Options Trading and the Cost of Debt*

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Abstract

Equity option markets can have a dual effect on firms' cost of debt. On one hand, options attract more informed investors that increase price informativeness and reduce information asymmetries in the market, facilitating firm financing. On the other, by attracting more informed investors that provide reassurance regarding managerial career concerns, options can increase the potential for risk shifting in firms. We explore these two channels via different tests on corporate bond yields and use different econometric specifications including quasi-natural experiments to mitigate endogeneity concerns. We find evidence consistent with a preeminence of the risk-shifting channel when private managerial risk-taking incentives are sufficiently high and debtholders are more exposed to expropriation.

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1 Introduction

Despite the exponential growth in the total equity option volume traded in the U.S., from 676 million contracts in 2000 to over 4,420 million contracts in 2019 [1], there is still considerable disagreement about the real effects of these instruments on the underlying firms. In this paper, we aim to unveil the influence of option markets on one of the key variables on the corporate front: the cost of debt. On the one hand, options are nonredundant securities in the real world that contribute by completing the market, attracting more informed investors and improving the overall information environment (e.g., Ross, 1976; Easley, O'Hara, and Srinivas, 1998; Pan and Poteshman, 2006; Hu, 2014, 2017), easing firm financing. On the other hand, options can act as a managerial disciplining mechanism that increases stock price informativeness so that it better reflects fundamentals (Holmström and Tirole, 1993). By attracting more informed investors that provide reassurance regarding managers' career concerns, options can encourage firms to undertake riskier activities, such innovation (Aghion, Van Reenen, and Zingales, 2013; Blanco and Wehrheim, 2017). Rational debtholders may, consequently, price firms' debt anticipating the potential for risk shifting.

These conflicting channels of influence raise an interesting empirical question regarding how bondholders, an important group of claimholders in the capital structure, view an active option market. In this paper, we aim to shed light on the trade-off between these two potential effects by studying whether equity options written on an underlying asset increase or reduce firms' cost of debt. While studies focusing on the effect of option markets on the cost of equity capital have generally found evidence consistent with the dominance of an informational effect (e.g., Naiker, Navissi, and Truong, 2013), the particular features of debt-like securities may lead to a different balance.[2] Indeed, our empirical investigation yields evidence consistent with the presence of both effects. In

[1] Data from Options Clearing Corporation: http://www.optionsclearing.com/webapps/historical-volume-query.

[2] For instance, risk shifting may be a particular concern for debtholders (and not so much for equity holders), as their bounded payoff limits the potential benefits from incorporating riskier, positive NPV projects into the firm. In addition, several recent studies (e.g., Benmelech and Bergman, 2018; Brancati and Macchiavelli, 2019) point out that debt is less sensitive to the incorporation of information than equity; thus, the net balance of the two channels is likely to differ for both securities.

general, when there is sufficient incentive for risk-taking (e.g., a more convex managerial compensation contract or firm potential for risk shifting), the second channel appears to dominate, and options have a detrimental (i.e., an increasing) effect on the cost of debt. The opposite situation seems to occur for firms in which the marginal informational gain that options bring is more valuable: options seem to help reduce information asymmetries and facilitate financing, thus reducing the cost of debt.

Our starting point is the recognition that active option markets alter the incentives for market participants to gather private information and that trading on such information makes stock prices more efficient (e.g., Ross, 1976; Kumar, Sarin, and Shastri, 1998; Cao, 1999; Chakravarty, Gulen, and Mayhew, 2004; Pan and Poteshman, 2006; Hu, 2017). However, the benefit to informed traders from option markets should depend on the volume of options trading activity because illiquid markets hamper both informed and uninformed traders. Accordingly, the informational benefit goes beyond the effect of the mere existence of an option market on the firm's stock and should be related to whether the market for the listed options has sufficient volume, as informed traders' incentives to trade are higher in high-volume markets (Pagano, 1989; Admati and Pfleiderer, 1988). Taken together, these works provide strong support for the conjecture that informational efficiency may be greater in highly liquid option markets. Lower levels of information asymmetry between firm insiders and outsiders would, consequently, facilitate firm financing (Myers and Majluf, 1984; Brennan and Kraus, 1987; Sufi, 2007). In this vein, Naiker, Navissi, and Truong (2013) explore the informational role of options in equity financing. Their results are consistent with option markets decreasing information asymmetries, leading to a lower cost of equity capital. Similarly, Roll, Schwartz, and Subrahmanyam (2009) link an active option market to increases in firm market valuations by stimulating more informed trading that allows for better resource allocation. We recognize this informational effect as the first channel through which option markets can influence debtholders by reducing firms' cost of debt.

However, there are other potential implications for debtholders derived from the existence of an active option market. Risk-averse managers are biased towards lower-risk projects due to, among other reasons, career concerns, which can lead them to reject positive net present value (NPV) projects that are variance increasing for the firm (Holmstrom and Costa, 1986; Holmström, 1999; Smith and Stulz, 1985; Ortiz-Molina, 2006). The presence of more informed investors with a higher tolerance for risk is a powerful mechanism for alleviating managerial career concerns and encouraging managers to pursue riskier projects. Aghion, Van Reenen, and Zingales (2013) show that in the presence of informed institutional investors, firms tend to engage more in riskier activities such as innovation. Option markets, in turn, are a particularly beneficial trading venue to attract informed investors due to the increased opportunities for leverage and liquidity (Black, 1975; Back, 1993; Easley et al., 1998; Cao, 1999). Moreover, a vast amount of literature provides evidence of informed trading in the option market preceding that of stocks (e.g., Poteshman, 2006; Roll, Schwartz, and Subrahmanyam, 2010; Hu, 2014; Ge, Lin, and Pearson, 2016; Augustin, Brenner, and Subrahmanyam, 2019). Combining these considerations, it follows that active option markets can constitute an effective mechanism for mitigating career concerns and encouraging managers to engage in riskier activities, as they attract an overall more informed investor base. Consistent with this idea, Blanco and Wehrheim (2017) find a positive effect of liquid option markets in spurring firm innovation. Debtholders, in turn, will price debt accordingly, anticipating that managers may now choose to undertake riskier projects that they would have bypassed in the presence of career concerns, (Hirshleifer and Thakor, 1992).

Combining these arguments, it seems that unveiling the net effect of option markets on firms' cost of debt is ultimately an empirical question. On the one hand, previous literature recognizes a beneficial effect of options decreasing information asymmetries and lowering the cost of equity capital. However, the informational efficiency that options bring may not have the same impact on creditors, and the dominance of one channel or another is likely to depend on specific firm characteristics.

To address this ambiguity, we assemble a rich dataset containing quarterly information on bond yields, firm-specific characteristics and options trading data. To approximate the total quarterly options dollar volume, we use the approach proposed by Roll, Schwartz, and Subrahmanyam (2009). We start our series of tests with time-series analyses investigating the effect of options trading on average quarterly bond yields. We gather bond-level data from TRACE to conform to a sample of 3,234 bonds from 766 publicly traded U.S. firms during the period 2002-2015. Our baseline results reveal a detrimental effect of options trading volume on the cost of debt for the average firm in the sample. Higher trading activity in the option market during a quarter is related to higher end-of-quarter yields. These results are robust to the inclusion of a wide range of firm-level control variables, as well as firm and time fixed effects. These results also hold when we move to a bond-level setting that includes bond fixed effects.

We are concerned, however, that these results could be explained by endogenous effects, such as option investors trading more heavily in companies with a more uncertain short-term future and, hence, costlier debt financing. Options are a mechanism for trading on information about future equity volatility, and thus investors with information about short-term stock price volatility can benefit from options (Ni, Pan, and Poteshman, 2008). To account for such selection issues, we rely on a few quasi-natural experiments. First, we make use of the first option listing event experienced by a company to investigate the behavior of bond markets around options trading initiation. The decision to list an option is, unlike stock market listing, exogenous to the firm and belongs to exchanges that are members of the Options Clearing Corporation (OCC). We document a significant increase in bond yields post option listing. Moreover, we simulate an option listing event on a sample of unlisted firms matched on the probability of option listing (Mayhew and Mihov, 2004) and other firm characteristics. We do not observe any significant reaction of bond yields in this matched sample. Second, we consider the quasi-natural experiment provided by firm inclusion in the CBOE Penny Pilot program as a positive exogenous shock to option market liquidity. Our analyses show that firms experience an increase in bond yields post program inclusion. Finally, we extend the endogeneity analysis and estimate a two-stage least squares (2SLS) model using options' moneyness as instrumental variable for option volume (Roll, Schwartz, and Subrahmanyam, 2009; Blanco and Wehrheim, 2017). These identification strategies suggest that the detrimental association between options trading and the cost of debt is not driven simply by self-selection.

In sum, these analyses are consistent with a predominance of the risk-shifting effect for the average firm in our sample. However, given the potential dual pathway for option markets to affect bondholders, it is clear that the preeminence of each channel in the trade-off between informational efficiency and risk-shifting effects will actively depend on certain related firm characteristics. We incorporate these features into the analysis to provide further evidence on the disentanglement of the forces driving this relationship. We argue that options can act as a catalyst for managerial risk-taking. However, managers will only engage in such if the private benefits from adding more risk to the firm are sufficiently high. We find evidence suggesting that this is indeed the case. When managerial compensation is more convex and firm potential for risk shifting is sufficiently high, the risk-shifting channel seems to dominate. Similarly, the enhanced informational efficiency that options bring should be more relevant for firms in which public information production is lower and bondholders can access mechanisms to mitigate risk shifting. Our empirical investigation yields results consistent with these premises.

Our paper makes several contributions to the literature. To the best of our knowledge, this is the first study to specifically examine the real effect of equity options trading on the firm's cost of debt. In this vein, the literature has most prominently focused on the effects on the cost of debt derived from the introduction of credit default swap contracts (Ashcraft and Santos, 2009; Bolton and Oehmke, 2011; Subrahmanyam, Tang, and Wang, 2014).

We identify a novel effect of option markets for bondholders, enhancing understanding of the determinants of the cost of debt. Empirical studies on the determinants of corporate bond spreads have examined, for instance, the effect of liquidity (Odders-White and Ready, 2006), competition (Valta, 2012), government ownership (Borisova, Fotak, Holland, and Megginson, 2015), an open market for corporate control (Qiu and Yu, 2009), political rights (Qi, Roth, and Wald, 2010) and strategic ownership (Aslan and Kumar, 2012). More recently, Gao, Wang, Wang, Wu, and Dong (2019) explore the role of media coverage in reducing the cost of debt paid by firms.

Finally, we also enrich the debate on the regulation of financial derivatives. Unlike stock market listings, where firms apply, option listings are exogenous to firm decisions; they are made within exchanges. These exchanges are self-regulating institutions that are members of the OCC, which operates under the jurisdiction of the Securities and Exchange Commission (SEC) (for exchange-listed options). Because the SEC plays an important role in determining the eligibility criteria for securities in options trading (Mayhew and Mihov, 2004), this topic is of particular interest to policy makers.

2 Data and Methodology

We compile information on corporate bonds, firm-specific characteristics and options trading data from a variety of sources. Bond-quarter information on outstanding bonds is gathered from TRACE (Trade Reporting and Compliance Engine), which contains information on OTC transactions of corporate bonds. We approximate a firm's cost of debt as the average bond's yield to maturity, provided that there is at least one year of available yield data in TRACE for the bond in the 2002-2015 period [3]. To approximate the end-of-quarter yield to maturity of a bond, we average the yield to maturity across all transactions in that bond on the last trading day of the quarter.

For data on options trading activity, we use Option Metrics. This database contains information on daily put and call contracts traded for each individual stock along with bid and ask closing prices from 1996 onwards. To define our measure of option volume, we follow Roll, Schwartz, and Subrahmanyam (2009). We first multiply the total trade in each option by the end-of-day quote midpoint for that option. Next, we aggregate this number quarterly across all trading days and all options on the listed stock. [4]

Existing empirical research on structural credit risk modeling and the market microstructure finds a significant role of firm-specific characteristics in determining the cost of debt (Collin-Dufresne, Goldstein, and Martin, 2001; Campbell and Taksler, 2003;

[3]TRACE coverage starts in 2002.

[4]We set the value of the option volume equal to zero when the firm is not quoted in the option market. However, we are aware that firms not listed in option markets could be idiosyncratic and should be treated with caution (Mayhew and Mihov, 2004). We explore these issues with further robustness tests later in the paper.

Odders-White and Ready, 2006; Avramov, Jostova, and Philipov, 2007; Ericsson, Jacobs, Oviedo, et al., 2009; Qiu and Yu, 2009). To control for these effects, we gather quarterly firm-specific data from the CRSP-Compustat Merged database. Specifically, we collect data to construct the following variables: size (as the log of total assets), return on assets or ROA (net income over total assets), leverage (total debt divided by total assets), growth opportunities as proxied by Tobin's Q (sum of the market capitalization of a firm's common equity, the liquidation value of its preferred shares and the book value of debt, all divided by the book value of assets), relative bid-ask spread, and stock volatility (as the standard deviation of daily stock returns during the previous year [5]). We drop firms that have missing observations for the quarter of interest for any of these variables and require firms to have reported to the CRSP database for at least two years to mitigate backfilling bias. We also remove from our sample firms that are not quoted in the three major American markets (Amex, NYSE, or NASDAQ). Finally, we exclude financial firms (Standard Industry Classification (SIC) code 6000-6999), as their leverage may be influenced by their idiosyncrasy, and their debt-like liabilities are not strictly comparable to those of nonfinancial firms (Rajan and Zingales, 1995). In line with the existing literature, all variables are winsorized at the 1st and 99th percentiles to ensure that our results are not driven by outliers, although the results remain virtually unchanged when not considering this procedure.

Because our datasets do not perfectly overlap after applying all filters, we lose some observations when merging data from these three sources. Our final sample comprises 34,462 bond-quarter observations [6] for 3,234 different bonds with at least one year of available yield data in TRACE in the 2002-2015 period. When we collapse this data to the firm-level, by averaging yields for every outstanding bond from a firm in a given quarter, we are left with 9,740 firm-quarter observations, corresponding to 766 firms. Table 1 provides the main summary statistics.

[Insert Table 1 around here]

[5] In unreported robustness tests, we replace this measure with firm cash-flow volatility; this does not change the results.

[6] Of these, 9,384 bond-quarter observations correspond to firms with no options trading activity.

The average bond in our final sample has a yield to maturity of 4.56%, with a median of 3.80%. The average (median) firm cost of debt is 5.90% (4.16%). Firms in our sample have an average (median) assets figure of $18 ($6) billion. The average dollar option volume traded for these firms is large (average $46 million), reflecting the exponential growth of equity option markets in recent years. The median number for options trading volume is much lower, around $1 million, consistent with almost 30% of the observations in the sample having no options trading activity. For other variables, firms have an average (median) Tobin's Q of 1.61 (1.33); ROA of 0.006 (0.009); leverage of 32% (29%); and stock volatility of 0.339 (0.275). The mean (median) relative bid-ask spread for the firms in our sample is 0.09 (0.042). Due to high skewness, which may jeopardize our results, we use the natural logarithm of option volume and total assets for the analysis.

2.1 Specification

In our initial time-series specification, we analyze the effect of options trading volume on a firm's cost of debt by estimating the following ordinary least squares (OLS) regression:

$$Yield_{i,t} = \alpha_{i,t} + \beta Ln(OptionVolume)_{i,t} + \gamma X_{i,t} + \delta_t + \lambda_i + \epsilon \tag{1}$$

where t indexes time (quarter of the year), and i indexes a specific firm. $Yield_{i,t}$ is the average bond yield to maturity at the end of quarter t. $Ln(OptionVolume)_{i,t}$ measures options trading volume during quarter t for bond i.[7] The vector X contains the set of time-varying controls, which include total assets, Tobin's Q, ROA, leverage, stock volatility, and illiquidity.[8] In line with existing research, we expect that firm size and profitability have positive impacts on (that is, that they reduce) the cost of debt. Conversely, leverage and firm risk (stock return volatility) are expected to increase the return demanded by bondholders, which is contrary to the firm's interest. Controlling for effects derived from

[7]In untabulated tests, we also employ the ratio of the options to stock volume (O/S) from Roll, Schwartz, and Subrahmanyam (2010) as a proxy for options trading activity and obtain similar qualitative results. In any case, we are more interested in the existence of an active option market for the effect, regardless of how active it is compared to the stock market (which we control for).

[8]Note that we do not consider specific bond-level characteristics, as we already account for them when using bond and time fixed effects.

stock return volatility is of special relevance because it is considered to be one of the key determinants of option listing by exchanges (Mayhew and Mihov, 2004). Furthermore, investors may trade out-of-the-money options to speculate in volatility (Ni et al., 2008) and, thus, may be particularly interested in highly volatile firms.

The control variable for stock market liquidity (or illiquidity) is also important for the analysis, first because exchanges are more prone to quote options from firms with high stock trading volume (Mayhew and Mihov, 2004) and second, and more importantly, because of the asymmetric information embedded in stock market liquidity measures [9]. In particular, Odders-White and Ready (2006) find a negative relationship between a firm's credit rating and equity market liquidity. Moreover, common microstructure measures of adverse selection, such as the relative bid-ask spread, can be used to predict future changes in ratings. Following this rationale, we expect the relationship between stock liquidity and debt cost to be negative. We control for stock liquidity by using the relative bid-ask spread.[10].

The specification also includes time and firm fixed effects with the variables δ_t and λ_i, respectively, to mitigate concerns related to time-invariant firm characteristics and specific time periods (e.g., dotcom bubble, financial crisis) driving the results. Additionally, in forward sections of the paper, we extend this specification to consider a bond-level setting with bond fixed effects. In that case, $Yield_{i,t}$ would be the specific bond yield to maturity at a given quarter, and, consequently, λ_i would account for bond fixed effects. The rest of the specification remains virtually unchanged. Finally, we report robust double-clustered standard errors clustered both at the firm and time levels (Petersen, 2009).

[9]See, among others, Roll (1984), Glosten and Harris (1988), Stoll (1989), Hasbrouck (1991), Easley, Kiefer, O'hara, and Paperman (1996) or Huang and Stoll (1997) for seminal work on this issue.

[10]In untabulated tests, we use alternative metrics for stock liquidity, such as the Amihud (2002) measure, with unchanged results.

3 Empirical Results

3.1 Time-series analysis

We display the results from the regression specification in Eq. 1 in Table 2. We begin in column 1 by employing a simple OLS regression of firm yields on options dollar trading volume, firm-level characteristics, and time fixed effects. The coefficient for option volume resulting from this specification is positive (0.060) and statistically significant (p-value$<$0.05), suggesting a positive relationship between bond yields and options trading volume. Indeed, when we incorporate firm fixed effects into the specification in column 2, the coefficient of options increases both in magnitude (0.111) and significance (p-value$<$0.01). This relationship between option volume and firm-level yields remains robust and virtually unaltered also after incorporating firm-level variables to the fixed-effects model (results in column 3).

We extend the analysis in columns 4 and 5 of Table 2 by considering a bond-level framework as described before, which allows us to incorporate bond fixed effects in order to control for bond-specific characteristics. The results for the option volume coefficient in this setting exhibit a slightly lower economic magnitude than before (0.072 vs. 0.110), but remain statistically strong (p-value$<$0.01).

[Insert Table 2 around here]

These results are consistent with a net positive effect of option markets (i.e., the effect increases) on firm's cost of debt. At this point in the analysis, given the characteristics of the average firm in our sample, the risk-shifting channel seems to have a more meaningful impact than that derived from potentially higher price efficiency. The economic magnitude of the effect is strong. For example, taking the conservative coefficient of 0.072 in the estimates of column 5 in Table 2, a one-standard-deviation increase in option volume from the mean is associated with an increase in yield to maturity of nearly 0.5% for the average bond in the sample. The remaining coefficients for the control variables in Table 2 take the expected direction. While firm size, profitability and liquidity relate negatively to a firm's cost of debt, firms leverage and risk are positively associated with bond yields.

3.2 Quasi-natural experiments

Option markets, where trading and short-selling costs are minimized, are considered a beneficial trading venue for informed traders and can be particularly advantageous in situations of high uncertainty (e.g., Ni et al., 2008). Given these particular features, it is fair to argue that our results could be explained by reverse causality, even in a demanding econometric setting such as ours. For example, options traders may migrate towards firms they expect to face a more turbulent future and that have, hence, costlier debt financing. Luckily for us, the time-series setting we consider here allows us to make use of a few quasi-natural experiments to shed light on the main driver of the relationship between options and cost of debt.[11]

3.2.1 Option listing decision

Unlike a stock market listing, the option market listing decision is made by options exchanges that operate under the jurisdiction of the SEC and are exogenous to the firm. This feature provides us with a good identification to address the potential endogeneity embedded in our study. We restrict our initial sample to bonds from firms that experienced their first option listing event in the 2002-2014 period. Furthermore, we require each bond to have nonmissing observations for at least one year before and one year after the listing event. After these filters, we are left with data on 104 corporate bonds.

To investigate the dynamics of bond yields around the initial option listing, we perform a small event study. Specifically, we regress quarterly bond yields on a set of dummy variables for the three quarters prior to the option listing event and the four quarters after the firm was listed (quarter zero is the omitted category), as well as firm-level

[11] Given the potential importance of bond-level features in explaining the differential reaction of firms to these time-dependent exogenous shocks, we have performed such analyses on the richer bond-level data sample accounting for bond fixed effects. The results from these analyses remain qualitatively unchanged, however, when performed on the clustered firm-level sample. These results are available upon request.

characteristics and bond fixed effects. Controlling for firm-level characteristics such stock volatility, liquidity, or leverage alleviates the concern that ex ante differences between firms are driving option listing and subsequent bond market reactions. Similarly, by including bond and time fixed effects, we ensure that different bond characteristics (e.g., seniority, callable/putable clauses, etc.) and time trends do not influence the results.

Even if we observe an increase in bond yields after the option listing event in this strong framework, one could still argue that there is some characteristic unaccounted for among these firms that positively relates to both the probability of listing and to bondholders' risk. For example, as argued in Mayhew and Mihov (2004) and Hu (2017), we would expect exchanges to list options when they anticipate high volatility, as their profits from market-making increase in these periods. This, in turn, would also increase the perceived risk of the firm and, as a consequence, bond yields.[12]

To reduce these concerns, we construct a matched sample of unlisted firms that have a high probability of being listed in the option market. Specifically, for each firm that experiences option listing in a given quarter, we identify a comparable firm in terms of ex ante probability of listing, quarter date of listing, and firm characteristics and simulate an option listing event. To approximate the probability of a given firm being listed in the option market, we rely on Mayhew and Mihov (2004) and estimate a logit model using pooled data from CRSP and Option Metrics containing quarterly observations of option listing, stock trading volume, firm size and volatility, which are identified as the main drivers behind option listing. We then roll this model to calculate a predicted probability of option listing for each firm-quarter using the model estimates.[13]

We require matched firms to not experience a listing event for at least one year after the listing quarter for which they serve as a control. Additionally, we apply the same filters as for the listed sample, such as continuous reporting to the database or nonmissing observations for at least one year after and one year before the simulated listing quarter. Because these requirements are hard to meet given the pool of non-

[12]We leave aside the question of whether it is realistic to assume that exchanges react to expectations about future prospects of the company faster than the bond market and focus instead on alleviating concerns regarding the potential for listing.

[13]See Table A1 in the Appendix for the efficiency of the model predicting option listing.

listed firms in the 2002-2014 period, we use matching with replacement. This procedure implies that an observation can act as a control for a number of treated observations. Far from presenting a problem, this methodology often decreases bias compared to one-on-one nearest neighbor matching since we do not impose a specific hierarchy for the assignment, and it is particularly helpful when there are few control individuals compared to treated individuals (Dehejia and Wahba, 1999, 2002). After all filters, we conform to a sample of matched firms with 560 observations. Table A2 in the Appendix contains information on the summary statistics for listed and matched firms on a number of relevant variables with similar values across samples. Interestingly, stock volatility for the control firms is slightly larger (0.507 versus 0.491) before listing, and it does not change much in the period after for either of the two groups. The largest differences in terms of sample means occur in the case of stock liquidity. The bid-ask spread is significantly larger for the control group before and after the listing event. Even though we include these variables as covariates in the regression specification, it is worth noting that these kinds of differences would, in any case, bias our estimation towards a greater cost of debt in the control group.

We run the same event study for the sample of listed firms and the matched sample and depict the within-firm estimation results for both samples in Figure 1. Complete regression results and estimates are contained in Table A3 in the Appendix.

[Insert Figure 1 around here]

Figure 1 contains the time estimates and confidence intervals from the event study on bond yields for the sample of firms that experience an option listing event while the bond was outstanding (treated firms) as well as for the matched sample of unlisted firms (control). Point estimates for both samples before listing overlap, revealing a fairly similar trend between the treated and control firms. This behavior persists in the first quarter after the option listing event, probably because the volume needed for active trading in the market takes time to build. However, in subsequent quarters after listing, there is a substantial increase in the bond yields of treated firms. The control sample, in turn, does not exhibit this behavior, and point estimates remain non-significantly different from the prelisting ones.

3.2.2 Penny Pilot program

The Penny Pilot program launched by CBOE in 2007 provides us with another quasi-natural experiment to identify exogenous changes in the option market. The Penny Pilot program allows the quoting and trading of certain option classes in minimum increments of $0.01 for all option series priced below $3 and in increments of $0.05 for series with prices equal to or above $3. The CBOE first initiated the program on January 26th, 2007, including 13 option classes and has subsequently expanded it to over 384 option classes, including public firms, ETFs and other funds. After being included in the program, option series experimented with important decreases in spreads. For example, the CBOE report from September 4th, 2008, documents an average industry decrease in penny series spreads of nearly 49%, from $0.10 to $0.05 post program initiation.[14]

We make use of a firm's inclusion in the Penny Pilot program as an exogenous positive shock to option market liquidity. There are 110 firms in our sample of bond yields that are included in the Penny Pilot program during the 2007-2014 time period. The inclusion of these firms in the program takes place gradually over time. For example Intel Corp. and General Electric were among the first firms to be included in February 2007, while American Airlines and Twitter joined in 2014.

To the extent that higher market liquidity eases investor trading, we expect a response from bond markets to exogenous increases in option market volume. We use the quarter a firm is included in the Penny Pilot program as the reference quarter for the positive shock on options trading volume and replicate the same event study methodology applied in the previous case of option listing. The results from the regression procedure are shown in Table A3 in the Appendix, while Panel (a) in Figure 2 contains the point estimates and confidence intervals from this event study. Overall, the results show an increase in

[14]Several CBOE reports document enhanced liquidity in the option market derived from the inclusion of an option class in the Penny Pilot program. See https://www.cboe.org/general-info/hybrid-reg-penny-pilot-program.

bond yields following exogenous increases in option liquidity derived from firm inclusion in the Penny Pilot program.

[Insert Figure 2 around here]

For the point estimates and confidence intervals in Panel (b) of Figure 2, we change the bond fixed effects employed before for industry (2-digit SIC code)-by-time fixed effects, mainly due to the concern that although CBOE exogenously decides to include firms in the program, these decisions may be somehow clustered by industry and time. For example, Anadarko Petroleum, XTO Energy, Occidental Petroleum, and Hess were all included in the program by February 1st, 2010. Similarly, Walmart, Target, and Home Depot were added to the program by March 28th, 2010. The results from the regression procedure are, as before, shown in Table A3 in the Appendix. The results show a strong escalation in bond yields after the inclusion of a firm in the Penny Pilot program.

Overall, these results shed more light on the leading factor in the options-cost of debt relationship. The empirical evidence provided shows that bond yields react after firms are listed in the option market and included in the Penny Pilot program, which points to a causal effect of options on the cost of debt.

3.3 Bond issues

As an add-on to our main sample on quarterly yields, we also explore whether options trading affects bond yields at the time of bond issuance. In addition to exploring a new venue, this analysis has the side benefit of focusing on at-issue yields, considered an additional direct measure for the cost of debt by many studies in the literature (e.g., Datta, Iskandar-Datta, and Patel, 1999; Elton, Gruber, Agrawal, and Mann, 2001; Maxwell and Stephens, 2003; Qi, Roth, and Wald, 2010; Francis, Hasan, John, and Waisman, 2010).

We extract bond-level data from the Thomson Reuters SDC Platinum Global New Issues Database and limit our sample to U.S. companies and issues of fixed-rate [15] corporate bonds defined in U.S. dollars over the 1996-2014 period. We retrieve from the SDC

[15] We retrieve bond issues for fixed- and floating-rate bonds from SDC Global New Issues. After applying all filters, floating bond issues represent less than 6.5% of all bonds. Given this small amount

Global New Issues the data on bond rating, yield spread at the time of issue, bond maturity and principal amount, and we construct two dummy variables that indicate whether the bond is callable [16] and public. These variables are common determinants of the cost of debt used in the literature (e.g., Qiu and Yu, 2009; Qi, Roth, and Wald, 2010; Francis, Hasan, John, and Waisman, 2010; Borisova, Fotak, Holland, and Megginson, 2015).

We measure the cost of debt at the time of issuance using bond yield spread (with respect to the same maturity treasury yield from the Fed H-15 Release) and bond rating from Standard and Poor's, as reported by SDC, which we convert to a numerical scale where lower values correspond to poorer ratings.[17] Both metrics are standard in the literature and provide direct values of the real cost incurred by firms to access debt financing via bond markets.

After merging these data with our quarterly data of options trading and firm-level characteristics, we are left with 4,330 bond issues in the 1996-2014 period for 808 different firms. Table A4 in the Appendix provides information on the number of issues per year and the number of issuers. The summary statistics for the sample of bond issues are shown in Table 3.

[Insert Table 3 around here]

The average issue in our sample has a spread over treasuries of approximately 216 basis points (bps) with a median of 157 bps, which is consistent with similar recent studies [18] in the literature (e.g., Borisova, Fotak, Holland, and Megginson, 2015). With respect to bond ratings, the average (median) according to our numerical scale is 11.54 (12.00), which corresponds to a Standard and Poor's rating between BBB and BBB+ (BBB+). The average firm in the issue sample has a quarterly options trading volume of \$165 million (median \$ 22.46 million), much larger than our initial time-series sample as

and the challenge of properly assessing yields to maturity on floating bonds with different complex benchmarks, and for the sake of homogeneity in our sample, we decide to drop issues of floating-rate bonds. In any case, when we add this small sample, the results remain qualitatively intact.

[16]There are no putable bonds in the sample once we apply all filters.

[17]The complete numerical scale is as follows: 1-CCC-, 2-CCC, 3-CCC+, 4-B-, 5-B, 6-B+, 7-BB-, 8-BB, 9-BB+, 10-BBB-, 11-BBB, 12-BBB+, 13-A-, 14-A, 15-A+, 16-AA-, 17-AA, 18-AA+, 19-AAA-, 20-AAA, 21-AAA+.

[18]Obviously, in existing studies with a sample ending before 2007, the average yield spread is much lower (approximately 120-140 bps.=). The average yield spread in our sample pre-2007 is 130 bps.

a consequence of most of these firms being quoted in the option markets.[19] Firms in this sample tend to be larger, with total assets averaging \$33.48 billion versus \$18.38 billion from the time-series sample, and slightly more volatile (0.35 vs. 0.339). The average bond in our sample has principal equal to \$558 million and a maturity of approximately 12 years. Finally, 99.5% of our bonds are public, and fewer than 5% include a callable option [20]. Due to high skewness that may jeopardize our results, we use the natural logarithm of some of the variables for the analysis. Specifically, we calculate the natural logarithm of the yield spread, option volume, total assets, bid-ask spread and (one plus) maturity.

To analyze the relationship between option markets and at-issue bond yields, we use a regression specification similar to that of Eq. 1 and display it in Eq. 2. Given the nature of these data, however, we rely on a pooled OLS model where options trading and firm-level variables are calculated for the quarter prior to that of bond issuance.

$$Y_i = \alpha + \beta Ln(OptionVolume) + \gamma Z_i + \delta_t + \lambda_i + \epsilon \tag{2}$$

The dependent variable, Y_i, measures a firm's cost of debt under the two previously discussed metrics. Thus, one econometric model in our analysis will take the natural logarithm of the at-issue bond yield spread, *Ln(Yield Spread)*, as the dependent variable; the other will use the bond's *S&P Rating* [21]. In addition to our usual firm-level control variables, the vector Z_i includes controls for bond maturity, principal amount, and two dummy variables to capture the callable option embedded in some of bonds and whether the bond is public. We include time fixed effects with the term δ_t, which accounts for

[19] As before, we set the value of the option volume to zero when the firm is not quoted in the option market. In the issue case, however, only 2 firms/observations do not have active options trading (compared to 9,384 bond-quarter observations in the time-series sample).

[20] Other studies in the literature report higher statistics for the number of callable bonds in the sample (approximately 7.5%). However, these studies tend to include both fixed-rate and floating-rate bonds, which are more likely to be subject to callable clauses.

[21] We are aware of the potential problems of using OLS regression with a count variable such as the S&P Rating. To mitigate concerns regarding this issue, we fit an ordered logit model for the S&P rating (in Table 4), and we repeat the analysis with negative binomial and Poisson models. Moreover, we transform the rating variable to the natural log of one plus the rating in a traditional OLS regression. All these tests yield the same qualitative effect of options trading and are available from the authors upon request.

year-month time dummies. In a similar fashion, following past studies in the literature, λ_i controls for industry dummies (at the two-digit SIC code level). Finally, we report robust double-clustered standard errors clustered both at the firm and month levels (Petersen, 2009).

We display the results from the regression specification in Eq. 2 in Table 4. We start in column 1 with a specification including only firm-level controls and time and industry dummies for the natural logarithm of bond yield spread as the dependent variable. The same specification for our second dependent variable, *S&P Rating*, is reported in column 3. We extend this analysis to include bond-level controls in columns 2 and 4 of Table 4. Column 5 reports the results of an ordered logit regression using *S&P Rating*.

[Insert Table 4 around here]

In general, the results from the analysis of bond issues displayed in Table 4 align with the previous one from the time-series setting. The coefficient estimate for option volume exhibits a large statistical significance (p-value$<$0.01) across all columns of Table 4, pointing to option markets exacerbating the cost of debt financing paid by firms for new bond issues. Firms with more active trading in the option market on the quarter prior to bond issuance tend to pay higher yields and obtain lower credit scores for their bond financing.

These results indicate that the risk-shifting channel embedded in options appears to dominate the trade-off for the average firm in the sample. However, we have already highlighted that, theoretically, this dominance should strongly depend on certain firm-level characteristics. We explore such characteristics in Section 4 and devote the next few sections to additional robustness tests to mitigate endogeneity concerns.

3.4 Instrumental variable approach

To provide a complete analysis of the endogeneity issues that may jeopardize our results, we extend our tests using an instrumental variable approach and a two-stage least squares (2SLS) regression. While it is true that our results for the time-series setting responded well to the quasi-natural shocks on option volume provided by our two regulatory events, the 2SLS analysis has the benefit of being also implementable with the at-issue sample of bond yields.

The ideal instrument in our setting is a variable that is highly correlated with options trading volume (relevance condition) but uncorrelated with the measures of cost of debt, except through other independent (control) variables (exclusion restriction). This is equivalent to saying that there is either no relationship at all between our instrumental variable and the cost of debt or that every potential relationship is captured by other variables in the 2SLS specification such stock liquidity, volatility, or option volume. Obviously, such an instrument is extremely challenging to obtain, especially since we cannot explicitly test whether the exclusion restriction holds.

We follow previous literature analyzing equity option markets and corporate outcomes and use options' average moneyness as an instrument (Roll et al., 2009; Blanco and Wehrheim, 2017). We follow Roll et al. (2009) to construct this variable, *Moneyness*, as the absolute difference between the stock's market price and the option's strike price averaged for all options in the quarter. As argued in Roll et al. (2009), we should not expect a mechanical link between average moneyness and firm values or volatility. First, exchanges continuously list new options with strikes close to the current market prices of the underlying stocks. Second, different kinds of agents will demand options at different moneyness levels. Agents speculating on volatility will trade at-the-money options for greater sensitivity and Vega; informed investors may eschew out-of-the-money options given their maximum leverage; and uninformed investors stick to in-the-money options to reduce volatility risk. Thus, while we should expect a close relationship between moneyness and option volume, this relationship is not unambiguous.

We use the natural logarithm of moneyness, *Ln(Moneyness)*, as an instrumental variable for Ln(Option Volume) in a two-stage least squares procedure. The results for both time-series (both at the bond and firm levels) and at-issue bond yields are displayed in Table 5. Specifically, columns 1 to 3 contain the first stage procedure and the second stage on bond yields and S&P rating as independent variables, respectively, for the sample of at-issue bond yields. In a similar fashion, columns 4 and 5 contain the first and second stages for the time-series sample of bond-level yields, respectively. Finally, columns 6 and 7 display, respectively, the first and second stage of the two-stage least squares procedure for the firm-level data where bond yields are averaged at the firm level.

[Insert Table 5 around here]

The positive and statistically strong coefficients (p-value<0.01) for the first stages in columns 1, 4 and 6 highlight the strong importance of moneyness in explaining option volume. The instrumented option volume coefficients are also highly significant (p-value<0.01) throughout columns 2, 3, 5, and 7 in Table 5, suggesting that option markets indeed drive the relationship towards a higher firm's cost of debt. While these coefficients are, for both samples and measures of the cost of debt, larger in magnitude than standard OLS estimates, these discrepancies between OLS and 2SLS procedures are common in practice (Beaver, McAnally, and Stinson, 1997; Irwin and Terviö, 2002).

Overall, the results from the extensive endogeneity analyses point to a causal effect of a more active option market on a firm's cost of debt financing, both in the primary time-series sample and at the time of bond issuance. This evidence seems to favor the dominance of the risk-shifting channel embedded in equity options over the enhanced price informativeness. However, as we highlighted during the analysis, there may be particular firm-level characteristics that tilt the net effect of options trading on certain firms towards one direction or the other. We devote the next section of the paper to summarizing additional robustness tests, and then we discuss how specific characteristics may influence the effect in Section 4.

3.5 Additional Robustness

To avoid deviating the focus of the analysis and for the sake of space, we perform a battery of additional robustness tests that we include in the Appendix. These tests help us mitigate several potential concerns. Here we summarize them.

First, we extend the option listing event analysis by considering a subsample of firms that just marginally meet the option listing minimum price requirement, as the listing decision is more likely to be exogenous for these firms as compared to those that do not meet the requirement (Hu, 2017). The regression results for this (reduced) subsample are shown in column 3 of Table A3, while coefficient estimates and confidence intervals are depicted in Figure A1. Moreover, in Fig. A2 we depict the estimates from the firm-level replication of the event study based on first option listing experienced by a company, with unchanged qualitative results.

In a time-series setting with bond fixed effects, we perform a two-way sorting, classifying firms on July 1st of each year into quartiles based on leverage and volatility. Then, we show that neither the trading volume nor the effect of options on quarterly bond yields as a catalyst of risk-shifting behavior is restricted to firms with high leverage and/or high volatility but also occurs in financially healthy firms (Tables A5 and A6). This evidence suggests that stock return volatility is not a primary driver of the effect.

In Table A7, we incorporate different proxies for institutional ownership structure. The inclusion of these variables has a limited effect on the results, and the effect of option volume on bond yields remains similar across different specifications.

Finally, given that option market volume may take time to build and that the options trading activity in one quarter may not properly reflect how active the market is, we extend the baseline construction of option volume to several other specifications with lower frequencies. The results are displayed in Table A8. These include a trailing 1-year option volume measure (columns 1 and 2); the 4-quarter average option volume (3 and 4); and an annual analysis of the effect of total option volume during the year on end-of-year bond yields (5 and 6). Overall, the results from using these alternative measures are qualitatively similar to the previous ones.

4 Potential Mechansims

Our tests so far have revealed a positive association between more active option markets and subsequent bond yields. These results point to a dominance of one of the potential channels (risk shifting) over the other (price informativeness). This dominance, however, is likely to depend on certain firm-specific characteristics that facilitate or impede managerial risk shifting. In the remainder of the paper, we analyze different relevant firm characteristics in an attempt to pinpoint the mechanisms at play.[22] Of course, we acknowledge that providing definite proof is an important challenge; hence, our tests are only suggestive.

4.1 Managerial compensation

We start our investigation of the variables that directly condition the net effect of option markets on bond yields by incorporating managerial compensation as an important variable into the analysis. Managerial compensation is an effective way for shareholders to influence risk-taking. For example, firms with high growth opportunities can benefit from encouraging a risk-averse manager to invest in high-risk, positive NPV projects via a more convex compensation structure (Guay, 1999; Core and Guay, 1999). Rational lenders will price bonds accordingly, taking into account future risk choices derived from managerial compensation structures (Ortiz-Molina, 2006). Hence, the question of whether the risk-shifting channel dominates price informativeness should depend heavily on whether the manager has indeed the proper incentives to take on risky investments.

To explore the role of managerial incentives in our framework, we follow Coles, Daniel, and Naveen (2006), who calculate pay-performance sensitivity (PPS) based on the methodology by Core and Guay (2002) using data from Execucomp.[23] We measure PPS and risk-taking incentives via CEO Delta (dollar change in wealth associated with a 1% change in stock price) and CEO Vega (dollar change in CEO's option holdings for

[22] Since these analysis are essentially part of a firm-level story, we limit our investigation in the paper to the firm-level yields data. Results, however, are qualitatively similar when performed on the bond-level and at-issue yields data.

[23] We are grateful to Lalitha Naveen for providing extensive explanations of these calculations along with the actual data estimates on her website.

a 1% change in stock return volatility). Table 6 displays the results from including these measures in the regression specification of Eq. 1.

[Insert Table 6 around here]

We begin the analysis in Table 6 by sequentially including both variables for CEO risk-shifting incentives as controls in the specification in columns 1 and 3, respectively. Both CEO Delta and Vega display significant effects (p-values<0.1) when entered as controls, in line with the increasing effect of risk-taking incentives on yields. Unfortunately, data on executive compensation are scarce and only available for a subset of the firms, thus forcing us to drop an important part of the sample observations (around 45%). This leads us to a positive but statistically insignificant coefficient for option volume across the different specifications in this reduced sample.[24]

Then, we investigate the interaction of these variables with our main effect of option volume in columns 2 and 4, respectively. Interestingly, the interaction terms of both of these variables with option volume exhibit a high statistical significance, indicating that the option effect is highly relevant for relatively high levels of managerial pay-performance sensitivity and risk-taking incentives. We display the results from the model including the interaction of option volume with CEO Delta in column 2 of Table 6. The interaction term is positive (0.297) and statistically significant (p-value<0.05), consistent with an increasing effect option markets on firm's cost of debt as CEOs have more incentives to take on risky investments. Similar conclusions arise from the interaction analysis with CEO Vega (coefficient 0.436, p-value<0.1), displayed in column 4.

Finally, columns 5 and 6 of Table 6 contain the results from running our baseline regression model from Eq.1 on two subsamples corresponding to firms low and high values of CEO Delta, respectively, according to the median. In line with the pattern we observed in the previous interaction terms analyses, the option volume coefficient is positive and only statistically significant (p-value<0.01) for those firms with above-median

[24]In untabulated tests, we check that the statistical significance of the coefficient is affected by the reduced sample considered, rather than the inclusion of CEO compensation control variables.

CEO pay-performance sensitivity in column 6. The coefficient itself is sizable in economic magnitude and even above the estimates from the full sample in baseline regression of Table 2 (0.146 vs. 0.110). On the other hand, the positive coefficient (0.053) for the low managerial pay-performance sensitivity case exhibits no significant statistical power.

Overall, the results from the analysis on managerial compensation incentives suggests that the effect of option markets on firm's cost of debt is more pronounce as the convexity of the compensation contract increases. These results point to a role of option markets as catalysts of managerial risk-shifting behavior, that debtholders seem to price. In the next sections, we continue to explore this potential channel to try to shed more light on the options-cost of debt relationship.

4.2 Potential for risk shifting

We revisit the results to provide further suggestive evidence of the potential forces driving the effect. At this point, we consider alternative measures for risk-shifting incentives that are not directly related to managerial compensation. The literature unveils several firm-specific characteristics that contribute to the potential for risk shifting in a firm, such as high levels of corporate investment and growth opportunities (Rajan and Zingales, 1995). Hence, we should expect risk shifting to have a more prominent effect in these cases. We display the results from this investigation in Table 7.

[Insert Table 7 around here]

In particular, we consider three different firm-level measures related to corporate investment intensity and growth opportunities. We start in column 1 of Table 7 by including in the baseline specification of Eq.1 the interaction term of options volume with Tobin's Q as a measure of a firm's growth opportunities. Columns 2 and 4 include as controls in the specification the amount of Capital and R&D expenditures, respectively, while in columns 3 and 5 we depict the results from models interacting these 2 variables with our option market liquidity measure. Interestingly, the coefficient for option volume is positive and highly significant across all specifications in Table 7. The significant coefficients for the interaction terms of corporate investment proxies with option volume in columns 1, 3, and 5 reveal a more positive and statistically significant effect (i.e., a more pronounced impact of options, consistent with a risk-shifting channel) as firm-level incentives for risk shifting increase.

Finally, in columns 6 and 7 of Table 7, we consider debt convertibility as an important feature into the analysis. Column 6 includes the ratio of convertible debt as a control variable in the specification, while the model in column 7 interacts this variable with option volume. Debt convertibility has been recognized as mitigating the damage to bondholders from pursuing riskier projects (Green, 1984; Hennessy and Tserlukevich, 2008; Eisdorfer, 2008). Thus, we expect that, consistent with lower debtholders' risk-shifting concerns in the presence of convertible debt, the effect of option markets on firm yields decreases for higher ratios of convertible debt. This is precisely what the results from the interaction terms analysis in column 7 of Table 7 suggest.

4.3 Information environment

In the final part of the analysis, we explore how different informational environments can influence the effect of options on bond yields. Specifically, we consider the role of analysts as information producers. Previous literature finds that stock analysts are an important source of public information that helps reduce asymmetries and, ultimately, reduce the cost of debt for the firm (e.g., Tang, 2009; Derrien and Kecskés, 2013). Ideally, we could make use of the information disseminated through these agents to check whether the informational role of options is more prominent in firms with low analyst coverage, where trading on private information is more important (Roll et al., 2009). This conjecture would, however, depend strongly on whether the information revealed through option markets is substitutional or complementary to analyst information.[25] For this reason, we first verify that the informational effect of options on the cost of debt is not a byproduct of analyst coverage by controlling for these effects. Then, we perform the interaction term analysis with coverage data.

[25]We thank an anonymous referee for pointing this out. Indeed, judging by the results in, among others, Roll et al. (2009), it seems that the former is generally the case.

To tackle these issues, we gather data on the number of analysts following a stock from I/B/E/S and include this variable in the regression specification used earlier. Specifically, column 1 in Table 8 includes analyst coverage as an additional control variable, while column 2 interacts this variable with option volume. The coefficient for analyst coverage in column 1 points to a weakly significant effect of this variable on bond yields (p-value<0.1), whereas the effect of options volume remains highly significant. In turn, the interaction of options volume with analyst coverage in column 2 displays a positive and significant coefficient (0.006, p-value<0.01). This result suggests that the potential risk-shifting effect of option markets seems to have a more pronounced impact for firms in which the marginal informational efficiency gain brought by options is lower.

[Insert Table 8 around here]

To further confront the suggested option channels of price informativeness vis-à-vis risk-shifting, we disentangle our analysis into firms with different levels of analyst coverage (low, medium, and high [26]). We display the information from these analysis in columns 3 to 5 in Table 8 for the subsample of firms with low, medium, and high analyst coverage, respectively. Consistent with Roll et al. (2009), who show that option markets have a stronger role in enhancing informational efficiency in stocks with low analyst following, the potential price-informativeness channel of options on firms' cost of debt should have a more relevant impact precisely for these firms. This is, indeed, what the results in column 3 of Table 8 suggest. The coefficient on option volume is negative (-0.083) and statistically significant (p-value<0.1). It seems that when the marginal informational gain that options bring is more relevant, this effect dominates on risk-shifting concerns. The opposite situation occurs for firms with high analyst following, displayed in column 5. Options have a positive (0.232), statistically-strong coefficient (p-value<0.01), pointing at risk-shifting concerns dominate when the informational environment is already rich enough and trading on private information becomes less important.

[26] We do this based on lowest, medium, and highest 33% of the distribution of analyst following data for covered firms on each quarter.

While the results from the cross-sectional and interaction-terms analyses of this section are only suggestive, they yield evidence consistent with the existence of two potential channels of influence of option markets on firms' cost of debt. On one hand, risk-shifting seems to be a prominent channel for the effect of option markets on firm's cost of debt. Debtholders seem to demand higher compensation from their money in the presence of active option markets when managerial and firm-level risk-shifting incentives are higher and the informational environment is already rich. On the other hand, when the marginal informational gain that options can bring is more valuable, that is for low analyst coverage firms, the potential price informativeness role of options seems to emerge. Of course, our results are only suggestive of these two potential channels. Much more research is needed to properly assess the exogenous impact of changes in the informational environment to firm's cost of debt in the presence of active derivative markets.

5 Conclusion

The increasing importance of option markets in the contemporary financial world contrasts with the relatively few papers studying the effects of such growth using real variables. In this paper, we offer a novel investigation into how an active equity option market relates to the firm's cost of debt. We hypothesize that options can have a dual effect on the firms' cost of debt: on the one hand, options enhance the information environment by attracting informed investors, which helps reduce information asymmetries and facilitate financing. On the other hand, attracting informed investors can reassure managerial concerns and encourage risk-taking, which debtholders will take into account when pricing bonds.

We find evidence consistent with the existence of a trade-off between these channels. While the informational effect appears to have a slightly more salient role when the information environment is poor, the risk-shifting channels seems to dominate when managerial private benefits and risk-taking incentives are high. Overall, our results highlight the notion that option listing, while potentially beneficial for stockholders, may convey important side effects for bond investors.

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Tables and Figures

Table 1. Summary Statistics: Time-series Sample

This table presents the summary statistics for the variables used in the time-series analysis. Bond Yield (in percentage points) is the yield to maturity of a bond on a quarterly basis from TRACE. Average Firm Yield (in percentage points) is the average yield to maturity of all bonds outstanding for a given firm on a quarterly basis from TRACE. Option Volume (in million dollars) is the total trade in all options over a stock multiplied by the end-of-day quote midpoint and aggregated quarterly. Size is measured as the book value of assets (in $billions). Tobin's Q is calculated quarterly using Compustat items as (prccq$\times$cshoq + atq -ceqq -txdbq)/atq. Return on assets (ROA)is calculated as net income over total assets. Leverage is the book value of debt over assets. Bid-Ask Spread corresponds to the difference between ask and bid prices over the price midpoint averaged for the quarter. Stock volatility is the standard deviation of daily stock returns during the previous year. The sample spans the 2002-2015 period.

	Mean	StdDev	25%	Median	75%	Observations
Individual Bond Yield	4.561	5.255	2.252	3.802	5.186	34462
Avg. Firm Yield	5.905	6.822	2.938	4.164	6.026	9740
Option Volume ($ millions)	46.302	208.407	0.000	1.027	15.505	9740
Total Assets ($ billions)	18.380	40.861	2.298	5.933	18.071	9740
Tobin's Q	1.612	0.878	1.052	1.338	1.824	9740
ROA	0.006	0.027	0.001	0.009	0.017	9740
Leverage	0.321	0.156	0.216	0.297	0.396	9740
Stock Volatility	0.339	0.230	0.205	0.275	0.395	9740
Bid-Ask spread (%)	0.090	0.131	0.024	0.042	0.088	9740

Table 2. Options trading and the Cost of Debt

This table presents OLS panel regression estimates of bond yield spreads on options trading volume (Option Volume) and a set of control variables. The variables are constructed on a quarterly basis. Bond yield (in percentage points) is the yield to maturity of a bond on a quarterly basis from TRACE. Average Firm Yield (in percentage points) is the average yield to maturity of all bonds outstanding for a given firm on a quarterly basis from TRACE. Option volume (in million dollars) is the total trade in all options over a stock multiplied by the end-of-day quote midpoint and aggregated quarterly. Size is measured as the book value of assets (in $billions). Tobin's Q is calculated quarterly using Compustat items as (prccq×cshoq + atq -ceqq -txdbq)/atq. Return on assets (ROA) is calculated as net income over total assets. Leverage is the book value of debt over assets. Bid-Ask Spread corresponds to the difference between the ask and bid prices over the price midpoint, averaged for the quarter. Stock volatility is the standard deviation of daily stock returns during the previous year. Standard errors are double-clustered by firm and time (in parentheses). The sample period is 2002-2015. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Avg. Firm Yield (%)			Bond Yield (%)	
	(1)	(2)	(3)	(4)	(5)
Ln(Option Volume)	0.060**	0.111***	0.110***	0.095***	0.072***
	(0.025)	(0.025)	(0.023)	(0.021)	(0.020)
Ln(Total Assets)	-0.479***		0.036		-0.377
	(0.054)		(0.477)		(0.404)
Tobin's Q	0.074		0.735***		-0.049
	(0.119)		(0.259)		(0.237)
ROA	-19.138***		-20.262***		-15.465***
	(3.694)		(3.308)		(2.728)
Leverage	-0.699		-1.243		-0.278
	(0.648)		(1.685)		(1.623)
Stock Volatility	7.934***		5.433***		4.503***
	(0.590)		(0.497)		(0.564)
Bid-Ask spread (%)	9.233***		14.216***		11.551***
	(0.876)		(1.387)		(1.557)
Fixed Effects Level	No	Firm	Firm	Bond	Bond
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
No. Firms/Bonds	766	766	766	3,234	3,234
Observations	9740	9740	9740	34462	34462
R^2	0.219	0.648	0.685	0.676	0.706

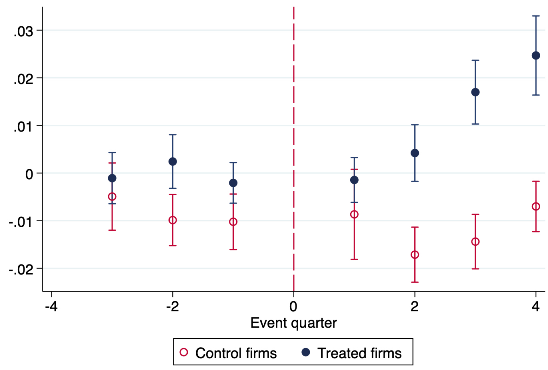
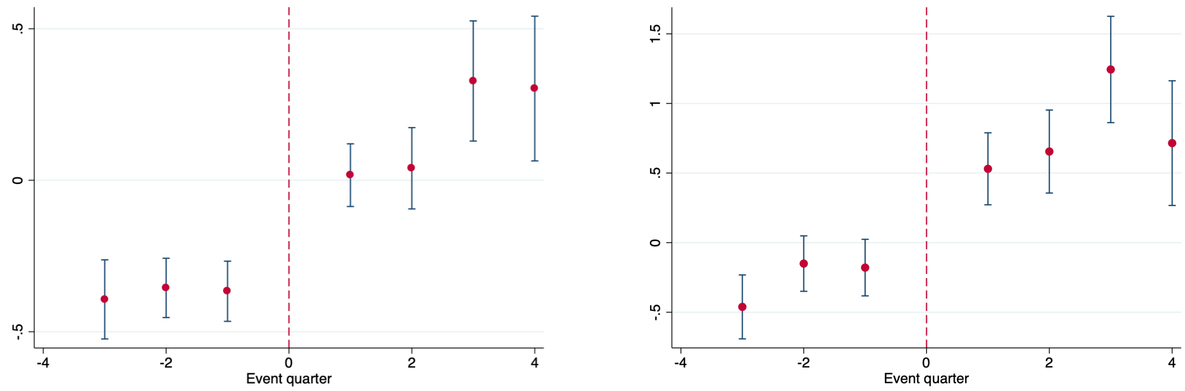


Figure 1. Bond yields around option listing. The figure plots coefficient estimates and confidence intervals of OLS panel regressions of bond yields to maturity on a set of dummy variables indicating the relative quarter around the event of option listing (the omitted category is the listing quarter) for a sample of listed (treated) firms and unlisted (control) matched firms. All regressions include bond and time fixed effects, as well as a set of firm-level control variables. The regression results are shown in Table A3 in the Appendix. Robust standard errors are double-clustered by firm and time.



(a) Bond F.E. (b) Industry-by-time F.E.

Figure 2. Bond yields around the Penny Pilot program. The figure plots coefficient estimates and confidence intervals of OLS panel regressions of bond yields to maturity on a set of dummy variables indicating the relative quarter around the implementation of the Penny Pilot program by CBOE (the omitted category is the implementation quarter). Regressions include time and bond fixed effects in subfigure (a) and industry (SIC-2 code)-by-time fixed effects in (b), as well as a set of firm-level control variables in both. The regression results are shown in Table A3 in the Appendix. Robust standard errors are double-clustered by firm and time.

Table 3. Summary Statistics: Bond issues

This table presents the summary statistics for the variables used in the bond issue analysis. Yield Spread (in basis points) is the yield to maturity of a bond over the yield of a maturity equivalent treasury bond. S&P Rating corresponds to the Standard and Poor's rating for the bond at the time of issue translated to a numerical scale where lower numbers correspond to poorer ratings. Option Volume (in million dollars) is the total trade in all options over a stock multiplied by the end-of-day quote midpoint and aggregated quarterly. Open Interest is the average open interest in the quarter for all options. Moneyness is calculated as the average absolute deviation between stock price and option strike averaged during the quarter. Tobin's Q is calculated quarterly using Compustat items as (prccq×cshoq + atq -ceqq -txdbq)/atq. Return on assets (ROA) is calculated as net income over total assets. Leverage is the book value of debt over assets. Bid-Ask Spread corresponds to the difference between ask and bid prices over the price midpoint averaged for the quarter. Stock volatility is the standard deviation of daily stock returns during the previous year. Callable and Public are dummy variables that take a value of one if the bond is public or includes a callable option, and zero otherwise. Maturity measures the time to maturity of the bond (in years). Principal Amount (in millions of dollars) corresponds to the principal amount issued for a bond. All variables are calculated quarterly unless specified otherwise. Option and firm-level variables are calculated for the quarter prior to bond issuance. These statistics correspond to 4,330 bond issues in the 1996-2014 period.

	Mean	StdDev	25%	Median	75%	Observation
Yield Spread (bps)	216.055	171.836	96.000	157.300	280.800	4330
S&P Rating	11.545	3.322	10.000	12.000	14.000	4330
Option Volume ($ Millions)	165.007	414.388	3.450	22.465	111.857	4330
Open Interest	1000.236	1681.358	117.367	382.986	1164.368	4330
Moneyness	0.283	0.138	0.200	0.256	0.323	4330
Total Assets ($ Billions)	33.482	59.887	5.062	13.586	33.883	4330
Tobin's Q	1.807	0.804	1.231	1.573	2.151	4330
ROA	0.015	0.016	0.006	0.014	0.023	4330
Leverage	0.273	0.156	0.161	0.251	0.355	4330
Bid-Ask Spread	0.003	0.006	0.000	0.001	0.003	4330
Stock volatility	0.353	0.216	0.215	0.295	0.415	4330
Callable Dummy	0.045	0.207	0.000	0.000	0.000	4330
Public Bond Dummy	0.995	0.071	1.000	1.000	1.000	4330
Maturity (in years)	11.354	8.298	5.353	10.014	10.077	4330
Principal Amount ($ Millions)	558.060	457.799	250.000	450.000	700.000	4330

Table 4. Options and Bond at-issue yields

This table presents OLS and ordered logit regression estimates of firm-level measures of the cost of debt (bond yield spread and bond rating) on options trading volume and a set of control variables. A definition of the variables can be found in Table 3. Robust standard errors (in parentheses) are double-clustered by firm and time. All regressions include a full set of two-digit SIC code dummies and time dummies. The sample period is 1996-2014. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Ln(Yield Spread)		S&P Rating		
	OLS	OLS	OLS	OLS	Ord. Logit
	(1)	(2)	(3)	(4)	(5)
Ln(Option Volume)	0.036***	0.031***	-0.193***	-0.188***	-0.229***
	(0.007)	(0.006)	(0.031)	(0.030)	(0.038)
Ln(Total Assets)	-0.288***	-0.316***	1.450***	1.509***	1.826***
	(0.013)	(0.013)	(0.062)	(0.064)	(0.085)
Tobin's Q	-0.291***	-0.280***	1.285***	1.301***	1.725***
	(0.017)	(0.016)	(0.071)	(0.071)	(0.104)
ROA	-5.301***	-5.901***	23.874***	23.569***	27.394***
	(0.707)	(0.681)	(3.283)	(3.268)	(4.143)
Leverage	0.925***	0.836***	-5.793***	-5.794***	-6.519***
	(0.065)	(0.061)	(0.304)	(0.301)	(0.365)
Stock Volatility	0.342***	0.329***	-1.604***	-1.529***	-1.806***
	(0.054)	(0.059)	(0.322)	(0.332)	(0.528)
Ln(Bid-Ask Spread)	0.122***	0.133***	-0.294***	-0.282***	-0.224***
	(0.017)	(0.017)	(0.069)	(0.068)	(0.086)
Public Bond Dummy		-0.259*		0.188	0.526
		(0.142)		(0.641)	(0.553)
Ln(Maturity)		0.236***		0.201***	0.178***
		(0.012)		(0.037)	(0.043)
Principal Amount ($bil)		219.221***		-371.957***	-337.532***
		(18.517)		(94.139)	(119.528)
Callable Dummy		0.301***			
		(0.030)			
Observations	4330	4330	4330	4330	4330
R^2	0.739	0.788	0.774	0.777	

Table 5. Option's Moneyness as an Instrumental Variable

This table presents two-stage least squares regression estimates of firm-level measures of the cost of debt (bond yield and at-issue bond rating) on options trading volume and a set of control variables with average quarterly moneyness as the instrumental variable. Moneyness is the absolute deviation from stock price to strike price averaged quarterly for all options traded on a stock. Columns 1 to 3 contain the estimates for the first and second stages of the 2SLS procedure for the sample of bond issues. Columns 4 and 5 replicate the same results for the time-series sample of bonds and bond-level yields. Columns 6 and 7 do the same for average firm-level yields. Detailed definitions of all variables are provided in Section 2. The sample period is 1996-2014 (2002-2015) for the bond issues (time-series) sample. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Bond Issues			Bond-level data		Firm-level data	
	1st stage	2nd stage		1st stage	2nd stage	1st stage	2nd stage
	Ln(Opt.Vol.)	Ln(Yield Spread)	S&P Rating	Ln(Opt.Vol.)	Bond Yield	Ln(Opt.Vol.)	Avg. Yield
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln(Moneyness)	1.116***			0.494***		0.338***	
	(0.100)			(0.091)		(0.065)	
Ln(Option Volume)		0.300***	-1.443***		0.640***		2.004***
(instrumented)		(0.034)	(0.151)		(0.232)		(0.740)
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects Level	SIC-2	SIC-2	SIC-2	Bond	Bond	Firm	Firm
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
No. Bonds	4,328	4,328	4,328	3,077	3,077		
Observations	4328	4328	4328	25078	25078	6999	6999
R^2	0.785			0.922		0.916	

Table 6. Managerial Compensation

This table presents OLS regression estimates of option volume on the firm's cost of debt including additional variables related to managerial compensation structure. Values for the Delta and Vega measures of CEO compensation are calculated as in Core and Guay (2002) and Coles et al. (2006). All regressions include firm-level control variables and fixed-effects. Robust standard errors are double-clustered by firm and time (in parentheses). The sample period is 2002-2015. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Avg. Yield (%)					
					Low Delta	High Delta
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Option Volume)	0.035	0.028	0.034	0.012	0.053	0.146***
	(0.032)	(0.032)	(0.032)	(0.036)	(0.043)	(0.052)
CEO Delta	2.445*	-1.871	0.944	1.248		
	(1.368)	(1.259)	(1.436)	(1.447)		
Ln(Option Volume) × CEO Delta		0.297**				
		(0.121)				
CEO Vega			4.711**	-2.653		
			(1.893)	(3.443)		
Ln(Option Volume) × CEO Vega				0.436*		
				(0.239)		
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects Level	Firm	Firm	Firm	Firm	Firm	Firm
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	5410	5410	5410	5410	2706	2704
R^2	0.697	0.697	0.697	0.698	0.645	0.811

Table 7. Options and risk shifting

This table presents OLS regression estimates for the interaction between option volume and several proxies for risk-shifting incentives. All regressions include firm-level control variables and fixed effects. Robust standard errors are double-clustered by firm and time (in parentheses). The sample period is 2002-2015. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Avg. Yield (%)						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Ln(Option Volume)	0.079***	0.104***	0.084***	0.108***	0.102***	0.124***	0.127***
	(0.027)	(0.021)	(0.022)	(0.023)	(0.023)	(0.021)	(0.021)
Ln(Opt. Vol.) × Tobin's Q	0.016**						
	(0.008)						
CapEx		-1.221**	-3.140***				
		(0.614)	(0.842)				
Ln(Opt. Vol.) × CapEx			0.066***				
			(0.014)				
R&D expenses				-5.348**	-4.662*		
				(2.509)	(2.487)		
Ln(Opt. Vol.) × R&D Exp.					0.069***		
					(0.026)		
Conv. Debt ratio						-7.414***	-6.127***
						(1.414)	(1.580)
Ln(Opt. Vol.) × Conv. Debt							-0.096*
							(0.054)
Control Variables	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects Level	Firm	Firm	Firm	Firm	Firm	Firm	Firm
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	9740	9587	9587	9740	9740	9453	9453
R^2	0.685	0.680	0.681	0.685	0.685	0.684	0.684

Table 8. Information environment

This table presents OLS regression estimates for the interaction of option volume and analyst coverage data from I/B/E/S as proxy of the firm's information environment. All regressions include a set of firm-level controls and fixed effects. Robust standard errors are double-clustered by firm and time (in parentheses). The sample period is 2002-2015. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Avg. Yield (%)				
			Analyst Coverage Level		
			Low	Med	High
	(1)	(2)	(3)	(4)	(5)
Ln(Option Volume)	0.094***	0.047*	-0.083*	0.022	0.232***
	(0.024)	(0.027)	(0.046)	(0.048)	(0.081)
Analyst Coverage	0.022*	-0.065***			
	(0.012)	(0.021)			
Ln(Option Volume) × Coverage		0.006***			
		(0.001)			
Control Variables	Yes	Yes	Yes	Yes	Yes
Fixed Effects Level	Firm	Firm	Firm	Firm	Firm
Time Fixed Effect	Yes	Yes	Yes	Yes	Yes
Observations	9740	9740	2430	2391	2373
R^2	0.685	0.685	0.725	0.762	0.700

Options Trading and the Cost of Debt

Online Appendix

This appendix provides additional material regarding the results in *'Options trading and the cost of debt'*. Specifically, we discuss various issues regarding firms' first option listing event, inclusion in the CBOE Penny Pilot program, and the robustness of the effect in various other dimensions.

A.1. Quasi-natural experiments

First, we discuss issues related to the use and implementation of quasi-natural experiments to isolate how plausibly exogenous shocks to options trading volume affect firms' cost of debt.

A.1.1. Option listing event and matching procedure

We perform the option listing event study on a sample of listed (treated) firms as well as a group of unlisted (control) firms matched on ex ante probabilities of listing, time of listing, and firm characteristics. To proxy for the probability of a firm being listed in the option market, we rely on previous work by Mayhew and Mihov (2004), who identify the main drivers of listing by options exchanges. Specifically, we replicate the following logit model:

$$L(LISTING) = \beta_0 + \beta_1 VOLUME + \beta_2 STD + \beta_3 ABVOL + \beta_4 ABSTD + \beta_5 SIZE + \epsilon \quad (3)$$

where L(LISTING) denotes the probability of a firm being selected for listing in the option market, VOLUME is the average daily stock trading volume over the previous 250 trading days, STD is the annualized standard deviation of log returns over the same period, ABVOL is the ratio of the average 30-day to 250-day daily stock trading volume, ABSTD is the ratio of 30-day to 250-day standard deviation of log returns, and SIZE is measured as the market capitalization of the firm.

We provide the results for the estimates of this model in Table A1, along with the results from Mayhew and Mihov (2004). While the latter run the model with monthly frequency, we do it on a quarterly basis, given the nature of our dataset and the quarterly bond yields we are interested in. As shown in Table A1, the model yields fair estimates of the probability of option listing, with almost 82% correctly classified observations, similar to estimates from previous work (Mayhew and Mihov, 2004; Hu, 2017). We then use these estimates to roll the model over the data and calculate the predicted probability of a firm being listed in the option market in a given quarter.

Next, we proceed to match our sample of firms experiencing an option listing event while having outstanding bonds to a sample of unlisted firms with an ex ante similar probability of option listing, time of listing, and firm characteristics such size, leverage, volatility or liquidity. We use nearest neighbor matching with replacement, given the scarce availability of data for unlisted firms with similar characteristics. Nonetheless, we are able to match the 832 observations of listed firms to 560 observations of unlisted firms. We provide the summary statistics of both samples in Table A2. Because we require several matched variables in a relatively small sample, some discrepancies between listed and control samples arise. Specifically, there are differences in firm size as measured by total assets, as well as in Tobin's Q. Control firms have larger mean values in these two dimensions before the listing event. Additionally, control firms are more illiquid (have a wider bid-ask spread) than listed firms in the prelisting period. Although these differences are statistically significant in terms of sample differences in means (*t-test*), the difference in absolute terms is quite small (e.g., 0.1 points for Tobin's Q and 0.001 for Bid-Ask spread). These differences are unlikely to drive our results, as we control for these firm characteristics in the event study regression analysis. Even in the delicate case of stock liquidity, the observed sample differences in means prelisting will, in any case, bias the results against finding a significant difference across samples, as more illiquid firms pay more for their debt. Similarly, the positive significant difference post-listing in average leverage or stock liquidity should, at most, introduce a downward bias in the effect.

More importantly, both samples exhibit no ex ante differences in terms of firm leverage or stock return volatility, which is likely to be the variable that generates more concerns due to its association with options trading. Overall, the matching procedure seems to produce a subsample of unlisted firms closely similar to the listed ones in terms of variables relevant for the analysis, mitigating concerns that the effect of options on bond yields is due to alternative factors such volatility or firm leverage.

In Table A3, we show the results from the OLS regression on option listing event quarter dummies, firm controls, and bond and time fixed effects. Column 1 contains the results from the specification using the sample of bonds from TRACE that experienced an option listing event during the life of the bond, while column 2 contains the estimates for our control sample. As evidenced by the positive and statistically significant coefficients for quarters $t + 3$ and $t + 4$ in column 1, average bond yields rise after a firm is listed in the option market. In turn, this positive effect does not exist in our control sample in column 2.

A.1.2. Minimum price requirement and Penny Pilot program

We extend the option listing experiment in column 3 of Table A3 by incorporating the effect of listing in a sample of treated firms with prices just above (less than $2 above) the minimum required stock price for listing.[a] As argued by Hu (2017), the minimum listing price requirement creates a discontinuity in the probability of option listing: the listing effect in firms that marginally meet the price criteria versus those comparable firms that do not is more likely the result of an exogenous decision. Unfortunately, these results are based on a significantly reduced sample. Nonetheless, the post-listing behavior of bond yields is consistent with the results from the first option listing experiment. We depict time estimates and confidence intervals for this subsample of firms in Figure A1.

Finally, we incorporate in columns 4 and 5 of Table A3 the regression results from the inclusion of a firm in the Penny Pilot program by CBOE, which produced a significant exogenous increase in the liquidity of the option market. We discuss the results from this experiment in the core of the paper.

[a]The minimum required price for option listing until the end of 2002 was $7.5 and $3 from January 2003 onwards.

A.2. Additional robustness checks

Next, we focus on several other items that are worth discussing given their direct relationship with our main results.

A.2.1. Two-way sorting by leverage and volatilty

In this section, we extend the analysis to investigate the effect across levels of firm leverage and volatility. As one important concern is that we are capturing effects purely derived from the potential positive association between options trading volume and firm leverage and volatility, we start by exploring this relationship. First, we look at the simple correlation between option volume and firm leverage throughout the whole time-series sample. This analysis yields a negative correlation of -0.2016, indicating that option volume is not mechanically related to firm leverage. The relationship between options trading volume and firm stock return volatility is also small, although positive (0.0003).

Second, we sort companies on July 1st each year by quartiles of leverage and stock return volatility. Theoretically, a firm's operating and financial risks are the key drivers of its bankruptcy risk. A firm with high volatility in its operating business and with high leverage has a higher likelihood of bankruptcy. To investigate whether options traders focus more prominently on firms with high risks (and, hence, higher cost of debt), we compute the average quarterly dollar trading volume in option markets for firms across quartiles of leverage and volatility. Table A5 contains these results. Overall, option volume seems to be concentrated on low-leverage firms, almost independently of the volatility quartile. Moreover, the average option volume in firms with the highest level of volatility and leverage (riskiest) is substantially lower than that of firms in the lowest leverage and volatility quartiles ($46.40 vs. $250.43 million). In sum, this evidence is not consistent with investors biasing their trades in the option market towards riskier firms.

We make use of these quartile classifications to run an additional test. Specifically, we run the regression model in Equation 1 at the core of the paper for firms in four different combinations of our volatility-leverage quartiles. Table A6 contains the regression results for the subsample of firms classified into high leverage and volatility (column 1), low leverage and volatility (column 2), high leverage and low volatility (column 3), and low leverage and high volatility (column 4). Consistent with risk shifting being a significant concern for near-bankruptcy firms (Eisdorfer, 2008), we find that the effect of options on risk shifting is more pronounced among firms that classify into both the high leverage and high volatility quartiles (coefficient of 0.348, p-value<0.05). However, we also find a highly significant effect for firms with low leverage and volatility (coefficient of 0.179, p-value<0.05), which corroborates that the effect of option markets on the cost of debt is not purely driven by firm leverage or volatility. Moreover, in the case of firms with high leverage and low volatility, the effect is reduced from the previous two (coefficient of 0.003) and not statistically significant, whereas the coefficient for option volume is also not significant in the case of low leverage and high volatility firms (coefficient of -0.032).

A.2.2. Institutional Ownership

Next, we account for the effect of institutional ownership in Table A7. Specifically, in Table A7, we analyze the effect of institutional ownership variables in the regression specification from Equation 1. We include control variables in the regression that account for the percentage of institutional ownership in the firm (column 1), the Herfindahl-Hirschman (HHI) concentration index (column 2), the amount of blockholder ownership in those institutions with more than a 5% stake (column 3), and the number of blockholders (column 4). In general, these control variables are highly statistically significant (p-value<0.01) but produce no major alterations in the options coefficient (stable at approximately 0.070) or in the R-square of the model (0.706).

A.2.3. Expanding option volume horizons

Thus far, we have maintained a fixed frequency (quarterly) for the computation of options dollar volume. However, it could be the case that just focusing on one quarter of volume may not be representative of the longer-term average trading volume in options of a firm. For this reason, we expand the calculation of the options dollar volume variable and repeat the baseline analysis of Table 2. The results are displayed in Table A8. Columns 1 and 2 consider the previous 1-year trailing option volume value for the analysis with and without introducing firm-level control variables, respectively. Columns 3 and 4 repeat the analysis by considering the 4-quarter average volume. Finally, columns 5 and 6 perform an annual analysis by considering the total annual option dollar volume and end-of-year bond yields. Overall, the results from this exercise remain qualitatively intact from previous ones.

Table A1. Probability of option market listing

This table presents logit estimates on the probability of a firm being listed in the option market following the model in Mayhew and Mihov (2004). Volume and Std. Dev. are the average daily trading volume and standard deviation of daily returns on the underlying stock over the prior 250 trading days. Ab. Volume and Ab. Std. Dev. are ratios of 30-day to 250-day prior trading volume and standard deviation. Market Cap is the market capitalization of the firm. Estimates for this paper are based on quarterly data, whereas those from Mayhew and Mihov (2004) have monthly frequency. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Prob. of option market listing			
	This paper	*Mayhew and Mihov (2004)*		
	2002-2014	1985-1991	1991-1996	1973-1996
	(1)	(2)	(3)	(4)
Volume	0.643***	-0.010	0.119***	0.074***
	(0.000)	(0.580)	(0.000)	(0.000)
Std. Dev.	0.632***	0.265***	0.261***	0.267***
	(0.000)	(0.000)	(0.000)	(0.000)
Ab. Volume	0.528***	0.153***	0.251***	0.200***
	(0.000)	(0.000)	(0.000)	(0.000)
Ab. Std. Dev.	0.456***	0.079***	-0.008	0.012
	(0.001)	(0.001)	(0.567)	(0.249)
Market Cap	-0.001	0.217***	-0.042*	0.070***
	(0.439)	(0.000)	(0.057)	(0.000)
Observations	41,449	49,556	69,876	155,567
Percent Classified Correctly	81.18%	71.5%	75,1%	72,8%

Table A2. Summary statistics option listing event

This table presents the summary statistics for the sample of firms that experienced the first option listing event while having outstanding bonds in the market, and a sample of unlisted firms (control) matched on the ex ante predicted probability of listing, the time of listing, and a set of firm characteristics. Both samples span the period 2002-2014.***, ** and * for the t-test (control - treated) denote significance at the 1%, 5% and 10% levels, respectively.

	Sample of listed firms			Sample of control firms			*Differences* (t-test)	
	Before	After	N	Before	After	N	Before	After
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Predicted Prob. of Listing	1.673	1.636	832	1.705	1.585	560	0.598	-1.045
Total Assets ($ Billions)	5.667	6.930	832	8.091	4.467	560	1.523*	-1.027
Tobin's Q	1.457	1.513	832	1.556	1.455	560	2.453***	-1.163
ROA	0.005	0.009	832	0.007	0.006	560	1.186	-1.369
Leverage	0.396	0.362	832	0.389	0.407	560	-0.392	2.376***
Bid-Ask Spread	0.003	0.002	832	0.004	0.006	560	2.734***	8.390***
Stock Volatility	0.491	0.490	832	0.507	0.511	560	0.656	0.819

Table A3. Quasi-natural experiments

This table presents OLS panel regression estimates for bond yield on a set of dummy variables indicating the relative quarter around the event of option listing and/or the implementation of the Penny Pilot program (the omitted category is the event quarter), a number of firm-level controls, and quarter and bond fixed effects. The variables are constructed on a quarterly basis. Bond yield (in percentage points) is the yield to maturity of a bond on a quarterly basis from TRACE. Column 1 employs a sample of bonds in TRACE that experience an option listing event during the life of the bond and have a sufficient number of observations before and after the option listing event. Column 2 runs the same model on a sample of unlisted firms matched on ex ante predicted probability of option listing, time of listing, and firm characteristics. Column 3 repeats the experiment in column 1 with only those firms that marginally meet the minimum price required by the SEC for option listing. Column 4 exploits the same model on the quasi-natural experiment of the Penny Pilot program by CBOE. Standard errors are double-clustered by firm and time (in parentheses). The sample period is 2002-2015. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Bond Yield (%)				
	Option Listing			Penny Pilot Program	
	Listed	Control	Min. Price		
	(1)	(2)	(3)	(4)	(5)
$t-3$	-0.001	0.002	0.011	-0.393***	-0.461**
	(0.005)	(0.003)	(0.026)	(0.131)	(0.230)
$t-2$	0.002	-0.001	0.069***	-0.355***	-0.150
	(0.006)	(0.003)	(0.000)	(0.098)	(0.199)
$t-1$	-0.002	-0.006	-0.0035	-0.366***	-0.179
	(0.004)	(0.004)	(0.045)	(0.099)	(0.203)
$t+1$	-0.001	-0.013**	0.041**	0.017	0.531**
	(0.005)	(0.006)	(0.017)	(0.103)	(0.259)
$t+2$	0.004	-0.018***	-0.002	0.040	0.655**
	(0.006)	(0.006)	(0.026)	(0.134)	(0.298)
$t+3$	0.017**	-0.020***	0.109***	0.328*	1.244***
	(0.007)	(0.007)	(0.000)	(0.198)	(0.382)
$t+4$	0.025***	-0.016**	0.244***	0.303	0.715
	(0.008)	(0.008)	(0.000)	(0.239)	(0.448)
Controls	Yes	Yes	Yes	Yes	Yes
Bond F.E.	Yes	Yes	Yes	Yes	No
Time F.E.	Yes	Yes	Yes	Yes	Yes
Industry×Time F.E.	No	No	No	No	Yes
Observations	832	560	40	4352	4352
R^2	0.619	0.750	0.913	0.829	0.616

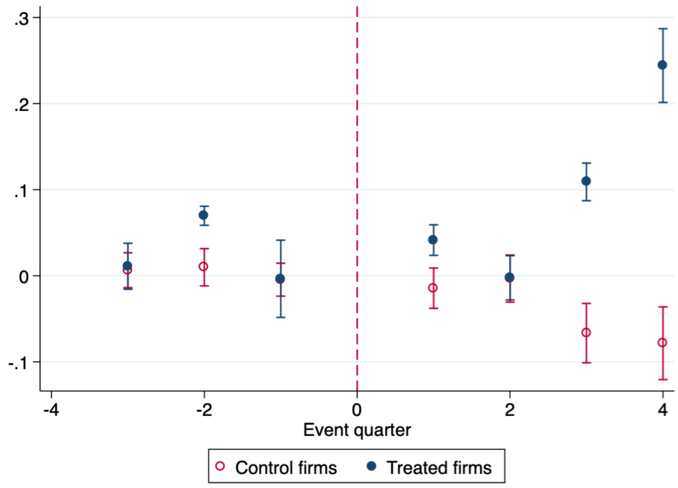


Figure A1. Bond yields around option listing in firms just above minimum requirement price. The figure plots coefficient estimates and confidence intervals of OLS panel regressions of bond yields to maturity on a set of dummy variables indicating the relative quarter around the event of option listing (the omitted category is the listing quarter) for a sample of listed (treated) firms and unlisted (control) matched firms. Firms in the sample are restricted to those with a stock price at the time of listing of less than \$2 above the minimum price requirement for option listing (\$3). All regressions include bond and time fixed effects, as well as a set of firm-level control variables. Robust standard errors are double-clustered by firm and time.

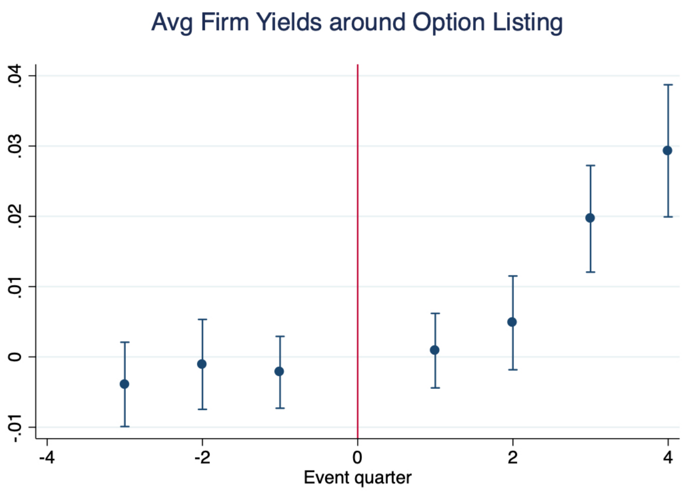


Figure A2. Firm-level yields around option listing. The figure plots coefficient estimates and confidence intervals of OLS panel regressions of average bond yields to maturity on a set of dummy variables indicating the relative quarter around the event of option listing (the omitted category is the listing quarter) for a sample of listed firms. All regressions include firm and time fixed effects, as well as a set of firm-level control variables. Robust standard errors are double-clustered by firm and time.

Table A4. Bond Issues per Year

This table presents the number of bond issues and issuer firms in the sample per year.

Year	Number of Issues	Number of Firms
1996	77	53
1997	144	85
1998	188	111
1999	101	71
2000	118	76
2001	170	102
2002	131	65
2003	101	66
2004	31	26
2005	87	56
2006	159	101
2007	229	117
2008	253	125
2009	349	213
2010	400	253
2011	384	212
2012	470	257
2013	441	224
2014	497	259
Total	4330	808

Table A5. Option volume by leverage and volatility quartiles

This table presents average quarterly dollar option volume traded by quartiles of firm leverage and volatility. On July 1st each year firms are classified into four quartiles of leverage and volatility.

		Leverage Quartiles			
		Low	**Q2**	**Q3**	**High**
Volatility Quartiles	**Low**	250.43	182.67	39.73	73.54
	Q2	209.88	61.84	27.70	27.18
	Q3	163.45	82.77	36.78	26.64
	High	253.63	145.91	25.79	46.40

Table A6. Two-way sorting by leverage and volatility

This table presents OLS regression estimates for bond yield as a dependent variable across different combinations of firm leverage and volatility. On July 1st each year, firms are classified into leverage and volatility quartiles. The sample of *High Lev. & High Vol.* firms (column 1) include those firms classified into the top quartile for leverage and volatility. *Low Lev. & Low Vol.* (column 2) includes firms in the bottom quartiles by leverage and volatility. *High Lev & Low Vol.* in column 3 includes the firms classified into the fourth leverage quartile and first volatility quartile. Similarly, *Low Lev & High Vol.* in column 4 includes firms in the first leverage quartile and fourth volatility quartile. Robust standard errors are double-clustered by firm and time (in parentheses). All regressions include bond and time fixed effects. The sample period is 2002-2014. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Bond Yield (%)			
	High Lev. & High Vol.	Low Lev. & Low Vol.	High Lev. & Low Vol.	Low Lev. & High Vol.
	(1)	(2)	(3)	(4)
Ln(Option Volume)	0.348**	0.179**	0.003	-0.032
	(0.147)	(0.072)	(0.028)	(0.055)
Controls	Yes	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Observations	1766	2380	1940	896
R^2	0.725	0.949	0.792	0.841

Table A7. Institutional ownership

This table presents OLS regression estimates of option volume on the firm's cost of debt, extending the model in Table 4 with additional variables related to institutional ownership and the principal amounts of the bonds. Panel A presents results for the sample of bond issues, while Panel B presents results for time-series bond yields. All regressions include firm and bond-level control variables. Robust standard errors are double-clustered by firm and time (in parentheses). The sample period is 1996-2014 for Panel A, and 2002-2014 for Panel B. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Bond Yield (%)			
	(1)	(2)	(3)	(4)
Ln(Option Volume)	0.071***	0.072***	0.066***	0.066***
	(0.019)	(0.020)	(0.020)	(0.020)
Inst. Ownership	0.722***			
	(0.241)			
Inst. Own. HHI		-1.608		
		(2.101)		
Block. Ownership			-1.501***	
			(0.423)	
# Blockholders				-0.119***
				(0.035)
Controls	Yes	Yes	Yes	Yes
Bond Fixed Effects	Yes	Yes	Yes	Yes
Time Fixed Effects	Yes	Yes	Yes	Yes
Observations	34462	34462	34462	34462
R^2	0.706	0.706	0.706	0.706

Table A8. Option volume horizons

This table presents OLS panel regression estimates of bond yields on options trading volume (Option Volume) and a set of control variables for different horizon measures of option volume. Bond Yield (in percentage points) is the yield to maturity of a bond from TRACE. Option Volume (in million dollars) is the total trade in all options over a stock multiplied by the end-of-day quote midpoint and aggregated quarterly. Size is measured as the book value of assets (in $billions). Tobin's Q is calculated quarterly using Compustat items as (prccq×cshoq + atq -ceqq -txdbq)/atq. Return on Assets (ROA) is calculated as net income over total assets. Leverage is the book value of debt over assets. Bid-Ask Spread corresponds to the difference between ask and bid prices over the price midpoint, averaged for the quarter. Stock Volatility is the standard deviation of daily stock returns during the previous year. Standard Errors are double-clustered by firm and time (in parentheses). The sample period is 2002-2014. ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively.

	Bond yield (%)					
	Trailing 1-yr Opt.Vol		4-quarter Avg. Opt.Vol.		Annual Analysis	
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(Option Volume)	0.233***	0.206***	0.222***	0.192***	0.183***	0.137**
	(0.052)	(0.047)	(0.050)	(0.046)	(0.055)	(0.056)
Ln(Total Assets)		-1.893***		-1.876***		-1.350
		(0.599)		(0.599)		(0.829)
Tobin's Q		-0.089		-0.085		-0.010
		(0.352)		(0.351)		(0.417)
ROA		-15.508***		-15.521***		-21.357***
		(3.456)		(3.456)		(5.261)
Leverage		0.515		0.502		-2.362
		(2.206)		(2.205)		(2.890)
Stock volatility		5.726***		5.737***		4.761***
		(0.693)		(0.693)		(1.068)
Bid-Ask spread (%)		12.324***		12.314***		19.330***
		(2.012)		(2.012)		(3.864)
Observations	22938	22938	22938	22938	10170	10170
R^2	0.748	0.781	0.748	0.781	0.711	0.761