmoil such as acquisitions or bankruptcy.

4.5.2 Portfolio sorts

The results in the previous section indicate a strong relation between *SKEW* and abnormal returns from inclusion but not exclusion announcements. I now examine if these results are supported by the portfolio sorts approach. Although portfolio sorts are a simple reflection of how average returns vary across the spectrum of *SKEW*, as Fama and French

(2008) note, one shortcoming of regressions is the potential of influential observation problem which may bias the results. Sorts provide verification for this issue. To do this, I rank all firms' *CAR*(0,1) based on their average volatility skew (*SKEW*) over the two days preceding the announcement and assign them into quintile portfolios. Table 5 presents CARs and means of *SIZE*, *BM*, *OPTVOL*, *O/S*, *ΔIVC*, *ΔIVP*, and *PUT-CALL* in each portfolio. For additions, the Low (High) portfolio has an average *SKEW* of -0.06 (0.09) and average *CAR*(0,1) of 5.62% (3.79%) with t-statistics of 7.62 (6.32). The *CAR*(0,1) difference between the High and Low portfolios is -1.83% and a two-sample t-test yields a *t*-statistic of -1.93. These results are consistent with the findings from the cross-sectional regressions in the previous section that show that higher (lower) *SKEW* is related to lower (high) *CAR*(0,1).

For each of the *SKEW* portfolios Table 5 also reports averages of firm and options characteristics. Specifically, I examine if *SIZE, BM, OPTVOL, O/S*, *ΔIVC*, *ΔIVP,* and *PUT-CALL* change monotonically with the different *SKEW* portfolios as does *CAR*(0,1). Noticeably, only *ΔIVC*, *ΔIVP* and *PUT-CALL* change monotonically across portfolios and consistent with the findings, the Low (High) portfolio has the lowest level of *ΔIVP* (*ΔIVC*). While the larger firms are concentrated in portfolios 3 and 4, firms with the highest *BM* are in portfolios 4 and 5. Interestingly, the lowest option trading volume is in the extreme portfolios (Low and High), indicating that the higher implied volatilities are not accompanied by higher trading volume which is consistent with the notion that volatilities increase by demand for, but not necessarily trading volume of, options. To summarize, the results from the portfolio sorts support the findings from the regression analysis that volatility skew is an important predictive measure of abnormal returns subsequent to inclusion announcements. For deletion announcements, while returns vary monotonically across portfolios, returns in each portfolio and in the High-Low portfolio are statistically insignificant in three out of the five portfolios (including the High and Low portfolios), supporting the results in the regression setting.

Table 5

Portfolio Sorts on *SKEW*

Sample Period: 1996 - 2010

This table presents results from portfolio sorts based on levels of *SKEW* over two days before the announcement (trading days -2,-1), where *SKEW* is the difference between the implied volatilities of out-of-the-money put and at-the-money call options. *CAR*(0,1) is the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. *SIZE* is market capitalization in millions of dollars at December of the previous year, defined as stock's price times shares outstanding. *BM* is the book-to-market ratio. *OPTVOL* is the average total put and call options trading volume. *O/S* is a the ratio of options trading volume to stock trading volume. *ΔIVC* and *ΔIVP* are the changes in implied volatilities over the two days before the announcement in at-the money call and put options, respectively. *PUT_CALL* is the difference between the implied volatilities of at-the-money put and call options. The *t*-statistics for High-Low is from a two-sample *t*-test. ***, ** and * indicate significance at the 1%, 5% and 10% level, respectively.

Portfolio	*SKEW*	%*CAR*(0,1)	*t-stat.*	*SIZE*	*BM*	*OPTVOL*	*O/S*	*ΔIVC*	*ΔIVP*	*PUT-CALL*
					Additions					
Low	-0.06	5.62	7.62***	6858	0.29	7801	0.10	0.02	-0.01	-0.03
2	-0.01	4.44	7.59***	7740	0.24	6370	0.13	0.02	0.00	-0.01
3	0.00	4.90	7.20***	10929	0.30	12946	0.14	0.00	0.00	0.00
4	0.01	4.69	7.19***	7932	0.28	7238	0.13	-0.01	0.00	0.01
High	0.09	3.79	6.32***	6631	0.36	4920	0.07	-0.04	0.04	0.09
High-Low		-1.83	-1.93*							
					Deletions					
Low	-0.11	-2.16	-0.77	2541	1.43	1996	0.03	0.06	-0.03	-0.09
2	-0.02	-2.53	-0.69	4694	0.92	9096	0.08	0.01	-0.01	-0.02
3	0.01	-4.73	-5.94***	9513	0.83	1492	0.06	-0.01	0.00	0.01
4	0.05	-6.84	-3.76***	6031	1.20	4452	0.03	-0.04	0.01	0.05
High	0.16	-6.42	-1.79	2061	1.44	5552	0.04	-0.05	0.08	0.13
High-Low		-4.26	-0.94							

4.6 Robustness Checks

The results presented in Section 4.5 show that *SKEW* has a strong predictive power for *CAR*(0,1) of S&P 500 Index inclusion but not exclusion announcements. In this section I examine if this relationship exists in pseudo *CAR* windows surrounding the announcement and if the predictive power is robust to different measures of *SKEW*. I also examine if the findings are robust to partitioning the sample based on size (big/small firms), the sign of the *CAR* (positive/negative), period (before and after 2008), and the level of options trading volume (high/low).

4.6.1 Predictive power of *SKEW* around pseudo CAR windows

It is plausible that the predictive ability of *SKEW* for *CAR*(0,1) is not uniquely related to abnormal returns following inclusion announcements. That is, the predictive ability exists for other two-day-window CAR independent from S&P 500 Index inclusion announcements (pseudo CAR windows), in which case it should predict other two-day CARs surrounding the announcement. In order to disentangle the predictive power of *SKEW* for *CAR*(0,1) from other two-day CARs, I again run multivariate cross-sectional regressions, as in Equation (2), with control variables (as in Model 4) on four two-day CARs before, and nine two-day CARs after the announcement, using *SKEW* over the two days preceding the predicted *CAR*. Since stocks are effectively added to the index after an average of 6.5 days after the announcement day I also examine the window *CAR*(6,10).

Table 6 reports results of these regressions and for comparison, I also include the results of the regression for *CAR*(0,1) from Model 4 in Table 4. For brevity, I only report coefficients and t-statistics of *SKEW* and not the 11 control variables. The results reported in Table 6 show that the coefficients of *SKEW* are statistically insignificant. The results also show that the *t*-statistics increase in magnitude as the tested windows approach the (0,1) window, indicating that information is gradually incorporated into *SKEW* and reaches a maximum level of information efficiency immediately prior to the announcement. This is consistent with prior research that shows that informed traders initiate a greater amount of long (short) positions immediately before good (bad) news (e.g., Amin and Lee (1997) among others).

Table 6
Multivariate Cross-Sectional Regressions with Control Variables for Predictability Power of *SKEW* for Pseudo *CAR* Periods
Sample Period: 1996 - 2010

This table presents results from multivariate cross-sectional regressions where the dependent variable is a two-day window *CAR*, defined as the cumulative abnormal returns for the two days, where abnormal returns are calculated as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. The independent variable in each regression are *SKEW* which is the average of the volatility skew over the two days prior to the two-day *CAR*, where the volatility skew is the difference between the implied volatilities of out-of-the-money put and at-the-money call options. The control variables are the variables from model 4 in Table 4. *** indicates significance at the 1% level.

CAR Predicted Period	*SKEW* Predicting Period	Coefficient of *SKEW*	*t*-statistics of *SKEW*	*f*-statistics of model	Adj.R^2
CAR(-4,-3)	*SKEW*(-6,-5)	0.002	0.03	1.87	0.054
CAR(-3,-2)	*SKEW*(-5,-4)	0.011	0.23	1.37	0.024
CAR(-2,-1)	*SKEW*(-4,-3)	-0.050	-0.81	1.80	0.050
CAR(-1,0)	*SKEW*(-3,-2)	-0.085	-1.33	5.97	0.246
CAR(0,1)	*SKEW*(-5,-1)	-0.189	-5.1***	7.22	0.281
CAR(1,2)	*SKEW*(-1,0)	-0.023	-0.40	1.38	0.024
CAR(2,3)	*SKEW*(0,1)	-0.044	-0.77	1.27	0.018
CAR(3,4)	*SKEW*(1,2)	0.123	1.50	1.67	0.042
CAR(4,5)	*SKEW*(2,3)	0.024	0.44	1.15	0.009
CAR(5,6)	*SKEW*(3,4)	-0.074	-1.40	1.74	0.046
CAR(6,7)	*SKEW*(4,5)	-0.023	-0.42	1.43	0.028
CAR(7,8)	*SKEW*(5,6)	-0.024	-0.30	2.25	0.076
CAR(8,9)	*SKEW*(6,7)	-0.006	-0.09	2.08	0.066
CAR(9,10)	*SKEW*(7,8)	-0.050	-0.82	0.51	-0.033
CAR(6,10)	*SKEW*(8,5)	-0.138	-1.58	1.43	0.027

4.6.2 Predictive power of different measures of options trading

In this section I test the predictive power of different measures of options trading. In particular, I examine *SKEW* with varying deltas, the put-call spread (*PUT-CALL*), the options to stock trading volume ratio (*O/S*), and innovations (as first difference) in call and put implied volatilities (*ΔIVC* and *ΔIVP*, respectively). Specifically, it is possible to construct the volatility skew, defined as the difference between the volatilities of OTMP and ATMC, using different moneyness (deltas) levels of OTMP options. Yan (2011) for example, defines the volatility skew as the difference between volatilities of put options with delta of -0.50 and call options with delta of 0.50. Using this measure as a proxy for jump risk, Yan (2011) documents a negative predictive relation between the slope of the implied volatility skew and stock returns. To the extent that the predictive ability of abnormal returns subsequent to S&P 500 Index inclusion and exclusion announcements by *SKEW* is affected by the choice of moneyness, I examine *SKEW*(-0.25), *SKEW*(-0.30), *SKEW*(-0.35), and the put call spread (*PUT-CALL*) as alternative measures of *SKEW* in which the deltas of the OTMP options are: -0.25, -0.30, -0.35, and -0.50, respectively. Roll et al. (2010) show that the *O/S* ratio is strongly related to stock returns and Johnson and So (2011) find that firms with low *O/S* outperform firms with high *O/S*. Since the *O/S* has the ability to predict stock returns, I use it as an alternative measure for *SKEW*. Lastly I examine innovations in call and put implied volatilities as an alternative measure for *SKEW* as Ang et al. (2010) show that *ΔIVC* (*ΔIVP*) indicate higher (lower) expected stock returns. I then use these measures and repeat the analysis in Section 4.5 in both cross-sectional and portfolio sorts settings.

Table 7 provides results of the multivariate cross-sectional regressions as in Equation (2), Model 4 in Table 4, for the alternative measures of options trading for both additions and deletions. For additions, the regressions with *SKEW*(-0.25), *SKEW*(-0.30), *SKEW*(-0.35), and *PUT-CALL* yield similar results to the regression with *SKEW* (as in Model 4, Table 4),

Table 7

Multivariate Cross-Sectional Regressions of the Predictability of Option Trading Measures

Sample Period: 1996 - 2010

This table presents results from multivariate cross-sectional regressions where the dependent variable is *CAR*(0,1), defined as the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. The independent variables are *SKEW*(-0.25), *SKEW*(-0.30), *SKEW*(-0.35), *PUT-CALL*, which are the averages over the two days prior to the inclusion announcement in the difference between the implied volatilities of out-of-the-money put options with deltas of -0.25, -0.30, -0.35, and -0.50, respectively, and at-the-money call options (call options with delta=0.50). O/S is the options to stock trading volume ratio, *ΔIVC* and *ΔIVP* are the first difference over the two days before the announcement in implied volatilities of call and put options, respectively. The other control variables are the variables from Model 4 in Table 4. *t*-statistics are in parenthesis. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

	Additions						
Intercept	-0.01	0.00	0.00	0.00	-0.02	-0.01	-0.01
	(-0.21)	(-0.1)	(-0.02)	(-0.06)	(-0.32)	(-0.18)	(-0.25)
SKEW(-0.25)	-0.18						
	(-5.13***)						
SKEW(-0.30)		-0.18					
		(-5.2***)					
SKEW(-0.35)			-0.18				
			(-5.38***)				
PUT-CALL				-0.16			
				(-5.33***)			
O/S					0.03		
					(1.35)		
ΔIVC						0.20	
						(3.96***)	
ΔIVP							-0.14
							(-3.57***)
CAR(-2,-1)	0.04	0.04	0.04	0.05	0.04	0.04	0.04
	(2.58**)	(2.55**)	(2.59**)	(2.7***)	(2.15**)	(2.36**)	(2.41**)
HSKEW	0.02	0.02	0.02	0.02	0.02	0.02	0.02
	(5.47***)	(5.48***)	(5.53***)	(5.48***)	(5.14***)	(5.45***)	(5.18***)
IDIOVOL	1.41	1.44	1.45	1.44	1.35	1.42	1.36
	(6.53***)	(6.64***)	(6.72***)	(6.68***)	(5.95***)	(6.42***)	(6.14***)
TURNOVER	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-1.87*)	(-1.86*)	(-1.85*)	(-1.86*)	(-1.50)	(-1.50)	(-1.83*)
LOGSIZE	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-0.34)	(-0.2)	(0.09)	(0.12)	(0.44)	(0.22)	(0.43)
BM	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-0.10)	(-0.22)	(0.30)	(0.31)	(-0.31)	(0.20)	(-0.16)
ILLIQ	131296.00	135610.00	144026.00	149369.00	116790.00	164040.00	113850.00
	(-1.04)	(-1.08)	(1.15)	(1.19)	(0.88)	(1.27)	(0.88)
PCR	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-0.47)	(-0.51)	(-0.52)	(-0.46)	(-0.25)	(-0.34)	(-0.36)
VOLPREMIU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-2.42**)	(-2.4**)	(-2.41**)	(-2.45**)	(-2.3**)	(-2.42**)	(-2.36**)
OPTVOL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-1.10)	(1.21)	(1.14)	(0.80)	(-0.91)	(-0.71)	(0.82)
OPENINT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-0.13)	(0.16)	(0.01)	(0.38)	(0.64)	(1.52)	(-0.20)
Adj.R^2	0.28	0.28	0.29	0.29	0.21	0.25	0.24

Table 7 Cont.							
Deletions							
Intercept	-0.04	-0.04	-0.03	-0.03	-0.06	-0.03	-0.03
	(-0.47)	(-0.47)	(-0.44)	(-0.40)	(-0.76)	(-0.45)	(-0.39)
SKEW(-0.25)	-0.07						
	(-0.85)						
SKEW(-0.30)		-0.06					
		(-0.77)					
SKEW(-0.35)			-0.04				
			(-0.43)				
PUT-CALL				0.04			
				(0.47)			
O/S					0.14		
					(1.45)		
ΔIVC						-0.04	
						(-0.38_	
ΔIVP							0.03
							(0.27)
CAR(-2,-1)	0.08	0.08	0.09	0.09	0.09	0.09	0.09
	(2.31**)	(2.34**)	(2.57**)	(2.78***)	(2.85***)	(2.76***)	(2.7**)
HSKEW	0.01	0.01	0.01	0.01	0.01	0.01	0.01
	(0.63)	(0.61)	(0.62)	(0.64)	(0.58)	(0.71)	(0.54)
IDIOVOL	-0.73	-0.72	-0.74	-0.73	-0.76	-0.73	-0.73
	(-2.34**)	(-2.3**)	(-2.36**)	(-2.34**)	(-2.49**)	(-2.33**)	(-2.35**)
TURNOVER	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(0.15)	(0.10)	(0.03)	(-0.13)	(0.27)	(-0.21)	(0)
LOGSIZE	0.00	0.00	0.00	0.00	0.01	0.00	0.00
	(0.34)	(0.34)	(0.32)	(0.33)	(0.58)	(0.37)	(0.30)
BM	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	(-1.04)	(-1.07)	(-1.08)	(-1.18)	(-1.06)	(-1.07)	(-1.12)
ILLIQ	-75362	-80013	-82682	-80252	-52474	-81377	-81164
	(-0.77)	(-0.82)	(-0.84)	(-0.82)	(-0.53)	(-0.83)	(-0.82)
PCR	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01
	(-0.97)	(-0.93)	(-0.92)	(-0.97)	(-1.51)	(-0.89)	(-1.01)
VOLPREMIU	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-0.24)	(-0.24)	(-0.27)	(-0.35)	(-0.28)	(-0.34)	(-0.33)
OPTVOL	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(-3.02***)	(-2.99***)	(-2.98***)	(-3.06***)	(-3.43***)	(-2.99***)	(-3.05***)
OPENINT	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	(4.02***)	(3.98***)	(4.05***)	(4.18***)	(4.49***)	(3.91***)	(3.94***)
Adj.R^2	0.33	0.33	0.32	0.32	0.35	0.32	0.32

all with similar coefficients and *t*-statistics (all significant at the 1% level). Thus, the choice of delta does not change the predictive power of the volatility skew. These results may not be surprising considering the fact that inclusion announcements are positive events by nature, thus informed traders may choose to invest in ATMC options which in turn increase in volatility relative to all put options regardless of their level of moneyness.

The coefficients of the relative trading volume (*O/S*) and options trading volume (*OPTVOL*) are both statistically insignificant indicating that trading volume is not predictive of abnormal returns following addition announcements and that implied volatility is driven by demand but not necessarily accompanied by higher trading volume. In the next sub-section I further investigate the predictive ability of *SKEW* for firms with high and low trading volume.

The coefficient of *ΔIVC* (*ΔIVP*) is positive (negative) and statistically significant (at the 1% level) which is consistent with Ang et al. (2010) who show that *ΔIVC* (*ΔIVP*) indicate higher (lower) expected stock returns. In addition, these results provide further support to the results obtained using *SKEW* as not only the difference between put and call option implied volatilities is predictive of abnormal returns but also changes in implied volatilities for call and put separately.

Consistent with findings of the regressions with *SKEW*, it seems that there is a high (low) demand for at-the-money call (put) options (which drives implied volatility up as in Bollen and Whaley (2004) and Gârleanu et al. (2009)) before the addition announcement, resulting in return predictability.

For deletions, none of the alternative measures is statistically significant. These results are consistent with the results obtained in the previous section providing further confirmation that options trading measures are not predictive of CARs following exclusion announcements.

I now turn to examine the predictive ability of the alternative options trading measures in a portfolio sorts setting. Table 8 presents results of portfolio sorts for *SKEW*(-0.25), *SKEW*(-0.30), *SKEW*(-0.35), *PUT-CALL*, *O/S*, *ΔIVC* and *ΔIVP*. Overall, results are similar to the results obtained in Table 5 when *SKEW* for both additions and deletions. For additions, the low and high abnormal returns are generally concentrated in the extreme portfolios (except for *PUT-CALL* and *O/S*), however, unlike the results for *SKEW* it seems that the *t*-statistics for the High-Low portfolios are insignificant. These results indicate that the implied volatilities of deep-out-of-the-money put options (delta -0.20) may contain different information from at-the-money put options (delta -0.50) prior to the inclusion announcement, possibly due to the higher demand for deep-out-of-the-money put options which can provide higher profit to investors. In addition, while all portfolios have *CAR*(0,1) which are statistically different from 0, the t-statistics from the two-sample t-test for the means of portfolios High and Low is not significant at the 1% level as it is for *SKEW*. Thus, I conclude that delta of -0.20 for put options relative to call options with delta 0.50 contain the most relevant information for S&P Index inclusion announcements. This is in contrast to the findings in Yan (2011) that the volatility skew with put options with delta -0.50 has the most significant predictive power. However Yan (2011) used the volatility skew to predict the cross-section of stock returns and not corporate events. For deletions, and consistent with the results obtained in the previous section for *SKEW*, other measures of options trading do not predict abnormal returns from exclusion announcements.

Overall, results in this section of both the regressions and portfolio sorts with alternative measures of SKEW support the results obtained in the previous section for both addition and deletion announcements. That is, the volatility skew and other measures of options trading have a strong predictive ability for inclusion, but not exclusion announcements.

Table 8

Portfolio Sorts for Different Measures of Options trading

Sample Period: 1996 - 2010

This table presents results from portfolio sorts based on *SKEW*(-0.25), *SKEW*(-0.30), *SKEW*(-0.35), PUT-CALL, which are the averages, over the two days prior to the inclusion announcement, of the difference between the implied volatilities of out-of-the-money put options with deltas of -0.25, -0.30, -0.35, and -0.50, respectively, and at-the-money call options (call options with delta=0.50). O/S is the options to stock trading volume ratio, *ΔIVC* and *ΔIVP* are the first difference over the two days before the announcement in implied volatilities of call and put options, respectively. CAR*(*0,1) is the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. The *t*-statistics for High-Low is from a two-sample t-test. ***, **, and * indicate significance at 1%, 5%, and 10% levels, respectively.

	SKEW(-0.25)		*SKEW*(-0.30)		*SKEW*(-0.35)		*PUT-CALL*		*O/S*		*ΔIVC*		*ΔIVP*	
Portfolio	*CAR*(0,1)	*t*-stat.	*CAR*(0,1)	*t*-stat.	*CAR*(0,1)	*t*-stat.	*CAR*(0,1)	*t*-stat.	*CAR*(0,1)	*t*-stat.	*CAR*(0,1)	*t*-stat.	*CAR*(0,1)	*t*-stat.
Additions														
Low	5.53	7.39***	5.60	7.63***	5.19	6.59***	6.37	7.73***	4.13	7.33***	4.83	7.39***	5.79	7.55***
2	4.81	7.45***	4.47	6.67***	4.63	7.73***	3.20	6.32***	5.03	7.88***	4.09	7.02***	4.25	7.02***
3	4.75	7.74***	4.44	7.58***	4.84	8.40***	4.74	8.99***	5.18	7.09***	4.47	6.59***	4.78	6.87***
4	4.11	6.45***	4.50	6.89***	4.10	5.57***	4.06	5.72***	4.43	6.64***	4.68	6.43***	4.36	6.65***
High	4.24	6.86***	4.43	7.10***	4.67	8.45***	5.04	8.49***	4.68	6.98***	5.36	8.58***	4.25	8.28***
High-Low	-1.29	-1.34	-1.17	-1.22	-0.51	-0.54	-1.32	-1.30	0.54	0.62	0.52	0.58	-1.54	-1.67
Deletions														
Low	-1.53	-0.56	-2.03	-0.76	-3.40	-1.18	-5.67	-4.61***	-1.99	-0.61	-5.64	-1.33	-2.51	-0.69
2	-3.27	-0.87	-2.51	-0.66	-5.14	-3.11***	1.81	0.43	-4.45	-2.38**	-2.81	-0.88	-3.54	-0.89
3	-5.18	-7.94***	-4.89	-7.56***	-2.36	-0.73	-5.29	-4.63***	-0.56	-0.15	-5.06	-5.20***	-6.20	-5.71***
4	-6.01	-3.29***	-6.74	-3.57***	-5.46	-2.97***	-6.43	-3.65***	-9.45	-4.43***	-2.65	-0.92	-6.05	-4.35***
High	-6.80	-1.88	-6.66	-1.84	-6.59	-1.82	-6.97	-1.88	-6.60	-4.26***	-6.55	-4.39***	-4.35	-1.37
High-Low	-5.26	-1.17	-4.62	-1.03	-3.18	-0.69	-1.31	-0.33	-4.61	-1.22	-0.91	-0.20	-1.83	-0.38

4.6.3 Sub-sample analysis

Results in the previous section provide strong evidence of the predictive ability of the volatility skew (and other options trading measures) for abnormal returns following announcements of inclusion to, but not exclusion from the S&P 500 Index. In order to provide further robustness for the results, I examine the predictive ability of the volatility skew for inclusion announcements for various sub-samples. Specifically, in this section I test whether the predictive power of *SKEW* remains significant when the sample is partitioned based on i) the median firm size, in order to test whether the predictive ability is driven by small or big companies, ii) the sign of the *CAR* (positive/negative), in order to test whether results are driven by firms with different market reaction to the announcement, iii) period (before and after 2008) in order to test whether the 2007-2008 liquidity and credit crunch (Brunnermeier (2009)) have any effect on the results, and iv) the level of options trading volume (high/low), in order to test whether results are driven by firms with thin options trading. Table 9 presents the results of the multivariate cross-sectional regressions as in Equation (2), Model 4 in Table 4. Table 9 indicates that the coefficient of *SKEW* remains negative and significant at the 5% level for both big and small firms. While companies with traded stock options are generally relatively large, this ensures the results obtained in this study are not solely driven by small firms. Table 9 also shows that the coefficient of *SKEW* is significant only for positive but not negative CARs. That is, market participants with private information can assess the magnitude of the market reaction thus buying call options before positive but not negative market reaction. However, since more than 90% of the companies in the sample experience positive market reaction, the results for the negative market reaction may be distorted due to a small sample size. For Period, the coefficient of *SKEW* remains negative and statistically highly significant (at the 1% level) for the post 2008 period but less

Table 9

Predictability of *SKEW* for Addition Announcements – Sub-Sample Analysis

Sample Period: 1996 – 2010

This table presents results from multivariate cross-sectional regressions where the sample is portioned based on size (big/small firms), the sign of CAR (positive/negative), period (before and after 2007) and high and low options trading volume. The dependent variable is *CAR*(0,1), defined as the cumulative abnormal returns for days 0 and 1, where abnormal returns are calculated as the difference between the firm's actual return and the return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index. The control variables are the variables from Model 4 in Table 4. *, **, and *** indicate significance at 10%, 5%, and 1% levels, respectively.

	Size				Sign of *CAR*(0,1)			
	Small		Big		Negative		Positive	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	0.14	1.04	-0.03	-0.36	-0.01	-0.15	-0.02	-0.53
SKEW	-0.15	-2.03**	-0.22	-4.86**	-0.04	-0.58	-0.12	-2.77***
CAR(-2,-1)	0.06	2.27**	0.02	0.71	0.00	0.07	0.03	2.29**
HSKEW	0.02	4.44***	0.02	3.81***	0.00	-0.01	0.01	5.46***
IDIOVOL	1.23	3.84***	1.8	5.69***	-0.33	-0.79	1.72	8.44***
TURNOVER	0.00	-2.15**	0.00	-0.7	0.00	0.09	0.00	-1.85*
LOGSIZE	-0.01	-0.95	0.00	0.19	0.00	0.06	0.00	0.54
BM	-0.01	-0.51	0.01	0.65	-0.01	-0.34	0.01	0.72
ILLIQ	-326280	-0.23	632068	2.1	-203580	-0.04	856770	0.79
PCR	0.00	-0.7	0.00	0.21	0.00	0.14	0.00	2.23**
VOLPREM	0.00	0.24	0.00	-3.15***	0.00	-0.92	0.00	0.67
OPTVOL	0.00	-1.42	0.00	1.21	0.00	0.28	0.00	0.12
OPENINT	0.00	1.84*	0.00	-0.37	0.00	-0.72	0.00	1.04
Adj.R^2	0.25		0.35		-0.16		0.36	
#Obs.	163		163		42		284	

	Period				Options Trading Volume			
	<= 2007		> =2008		Low		High	
	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.	Coeff.	*t*-stat.
Intercept	0.02	0.42	-0.11	-1.1	0.02	0.27	-0.03	-0.45
SKEW	-0.23	-6.12***	0.25	1.71*	-0.19	-2.67***	-0.17	-3.62***
CAR(-2,-1)	0.08	4.28***	-0.06	-1.45	0.07	2.97***	0.03	1.24
HSKEW	0.02	5.22***	0.02	2.15**	0.02	6.03***	0.01	1.75*
IDIOVOL	1.28	5.72***	1.61	2.44**	1.55	4.93***	1.38	4.4***
TURNOVER	0.00	-0.85	0.00	-1.72*	0.00	-1.69*	0.00	-0.83
LOGSIZE	0.00	-0.43	0.02	1.30	0.00	-0.15	0.00	0.6
BM	0.01	0.63	-0.02	-1.22	-0.01	-0.59	0.01	0.51
ILLIQ	141480	1.13	-1102057	-1.33	769080	0.6	-82330	-0.23
PCR	0.00	-0.46	0.00	0.61	0.00	-0.08	0.00	-0.11
VOLPREM	0.00	-1.82	0.00	0.65	0.00	-0.59	0.00	-2.15**
OPTVOL	0.00	0.11	0.00	0.74	0.00	-2.06**	0.00	0.74
OPENINT	0.00	0.96	0.00	0.03	0.00	1.47	0.00	-0.29
Adj.R^2	0.38		0.21		0.43		0.16	
#Obs.	266		60		163		163	

significant for the post 2008 period (significant only at the 10% level). While this result may be due to a smaller sample size for the post 2008 period, it is possible that the predictive power of the volatility skew has attenuated over time. Future research with longer post 2008 time period may shed more light on these results. Finally, the coefficient of *SKEW* remains negative and statistically highly significant (at the 1% level) for both the low and high trading volume sub-samples indicating that the results are not unique for companies with thin options trading.

4.7 Conclusions

The literature documents significant positive (negative) abnormal returns following index inclusion (exclusion) announcements. These announcements are unscheduled and therefore (to an extent) unanticipated[45] by the market, and with a total index assets value in excess of $1 trillion, there is a clear incentive for investors to acquire information about inclusion announcements. Prior research also indicates that informed traders are likely to operate in the options market prior to the stock market, as options offer advantages such as higher leverage and lower transaction costs. As a result, options play an important informational role, and the information extracted from options prices is a useful predictor of stock returns.

This study is the first to examine the informational role and predictive power of the options volatility skew (and other options trading measures), which is used as a proxy for jump risk, prior to S&P 500 Index inclusion and exclusion announcements. I study the relationship between S&P 500 Index inclusion announcements and options trading as these announcements are unique. They are unscheduled, unanticipated, not announced by the firm, and should convey no new information. I find that in the two days preceding the inclusion announcement there is a strong demand for at-the-money call relative to out-of-the-money put options on the underlying soon-to-be-included firm. Specifically, I find that this demand is significantly predictive of the abnormal returns on days 0 and 1 immediately after the announcement. In contrast, I find no evidence for a predictive ability of options for abnormal returns following exclusion announcements. These results may be due to the smaller sample size of exclusion announcements or the large price fluctuation around these announcements which is usually the result of other corporate events such as mergers and acquisitions or bankruptcy. The results are robust to various methods (e.g., regressions and portfolio sorts)

[45] This is discussed in footnote 34.

and other options trading measures (e.g., skew with different deltas, the put-call spread, the O/S ratio, and innovations in implied volatilities). The results in this study support the conjecture that traders possess information about inclusion announcements as well as the notion that informed traders operate in the options market, and that private information is incorporated into options prior to stocks. In addition, I provide evidence that the volatility skew is a useful measure of jump risk prior to positive, and not only negative events.

Chapter 5 – Conclusions

The objective of this thesis is to examine the informational role that stock options play in financial markets. The thesis consists of three essays, each exploring the information content of options in a different context. The first essay considers the joint cross section of option and bond prices. In particular, it explores whether information is incorporated into option prices prior to bond prices or vice versa. The second essay explores the informational role that options play around seasoned equity offerings (SEOs). Specifically, it examines whether options contain important information around both the announcement and issue dates of SEOs. The third essay considers the information content of options trading prior to announcements of changes to the S&P 500 Index. In particular, it explores if investors are informed about these announcements and whether they disseminate their information via the options market.

The decision to focus on the information content of options, the unifying theme of the three essays in this thesis, is motivated by a central question in financial economics: How does information diffuse across markets and how quickly is it incorporated into security prices? The choice to focus on option prices is justified by the finance literature examining whether options are redundant assets and if informed traders trade in the options market.

Overall, the finance literature provides important insights into how information is incorporated into security prices, particularly what informational role options play in financial markets. While some studies suggest that informed traders do not operate in the options market and that stock prices lead option prices, most of the evidence supports the conjecture that informed traders operate in the options market prior to other markets due to the advantages options offered. Nevertheless, to provide a better understanding of the informational role of options in financial markets, further careful analysis of the information content of options in different venues is warranted.

The first study explores the joint cross section of option and corporate bond prices. Theoretical and empirical work in finance suggests that the stocks and bonds of the same issuing firm should share common risk factors. Therefore, new information about a firm should affect both its stock and bond prices. It is suggested that if one market offers trading incentives over other markets, informed traders and traders with better ability to process information may choose to trade in that market over other markets. As a result, securities that offer advantages over other securities will incorporate information first. This study examines whether information is incorporated into option prices first and can therefore predict bond returns or vice versa. Specifically, it is hypothesized that i) the options market contains information that is predictive of bond returns since informed traders prefer to trade in the options market due to the various advantages it offers, and that ii) the corporate bond market contains information that is predictive of option prices, since the corporate bond market is characterized by sophisticated and professional institutional investors that may have better ability to process information.

The empirical evidence in Chapter 2 documents a statistically significant negative relation between changes in option implied volatility (on individual stocks) and future corporate bond returns. Specifically, sorting bonds into quintile portfolios based on changes in option implied volatility, I find that a strategy of buying the low volatility portfolio and selling the high volatility portfolio yields an average monthly bond return of 1.03% (in excess of the risk-free rate) that is statistically highly significant (at the 1% level) and economically very meaningful. Further examination reveals that these results are robust to using different methods and alternative measures, that these returns are not compensation for systematic risk, and that the returns are persistent for up to two months.

In contrast, examining if information is incorporated into bond prices prior to option prices, I find that changes in bond prices are not predictive of options, nor are they able to predict stock returns. Since bond investors are generally sophisticated institutional investors that process information efficiently and the predictive ability of options is relatively long-lived, I conclude that informed trading rather than superior information processing abilities is responsible for the predictive ability of options.

To the best of my knowledge, this is the first study to examine the joint cross section of options and corporate bond returns. As such, it makes an important contribution to a number of major strands of the finance literature. First, this study is related to the literature on the informational role of options, mainly in equity markets, in which there is ample evidence that options are not redundant assets and that options play an important informational role in general financial markets. I contribute to this strand of literature by providing the first study to examine the informational role of options in future corporate bond returns. Since corporate bonds are part of the firm (the debt part) and play an important role in its financing, an examination of the informational role of options in the corporate bond market seems warranted. I find that options incorporate information prior to bonds and attribute this finding to the fact that informed traders favor the options market over the bond market, because of the advantages that the options market offers over bonds (and stocks), such as low cost, higher leverage, greater liquidity, and no short-sale restrictions.

Second, this essay makes an important contribution to the strand of literature on the predictability of returns. While this literature is voluminous, this study is the first to investigate the predictive power of option implied volatilities on expected corporate bond returns. The relationship between the stocks and bonds of the same issuing firm and the common risk they share imply that these measures should contain important information about both stock and bond prices. This research, therefore, provides important evidence on how option implied volatility and other measures derived from it are related to future bond prices.

Last, this study contributes to the literature exploring how information (private and public) diffuses across markets and how quickly it is reflected in security prices. The literature provides mixed evidence on how information is diffused across stock and bond markets. This research contributes to this strand of literature by showing that option prices incorporate information prior to bond prices, but not vice versa, again, due to the incentives that options offer over bonds.

The second essay examines the informational role of options around SEOs. Specifically, I investigate options trading around two important SEO dates: the announcement date and the issue date. The literature on SEOs indicates that announcements and issue dates contain important information about firms and therefore provide profitable opportunities for traders with private information. While prior research has focused on the information content of short sales around SEOs, this study focuses on the information content of options trading around SEOs. The motivation to focus on options trading around SEOs stems from the fact that traders with information about an approaching announcement can choose to either short sell the firm's stock or buy put options, since put options can act as an alternative for short selling a stock. With regard to SEO issue dates, investors can manipulate the offer price and profit at the expense of the issuer by short selling the firm's stock or by purchasing put options. Thus, this study offers a unique insight into the research on SEOs, using options trading as an alternative to short sales.

The empirical evidence in Chapter 3 indicates a statistically significant negative relation between options trading and cumulative abnormal returns following SEO announcements. In particular, the results show that higher demand for out-of-the-money put options relative to at-the-money call options (volatility skew) in the two days preceding the announcement is strongly associated with abnormal returns following SEO announcements. Additional analysis reveals that these results are robust to alternative methods and options trading measures.

Examining issue discounts, the results in Chapter 3 indicate that higher levels of put option implied volatility are associated with larger issue discounts. Further examination indicates that the results for the issue discount are robust to controlling for various factors known to influence the issue discount and to models with various levels of put option moneyness. In addition, abnormal levels of put option implied volatility are also associated with larger issue discounts. The empirical evidence in Chapter 3 is consistent with manipulative trading under the model of Gerard and Nanda (1993); that is, traders opt to manipulate the offer price downward by purchasing put options and subsequently purchase stocks at the discounted offer price to cover their positions.

Chapter 3 contributes to the finance literature in at least two important ways. First, to the best of my knowledge, this is the first study to document that informed traders trade on their private information about impending SEO announcements and that they disseminate this information in the options market in the period preceding the announcements. This contribution to the literature on SEOs is unique, since prior research finds no evidence of informed trading via short selling prior to SEO announcements. While informed traders may not execute their information by short selling the firm's stocks, they may opt to buy put options due to the advantages they offer over short selling (e.g., higher leverage). Indeed, evidence in this chapter shows that informed trading takes place in the options market prior to SEO announcements.

Chapter 3 also contributes to the literature examining price manipulation prior to the issue date. While evidence on price manipulation prior to SEO issue dates using short-interest data is mixed, this chapter provides evidence that abnormal levels of put option implied volatility are related to higher issue discounts, which implies manipulative trading under the model of Gerard and Nanda (1993).

The results in Chapter 3 provide important implications for both issuers and decision makers. Issuers should be wary of price manipulation via options trading and regulators should consider extending the short-sale restrictions of Rule 105 to restrict trading in related securities.

The third essay investigates the information content of options prior to S&P 500 Index inclusion and exclusion announcements. These S&P 500 Index inclusion and exclusion announcements are unique events because i) they are unscheduled and therefore, to an extent, unanticipated[46] by the market (as opposed to scheduled events, such as earnings announcements), ii) they are not announced by the firm but by the S&P 500 Committee, and iii) they should convey no new information. Despite S&P's claim that inclusion to, or exclusion from the index conveys no new information, the literature consistently documents a large average announcement-day abnormal return that clearly provides a strong incentive for investors to acquire information about inclusion and exclusion announcements. In addition, given the enormous amount of money involved in index tracking, index funds have large incentives to be informed on impending index change announcements.

The empirical evidence in Chapter 4 indicates a significant negative relationship between the levels of the volatility skew in the two days preceding the index inclusion

[46] This is discussed in footnote 34.

announcement and abnormal returns subsequent to the announcement. In contrast, I find no evidence for a relationship between the volatility skew and abnormal returns following exclusion announcements. In particular, examination of cross-sectional regressions reveals that levels of the volatility skew have strong predictive power for cumulative abnormal returns on days 0 and 1 immediately after the inclusion announcement. These results are robust to various methods, measures, and sub-samples. The results in this chapter support the conjecture that information about impending inclusion announcements leaks before these announcements and the notion that informed traders operate in the options market.

Chapter 4 contributes to the literature on index composition changes and on the informational role of options. While the S&P Committee clearly states that changes to the index do not reflect opinions about a firm's future prospects, the empirically observed abnormal returns following index change announcements are at odds with this claim. While the literature has almost solely focused on explanations for these returns, since they are inconsistent with the efficient market hypothesis, no prior study has examined whether these returns can be predicted by measures derived from options trading. Therefore, this study makes a unique contribution to the literature by examining the informational role and predictive power of options before S&P 500 Index inclusion and exclusion announcements. In addition, the third essay contributes to the literature on the volatility skew. While most prior work has used the volatility skew as a proxy for negative jump risk (at either the index or firm level), I use the volatility skew as a predictor of extreme unscheduled positive events, since inclusion announcements are positive events by nature.

Last, the results in Chapter 4 provide evidence consistent with the notion that informed investors trade in the options market prior to the stock market. Since index change announcements are unscheduled and therefore unanticipated by the market, any information revealed by options prior to index change announcements indicates that informed trading takes place prior to the announcements. This is because, in the case of unscheduled events such as index inclusion and exclusion announcements, only investors that possess material information will trade in the options market prior to the announcement; therefore, any information revealed by options will necessarily indicate informed trading.

Overall, this thesis contributes to the literature on the informational role of options and price discovery. While some studies suggest that informed traders do not operate in the options market and that stock prices lead option prices, most of the evidence supports the conjecture that informed traders operate in the options market prior to other markets due to the advantages options offer. This thesis, therefore, provides important evidence that informed traders operate in the options market and that option prices incorporate information prior to stock and bond prices.

The results in this thesis have important implications for both investors and regulators. Overall, the evidence that informed traders operate in the options market should warrant a closer scrutiny from the SEC's enforcement program for detecting insider trading. In addition, the results in Chapter 3 indicate that regulations of short-sale restrictions prior to SEO issuance (Rule 105) should be extended to include the restriction of trading in options, which can act as an alternative to short sales. The results in Chapter 4 indicate that the S&P 500 Committee should be wary of any information released prior to announcements of changes to the S&P 500 Index. While candidates for inclusion to, or exclusion from the index are generally anticipated to some extent by investors, the S&P 500 Committee should ensure that no information leaks prior to these announcements.

The results in Chapter 2 have important implications for both investors and scholars. For investors, a new source of bond alpha in the corporate bond market is exposed and the results indicate that bond investors should take into account the information incorporated into bond-related securities such as options. In addition, the results of Chapter 2 pose a challenge to the efficient market hypothesis, showing that information is incorporated into some assets prior to others and that bond prices are predictable. Naturally, further research on the informational role of options in other venues and important corporate events is needed in order to improve our understanding of how information is incorporated into security prices.

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A Appendix to Chapter 2

Table 1
US Corporate Issuance by Security and Credit Classes 1999 – 2012 ($ Billions)

This table presents amounts (in billions of dollars) of US corporate issuance for total firm equity, total firm debt and corporate debt. In addition, issuance amount of investment and non-investment grade bonds out of the total corporate debt is presented.

Year	Total Equity	Total Debt	Corporate Debt	Investment Grade	Non-Investment Grade
1999	191.7	3,081.8	629.2	544.9	84.3
2000	204.5	2,513.2	587.5	553.2	34.3
2001	169.7	4,383.0	776.1	698.3	77.8
2002	154.0	5,230.4	636.7	579.5	57.2
2003	156.3	6,703.8	775.8	644.7	131.1
2004	202.7	4,424.3	780.7	642.8	137.9
2005	190.4	5,296.4	752.8	656.5	96.3
2006	190.5	5,722.9	1,058.9	912.3	146.6
2007	247.5	5,810.9	1,127.5	991.5	136.0
2008	242.6	4,602.1	707.2	664.1	43.0
2009	264.2	6,717.2	901.8	754.0	147.8
2010	261.7	1,218.4	1062.8	798.9	263.9
2011	198.4	1,180.5	1012.1	788	224.1
2012	278.9	1,618.5	1360.1	1030.9	329.2

Source: Securities Industry and Financial Markets Association (www.sifma.org)

Table 2
Outstanding US Bond Markets Debt 1999 – 2012 ($ Billions)

This table presents amounts outstanding (in billions of dollars) of US corporate debt, total municipal debt, treasury securities, mortgage related debt, money markets, asset-backed securities and federal agency securities along with total outstanding debt.

Year	**Corporate Debt**	Municipal	Treasury	Mortgage Related	Money Markets	Asset-Backed	Federal Agency Securities	Total
1999	3,046.5	1,457.1	3,529.5	3,334.3	2,338.8	900.8	1,620.0	16,227.0
2000	3,358.4	1,480.5	3,210.0	3,565.8	2,662.6	1,071.8	1,853.7	17,202.8
2001	3,836.4	1,603.6	3,196.6	4,127.4	2,587.2	1,281.2	2,157.4	18,789.8
2002	4,132.8	1,763.0	3,469.2	4,686.4	2,545.7	1,543.2	2,377.7	20,518.0
2003	4,486.5	1,900.7	3,967.8	5,238.6	2,519.8	1,693.7	2,626.2	22,433.3
2004	4,801.8	2,030.9	4,407.4	5,930.5	2,904.2	1,827.8	2,700.6	24,603.2
2005	4,965.7	2,226.0	4,714.8	7,212.3	3,433.7	1,955.2	2,616.0	27,123.7
2006	5,344.6	2,403.4	4,872.4	8,635.4	4,008.8	2,130.4	2,651.3	30,046.3
2007	5,946.8	2,618.9	5,075.4	9,142.7	4,171.3	2,472.4	2,933.3	32,360.8
2008	6,201.6	2,680.4	6,082.5	9,101.9	3,790.9	2,671.8	3,210.5	33,739.6
2009	6,869.0	2,811.2	7,610.3	9,187.7	3,127.8	2,429.0	2,727.3	34,762.3
2010	7,853.8	3,795.9	8,853.0	8,475.2	2,865.1	2,053.3	2,538.8	36,435.1
2011	8,324.9	3,719.3	9,928.4	8,339.1	2,572.3	1,834.3	2,326.9	37,045.3
2012	9,100.7	3,714.5	10,920.9	8,168.1	2,460.8	1,701.1	2,095.8	38,161.9

Source: Securities Industry and Financial Markets Association (www.sifma.org)

Table 3 – Variables Source and Definition – Chapter 2		
Variable	Source	Definition
SIZE ($M)	CRSP	Market capitalization in millions of dollars, calculated as number of shares outstanding times share price
RETURN (%)	TRACE	Percentage bond excess return calculated as the difference between bond return and the risk free rate
ISSUANCE	Mergent FISD	Bond initial total issuance amount
COUPON	Mergent FISD	Bond coupon rate (%)
TRADE SIZE	TRACE	Bond transaction size in thousands of dollars
YIELD (%)	TRACE	Current bond yield
RATING	Mergent FISD	Numerical representation of the credit rating provided by S&P where AAA=1, AA+=2, AA=3, AA-=4, A+=5, A=6, A-=7, BBB+=8, BBB=9, BBB-=10, BB+=11, BB=12, BB-=13, B+=14, B=15, B-=16, CCC=17, CCC=18, CCC-=19, CC=20, C=21, D=22, or, if unavailable, by Moody's where Aaa=1, Aa1=2, Aa2=3, Aa3=4, A1=5, A2=6, A3=7, Baa1=8, Baa2=9, Baa3=10, Ba1=11, Ba2=12, Ba3=13, B1=14, B2=15, B3=16, Caa1=17, Caa2=18, Caa3=19, Ca=20, C=21
TIME TO MATURITY	Mergent FISD	The bond time to maturity in years
AGE	Mergent FISD	The time since issuance in years
IMPLIED VOLATILITY	OptionMetrics	The average at-the-money (delta of 0.50 and 30 days to maturity) call and put option implied volatility
CALL IMPLIED VOLATILITY	OptionMetrics	At-the-money (delta of 0.50 and 30 days to maturity) call option implied volatility
PUT IMPLIED VOLATILITY	OptionMetrics	At-the-money (delta of 0.50 and 30 days to maturity) put option implied volatility
SKEW	OptionMetrics	Implied volatility of out-of-the-money put options with delta of -0.20 and 30 days to maturity - implied volatility of at-the-money call options with delta of 0.50 and 30 days to maturity

OPTIONS TO STOCK TRADING VOLUME RATIO (O/S)	OptionMetrics	Total options (put and call) trading volume / Stock trading volume
PUT-CALL SPREAD	OptionMetrics	Implied volatility of at-the-money put options with delta of 0.50 and 30 days to maturity - implied volatility of at-the-money call options with delta of 0.50 and 30 days to maturity
CALL VOLUME	OptionMetrics	Total call options trading volume
PUT VOLUME	OptionMetrics	Total put options trading volume

B Appendix to Chapter 3

Table 1 – Variables Source and Definition – Chapter 3

Variable	**Source**	**Definition**
Firm Size (*LOGSIZE*)	SDC Platinum	Natural logarithm of market capitalization
Price-to-Book Ratio (*MB*)	SDC Platinum	Stock price / Book value
Real Offer Size (*RELOFRSIZE*)	SDC Platinum	Number of shares offered in the SEO divided by the number of shares outstanding prior to the offering
Positive Cumulative Abnormal Return (*CARPOS*)	SDC Platinum	Cumulative abnormal return over the five days preceding the offering if it is positive and zero otherwise
Negative Cumulative Abnormal Return (*CARNEG*)	SDC Platinum	Cumulative abnormal return over the five days preceding the offering if it is negative and zero otherwise
Logged Price (*LOGPRICE*)	SDC Platinum	Logged price the day before the issue
Offer Price Cluster (*OFPRCLUSTER*)	SDC Platinum	A dummy variable equal to one if the decimal portion of the offer price is 0.00, 0.25, 0.50, or 0.75
Exchange Listed (*EXCHANGE*)	SDC Platinum	A dummy variable that takes the value of 1 for NYSE/AMEX or 0 for NASDQ
Stock Turnover (*TURNOVER*)	CRSP	Stock’s volume / Number of shares outstanding
Historical Skewness (*HSKEW*)	CRSP	Skewness of stock returns

Cumulative Abnormal Returns (*CAR*)	CRSP	Firm's actual return - Return from the CRSP value-weighted return index (VWRETD) as the
Idiosyncratic Volatility (*IDIOVOL*)	CRSP	Standard deviation of residuals from estimating the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index
Illiquidity (*ILLIQ*)	CRSP	Absolute stock returns / Trading volume
Abnormal Put Option implied Volatility (*ABPUTIV*)	OptionMetrics	Average put option implied volatility over the five trading days pre-issue divided by the average put option implied volatility over the benchmark period (days -50,-30) with put options deltas of -0.20, -0.25, -0.30, -0.35 and -0.50
Volatility Skew (*SKEW*)	OptionMetrics	Volatility of out-of-the-money put options with delta of -0.20 and 30 days to maturity - Volatility of at-the-money call options with delta of 0.50 and 30 days to maturity
Call Options Volume (*OPTVOL_C*)	OptionMetrics	Total call options trading volume
Put Options Volume (*OPTVOL_P*)	OptionMetrics	Total put options trading volume
Put-Call Trading Volume Ratio (*PCR*)	OptionMetrics	Average put options trading volume / Average call options trading volume
Call Open Interest (*OPENINT_C*)	OptionMetrics	Total open interest on call options
Put Open Interest (*OPENINT_P*)	OptionMetrics	Total open interest on put options
Volatility Premium (*VOLPREMIUM*)	OptionMetrics	Average at-the-money call implied volatility / Stock's realized volatility

Options to Stock Trading Volume Ratio (*O/S*)	OptionMetrics	Total options (put and call) trading volume / Stock trading volume
Call Implied Volatility Innovation (*ΔIVC*)	OptionMetrics	First difference in implied volatilities of at-the-money call options
Put Implied Volatility Innovation (*ΔIVP*)	OptionMetrics	First difference in implied volatilities of at-the-money put options

C Appendix to Chapter 4

Table 1 – Variables Source and Definition – Chapter 4

Variable	**Source**	**Definition**
Book-to-Market Ratio (*BM*)	Compustat	Value of common equity plus balance-sheet deferred taxes for the firm's latest fiscal year ending in prior calendar year / Market capitalization
Firm Size (*LOGSIZE*)	CRSP	Natural logarithm of Stock's price x Shares outstanding
Stock Turnover (*TURNOVER*)	CRSP	Stock's volume / Number of shares outstanding
Historical Skewness (*HSKEW*)	CRSP	Skewness of stock returns
Cumulative Abnormal Returns (*CAR*)	CRSP	Firm's actual return - Return estimated from the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index
Idiosyncratic Volatility (*IDIOVOL*)	CRSP	Standard deviation of residuals from estimating the market model in the period (-250,-30) using the CRSP value-weighted return index (VWRETD) as the proxy for the market return index
Illiquidity (*ILLIQ*)	CRSP	Absolute stock returns / Trading volume
Volatility Skew (*SKEW*)	OptionMetrics	Volatility of out-of-the-money put options with delta of -0.20 and 30 days to maturity - Volatility of at-the-money call options with delta of 0.50 and 30 days to maturity
Call Options Volume (*OPTVOL_C*)	OptionMetrics	Total call options trading volume
Put Options Volume (*OPTVOL_P*)	OptionMetrics	Total put options trading volume

Put-Call Trading Volume Ratio (*PCR*)	OptionMetrics	Average put options trading volume / Average call options trading volume
Call Open Interest (*OPENINT_C*)	OptionMetrics	Total open interest on call options
Put Open Interest (*OPENINT_P*)	OptionMetrics	Total open interest on put options
Volatility Premium (*VOLPREMIUM*)	OptionMetrics	Average at-the-money call implied volatility / Stock's realized volatility
Options to Stock Trading Volume Ratio (*O/S*)	OptionMetrics	Total options (put and call) trading volume / Stock trading volume
Call Implied Volatility Innovation (*ΔIVC*)	OptionMetrics	First difference in implied volatilities of at-the-money call options
Put Implied Volatility Innovation (*ΔIVP*)	OptionMetrics	First difference in implied volatilities of at-the-money put options