Three essays on corporate finance

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Summary

This dissertation contains three essays on corporate finance. In Essay One, we provide empirical evidence on the adverse effects of supplier firms' environmental risk exposures on their relationships with principal customers. We document that supplier firms with high environmental risk are less likely to have principal customers. Moreover, from the principal customers' perspective, a higher level of environmental risk lowers a supplier firm's probability of being selected relative to its industry peers by its potential customer. Conditional on an ongoing relationship with principal customers, supplier firms with high environmental risk have lower sales to principal customers and shorter relationship durations. These results are more pronounced when customers' environmental risk is lower. Collectively, our findings suggest that improving the trading relationship with principal customers is an important channel through which firms can benefit economically from being environmentally responsible.

Essay Two investigates the capital structure implications of corporate environmental liabilities, which are captured using the amount of firms' toxic production-related waste. We document that firms with higher environmental liabilities maintain lower financial leverage ratios, suggesting that environmental liabilities work as a substitute for financial liabilities. The substitution effect is more pronounced for larger firms, firms covered by more analysts, firms that have higher sales to principal customers, and firms with greater community concerns. Further analysis shows that less environmentally responsible firms have a lower fraction of bank debt in total debt, all else equal, consistent with the notion that banks are more environmentally sensitive than

other lenders. Overall, our findings imply that being environmentally responsible can enhance firms' debt capacity and improve the availability of bank credit.

Essay Three provides evidence that options trading affects firms' financing decisions. We find that firms with exchange-listed options are more likely to issue equity as opposed to debt. They issue equity more frequently but in smaller amounts and maintain low leverage ratios. The effect of options trading on financing decisions is more pronounced for firms with larger options trading volume, higher information asymmetry, and greater short-sale constraints. Further analysis shows that optioned firms attract more short-term institutional investors, have greater analyst coverage, and experience higher abnormal returns at seasoned equity offerings announcements. These findings are consistent with the notion that options trading reduces firms' information asymmetry, which makes equity financing more favourable.

Essay One:
**Corporate Environmental Risk and the Customer-Supplier
Relationship**

Abstract

We provide empirical evidence on the adverse effects of supplier firms' environmental risk exposures on their relationships with principal customers. We document that supplier firms with high environmental risk are less likely to have principal customers. Moreover, from the principal customers' perspective, a higher level of environmental risk lowers a supplier firm's probability of being selected relative to its industry peers by its potential customer. Conditional on an ongoing relationship with principal customers, supplier firms with high environmental risk have lower sales to principal customers and shorter relationship durations. These results are more pronounced when customers' environmental risk is lower. Collectively, our findings suggest that improving the trading relationship with principal customers is an important channel through which firms can benefit economically from being environmentally responsible.

IBM is committed to doing business with environmentally responsible suppliers.

IBM and the Environment Report (2012)

I. Introduction

Environmental risk can generally be defined as the actual or potential threat of adverse effects on living organisms and the environment by, e.g., effluents, emissions, waste, or resource depletion that arise from an organization's activities.¹ As urbanization and industrialization have increased, companies' levels of exposure to environmental risk have received concurrently increasing amounts of public and political attention. Recent studies have documented that corporate environmental performance and environmental risk exposure affect firm valuation and various corporate policies.² However, there is scant empirical evidence on whether and how corporate environmental risk exposure influences product market relationships, especially supplier firms' relationships with their principal customers. Our study takes an initial step toward closing this gap.

The customer-supplier relationship is a key aspect of a firm's operations, and extends beyond purely providing a product or service (Chen et al., 2014). For supplier firms, principal customers are among their most important stakeholders, enhancing long-term operating performance and shareholder value (e.g., Fee and Thomas, 2004; Johnson, Kang, and Yi, 2010; Patatoukas, 2012). As such, supplier firms desire to maintain strong and long-term relationships with their major customers. For customer firms, choosing suppliers is an important operating decision because the quality of the supply

¹ This definition comes from Enterprise Risk Management (ERM) Strategies: <http://www.erm-strategies.com/enterprise-risk-management/environmental-risk/>.

² See, among others, Hughes (2000), Clarkson, Li, and Richardson (2004), Sharfman and Fernando (2008), and Chava (2014). A more detailed literature review is presented in section II.

chain can greatly impact their success in the product market. In this paper, we focus on supplier firms' environmental risk exposure, and expect it to have an *adverse* effect on the existence and strength of the relationship with principal customers for three primary reasons.³

First, incomplete contract theory suggests that supplier-customer relationships are governed by both explicit and implicit contracts.⁴ Compared with explicit contracts, implicit contracts are more informal, more relational, and more likely to be breached with no legal remedy. Thus, the value of implicit contracts relies heavily on both parties' trustworthiness, financial stability, and incentive and ability to honor the commitment to the relationship. Prior implicit contracting studies (e.g., Maksimovic and Titman, 1991; Hertz, Officer, and Rodgers, 2008; Cen et al., 2014) have shown that customers are reluctant to conduct business with high business risk suppliers because the higher levels of risk exposure reduce suppliers' willingness to honor implicit contracts, make relationship-specific investments, and produce high-quality products. Corporate environmental risk is a key source of business risk. It contributes significantly to firms' future operational risk and poor financial performance (Clarkson et al., 2011; Flammer, 2013). As environmental regulations have become increasingly stringent, supplier firms with higher

³ Anecdotal evidence suggests that firms have become increasingly aware of their suppliers' environmental practices and have begun explicitly outlining environmental requirements. For example, Procter & Gamble (P&G) has issued an environmental sustainability scorecard to track and rate the environmental performances of its key suppliers since 2010. This scorecard is further incorporated into P&G's annual supplier performance measurement process, and thus impacts suppliers' opportunities for future business with P&G. *The Economist* (May 19th, 2012) reports that environmental responsibility is now at the heart of product design and corporations' supply chain management.

⁴ See, e.g., Williamson (1979), Grossman and Hart (1986), Cornell and Shapiro (1987), and Hill and Jones (1992). For supplier-customer relationships, explicit contracts, such as supplier contracts and product warranties, are enforceable by law. Implicit contracts, such as continued service to customers and product quality, involve obligations or deliverables that cannot be specified precisely or objectively in advance.

environmental risk exposure are inevitably subject to more uncertainty from, e.g., market demand due to damaged reputation, operating costs associated with waste management and future compliance, future litigation and enforcement activities, and the cost of external financing (e.g., Chava, 2014). All of these issues could weaken suppliers' abilities to fulfill contracts or other relationship commitments.⁵ In other words, customers may find it difficult to trust and make long-term relationship-specific investments with a supplier if it is irresponsible environmentally.⁶

Second, in many developed countries, including the U.S., the environmental regulations and standards often stem from the best available technology (BAT).⁷ As a result, supplier firms with superior environmental performance (low environmental risk exposure) effectively set environmental standards, and drive the evolution of future regulations for the entire industry (Clarkson, Li, and Richardson, 2004). They are motivated to innovate or increase environmental capital expenditures in order to convince regulators that more stringent environmental standards are economically achievable. By doing so,

⁵ A recent example illustrates how high environmental risk exposure can lead to significantly negative earnings shocks. In August 2012, the U.S. Environmental Protection Agency and the U.S. Department of Justice fined Sinclair Oil Corporation \$3.8 million for violations of air pollution limits at refineries in Wyoming. The company was also ordered to pay approximately \$10.5 million for additional pollution control equipment to reduce emissions of nitrogen oxides by 24 tons per year, sulfur dioxide by 385 tons per year, and particulate matter by 59 tons per year (Li, Simunic, and Ye, 2014). Penalties for non-compliance ranged from the temporary shutdown of operations to bankruptcy. Since 2002, eighty-five firms have filed for bankruptcy due to asbestos liabilities. Recent examples include Solutia Inc. and Tronox Inc., which filed for bankruptcy in 2003 and 2009, respectively, due to significant environmental risk exposure.

⁶ On the other hand, note that a supplier's investment in reducing environmental risk exposure can be viewed as long-term "sunk" production capital, signaling the supplier's positive attitude toward honoring implicit contracts. This is similar to the role of long-term non-salvageable capital elements suggested by Klein and Leffler (1981). Bénabou and Tirole (2010) argue that firms' superior socially responsible behavior encourages stakeholder engagement (for example, principal customers), thereby reducing overall contracting costs.

⁷ BAT is defined in section 5 of the Environmental Protection Agency Acts, 1992 and 2003, as the "most effective and advanced stage in the development of an activity and its methods of operation, which indicate the practical suitability of particular techniques for providing, in principle, the basis for emission limit values designed to prevent or eliminate or, where that is not practicable, generally to reduce an emission and its impact on the environment as a whole."

they can enjoy the early-mover advantage and enhance their competitiveness either from discouraging rival firms from entering the space, or by effectively diminishing their competitiveness in that market (Salop, 1979). Dechant and Altman (1994) suggest that good environmental performance has become an important competitive advantage for firms to maintain leadership positions in an industry. Moreover, good environmental performance also allows supplier firms to tap into markets where customers value low-pollution and energy-efficient products (Porter and van der Linde, 1995). Arora and Gangopadhyay (1995) and Hillman and Keim (2001) show that firms with superior environmental performance can attract and retain environmentally conscious consumers willing to pay a premium for the products for the sake of “green goodwill.” In contrast, suppliers with poor environmental performance may be forced to increase spending on environmental capital expenditures to comply with more stringent standards. They thus face higher costs and the loss of customers to “greener” industry rivals (Salop and Scheffman, 1987). To summarize, the environmental regulatory setting puts suppliers with poor environmental performance at a significant disadvantage when competing with industry rivals for major customers.

Finally, there is an extensive branch of the marketing literature that shows a positive correlation between corporate social responsibility (CSR hereafter) and customer loyalty.⁸ This literature generally maintains that corporate social and environmental responsibility plays a role similar to that of advertising in terms

⁸ For example, Bhattacharya and Sen (2004) suggest that CSR leads to customer-company identification. Berens, van Riel, and van Bruggen (2005) show that CSR influences customers' attitudes toward products. Luo and Bhattacharya (2006, 2009) establish a link between CSR and customer satisfaction, and point out that higher customer satisfaction creates firm value. Homburg, Stierl, and Bornemann (2013) show that business practice CSR fosters customers' trust, while philanthropic CSR strengthens customer-company identification, which in turn enhances customer loyalty.

of enhancing a firm's brand name awareness and product recognition. Thus, CSR activities can increase demand for products and services, increase customer loyalty, and lower consumers' price elasticity (e.g., Sen and Bhattacharya, 2001; Albuquerque, Durnev, and Koskinen, 2012). To the extent that supplier firms with low environmental risk exposure are viewed as more socially and environmentally responsible, their relationship with customers should be stronger and more durable. Taken together, these three rationales based on contract theory, regulation-induced competitive advantage, and customer preferences all suggest that supplier firms' environmental risk exposures adversely influence the relationships with their principal customers.

We use Compustat's Business Information File to manually identify principal customers for supplier firms in manufacturing industries over the 1988-2009 period (principal customers are defined as those that account for 10% or more of total sales). We successfully identify at least one principal customer for 41.6% of supplier firms in our sample. We rely on the Toxic Release Inventory (hereafter referred to as TRI) program data supplied by the U.S. Environmental Protection Agency (EPA hereafter) to define environmental risk exposure based on the toxicities and quantities of chemicals directly released into the environment. Our main measure of environmental risk exposure is firm-level toxicity-weighted releases scaled by total sales. We use percentile ranks of this measure in regression analyses to mitigate the effects of outliers and skewness in the data.

We document that supplier firms with high environmental risk are less likely to have principal customers, particularly publicly listed principal customers. This suggests that publicly traded firms are more concerned about

the environmental performance of their suppliers. We then take principal customers' perspectives, and explore whether their supplier decisions are affected by the suppliers' environmental risk levels. Our results reveal that higher environmental risk lowers a supplier firm's probability of being chosen relative to its industry peers by its potential customers. Furthermore, conditional on having a principal customer, we find a negative correlation between a supplier's sales to the principal customer and its environmental risk. Higher environmental risk of supplier firms is associated with less durable trading relationships with principal customers. These results are both economically and statistically significant. We then perform a variety of checks to ensure that our main results are robust to alternative model specifications and variable definitions.

To alleviate concerns over endogeneity, we adopt an instrumental variable approach that uses three instruments to measure environmental risk exposure: 1) the natural log of the weighted average geographic distance between the regional EPA office and firm facilities, 2) the weighted average population density within 100 kilometres of the census tract in which a firm's facility operates, and 3) the natural log of the number of facilities reporting non-zero toxicity-weighted waste to the TRI database. We justify the choice of these instruments in section IV.D. The main results still hold, suggesting there is a causal effect of supplier firms' environmental risk on the customer-supplier relationship.

We then examine how customers' environmental performance affects the link between suppliers' environmental risk and the customer-supplier relationship. To that end, we partition the sample according to the customers'

levels of environmental risk exposure. We find stronger effects when customer production processes are more environmentally responsible. This suggests that environmentally conscious customers are more concerned about potential disruptions caused by supplier environmental risk, and are thus more likely to choose suppliers that more closely match their own environmental practices.

Our paper contributes to the extant literature in three ways. First, we identify corporate environmental risk as a key determinant of product market relationships. Prior studies have established that the bilateral relationship between customers and suppliers is influenced by various counterparty risks that may lead to supply chain disruptions, such as bankruptcy risk (Hertzel et al., 2008), managerial turnover risk (Intintoli, Serfling, and Shaikh, 2013), takeover risk (Cen, Dasgupta, and Sen, 2012), and litigation risk (Cen et al., 2014). To the best of our knowledge, we are among the first to empirically show that corporate environmental risk has an adverse impact on the existence and strength of the relationships with firms' major stakeholders, i.e., principal customers. Second, our analysis reveals that customers' purchase decisions are significantly influenced by the amount of toxic releases of suppliers, supporting the important role of non-financial measures in corporate performance evaluation and decision making (e.g., Barth and McNichols, 1994; Hughes, 2000; Clarkson, Li, and Richardson, 2004).⁹ Third, a number of studies have found that companies can do well (in terms of firm value and operating performance) by doing good for the environment and society (e.g., Orlitzky, Schmidt, and Rynes, 2003; Guenster et al., 2011). However, few have examined the specific channels through which being environmentally

⁹ Recent studies show that non-financial environmental information is captured in earnings forecasts and stock recommendations by equity research analysts (De Franco, Li, and Zhou, 2013), and in audit fees by auditors (Li, Simunic, and Ye, 2014).

responsible (irresponsible) brings economic benefits (costs). Our findings imply that corporate environmental risk exposure can harm firm performance by weakening the trading relationship with principal customers. We thus answer the call of Bénabou and Tirole (2010) and Moser and Martin (2012) for more research on the role of non-shareholder parties in CSR strategies.

The remainder of the paper proceeds as follows. Section II provides a brief review of the related literature. We describe the data sources, variable construction, and summary statistics in section III. The main results are presented in section IV, followed by additional analysis in section V. Section VI concludes.

II. A Brief Literature Review

Our paper brings together two strands of literature that have attracted strong research interest in recent years: CSR and the product market relationship.

First, there is an ongoing debate over whether social or environmental responsibility is positively correlated with financial performance. As Coase (1960) noted, a high standard of environmental responsibility benefits entire communities, but the shareholders may bear the costs of the positive externalities. For example, setting up and maintaining systems to reduce toxic waste from manufacturing plants may increase corporations' production costs significantly. And Friedman (1962) pointed out that if corporate executives accept a social responsibility other than maximizing shareholder wealth, the very foundation of free society would be undermined.

Moreover, numerous studies have examined how social and environmental responsibility is related to firm performance, but the results are mixed and

difficult to interpret because of various methodological issues (e.g., Margolis, Elfenbein, and Walsh, 2009; Molina-Azorin et al., 2009). Bénabou and Tirole (2010) point out that empirical designs should focus on identifying the specific channels through which CSR may bring benefits. Moser and Martin (2012) suggest that empirical research should go beyond the financial performance perspective and investigate the role of non-shareholder parties in determining CSR strategies.

Accordingly, a number of studies show that more socially responsible firms tend to perform better because they attract and retain higher quality employees, make better investment decisions, have better access to financing and valuable resources, encourage more stakeholder engagements, and create more intangible assets.¹⁰ On the other hand, environmentally irresponsible firms also tend to have higher costs of capital (Chava, 2014), higher credit risk (Schneider, 2011), higher litigation risk (Boone and Uysal, 2012), lower investment opportunities (Gormley and Matsa, 2011), lower analyst forecast accuracy (De Franco, Li, and Zhou, 2013), and higher audit fees (Li, Simunic, and Ye, 2014). We add to this literature by showing that environmental responsibility is positively related to the strength and durability of principal customer trading relationships. This is consistent with the view that social and environmental responsibility makes good economic sense for companies.

Second, a relatively nascent literature points out that durable trading relationships with principal customers are valuable assets. Supplier firms invest heavily to initiate and maintain long-term relationships with their principal customers (e.g., Fee and Thomas, 2004; Banerjee, Dasgupta, and Kim, 2008).

¹⁰ See, for example, Deng, Kang, and Low (2013), Cheng, Ioannou, and Serafeim (2014), Dhaliwal et al. (2011), Turban and Greening (1997), Choi and Wang (2009), and Gardberg and Fombrun (2006).

From the perspective of a customer firm, choosing a supplier is a highly important operating decision, because the quality of its supply chain may play a vital role in its eventual market success. Johnson, Kang, and Yi (2010) point out that firms with large customers tend to have higher IPO valuations and better long-term performance.

Fee and Thomas (2004) show that the performance of supplier firms can be significantly affected when their large customers are involved in mergers or takeover activities. Cen, Dasgupta, and Sen (2012) argue that a hostile takeover disrupts the implicit contracts that form the basis for long-term stakeholder relationships. Their results suggest that firms with principal customers will gain increased shareholder value when the stability of principal customer relationships increases as a result of an exogenous increase in anti-takeover provisions. Cen et al. (2014) show that the litigation risk of suppliers adversely affects the continuation and strength of customer-supplier relationships.

Several papers have also noted how supplier firms adjust their corporate policies to remain attractive to their customers and suppliers. Titman (1984) presents a model in which large stakeholders need to make relationship-specific investments, and would therefore suffer losses if the other party entered into financial distress or liquidation. As a result, large corporate customers, particularly those considering long-term relationships, have an interest in the stability and financial health of their suppliers. Hui, Klasa, and Yeung (2012) find that firms with corporate customers tend to maintain conservative accounting practices in an effort to address information asymmetries. Furthermore, their conservatism increases when their customers are relatively stronger. Itzkowitz (2013) shows that supplier firms often hold additional cash

in order to signal that they are unlikely to experience financial distress. Raman and Shahrur (2008) find that firms engage in earnings management and inflate reported earnings in order to favorably influence stakeholder perceptions within supply chains. Banerjee, Dasgupta, and Kim (2008) provide evidence that firms with substantial customer-supplier relationships maintain lower leverage, particularly if they supply specialised and durable products. In this paper, we show that the environmental risk of suppliers has a significant influence on their relationships with principal customers.

III. Data and Empirical Methodology

A. Data and Sample

Our sample consists of manufacturing firms (with primary SIC codes within 2000 and 3990) that are included in the Compustat database and have at least one facility that reported to the EPA's TRI program at any point between 1988 and 2009.¹¹ We identify principal customers using the Business Segment File of Compustat. To measure environmental risk, we rely mainly on the TRI program's toxic emissions data, a unique source of annually reported and legally mandated firm-specific facility-level environmental performance data. Financial data come from the Compustat Industrial Annual files. We obtain data on stock prices from the Center for Research in Security Prices (CRSP) files. We convert dollar values into 2005 constant dollars using the GDP deflator.

We begin our sample period in 1988 because the EPA started collecting TRI data in 1987, and we use one-year lagged values of environmental risk

¹¹ We follow Banerjee, Dasgupta, and Kim (2008) and restrict our attention to the manufacturing sector because its production process is more relationship-specific than other sectors. Note that firms in other sectors, such as mining or utilities, also face significant environmental risk. However, their customer-supplier relationships are less stable because of more homogenous products and lower switching costs for suppliers.

measures when predicting the customer-supplier relationship. We end our sample in 2009, up to which we manually identify principal customers. We exclude firms with missing values for environmental risk and for variables used in regressions. These restrictions yield an unbalanced panel that consists of 16,895 firm-year observations from 1,557 supplier firms.

B. Identifying Principal Customers

We extract the identities of firm customers and sales to customers from the Business Segment File of Compustat. The Statement of Financial Accounting Standards No. 14 (SFAS No. 14 - “Financial Reporting for Segments of Business Enterprise”) of the Financial Accounting Standards Board (FASB) requires firms to disclose customer sales data if the revenue generated from a customer exceeds 10% of total firm revenue, or if the firm considers the sale important to its business.¹² Following Banerjee, Dasgupta, and Kim (2008), we define principal customers as those accounting for 10% or more of a firm’s reported sales.¹³

We then classify principal customers as public, private, government, or unidentified. Specifically, we first match the customer names with the historical names file in the CRSP/Compustat merged data file to identify the public customers. For unmatched customers and those with multiple matches, we

¹² In 1997, SFAS 14 was superseded by SFAS 131, which mandates that firms report sales to each principal customer, but not the customer identity. However, under Securities and Exchange Commission (SEC) Regulation S-K, firms with publicly traded equity are still required to disclose the names of customers that comprise 10% or more of their sales if the loss of such a customer would have a materially adverse effect on the firm (Ellis, Fee, and Thomas, 2012).

¹³ Some firms (roughly 41.6% of firms that disclose their customers) voluntarily disclose information about customers that are responsible for less than 10% of their annual sales. Robustness checks (untabulated) show that our results remain qualitatively the same if we include voluntarily disclosed customers that account for less than 10% of net sales as principal customers.

manually search names using the LexisNexis Academic Universe, and by checking 10-K filings of the possible parent companies and their subsidiaries in the relevant time period.¹⁴

To measure the existence of principal customers, we set the indicator variable *Customer* equal to 1 if the firm has at least one principal customer that year, and 0 otherwise. To explore heterogeneity across customers, we construct four customer category indicator variables (i.e., *Public*, *Private*, *Government*, and *Unidentified*) to indicate whether a firm has at least one principal customer from each category. Note that we expect government customers to differ substantially from publicly traded or private customers in many aspects. For example, they generally purchase for consumption, and their purchases are not profit-driven (Banerjee, Dasgupta, and Kim, 2008).

After identifying the principal customers, we organize our data at the customer-supplier pair level to study how a supplier's environmental risk exposure affects its probability of being chosen by principal customers (Table IV), as well as the intensity and duration of the customer-supplier relationship (Table V). For these tests, the exact identities of principal customers need to be known. Therefore, we follow Cen et al. (2014) and exclude government and

¹⁴ The classification requires a certain amount of discretion, because the reported principal customer names do not follow a set pattern and are often abbreviated. We again follow Banerjee, Dasgupta, and Kim (2008), and use the historical names file of the CRSP/Compustat merged data file and the LexisNexis Academic Universe search based on customer company names of both listed and unlisted firms. We also conduct news searches around the time period to determine whether a customer was a wholly owned subsidiary of a listed company. We eliminate matches that we deem unrelated to the product of the segment concerned. If we are left with one listed company or one private company that would be the only possible match, we classify the customer accordingly. However, based on the reported abbreviated customers, if we are left with more than one public company match, or at least one public and one private company between which we cannot distinguish, we classify the principal customer as "unidentified." Some customer names are deliberately suppressed by assigning names such as "Not reported" or "2 customers." They are thus also placed in the "unidentified" group. If more than one private and no public company meet the search criteria, we classify the customer as "private." Customers reported as "Domestic Government" or "U.S. Navy," etc., are classified as "government." Few companies report foreign governments as their principal customers, so we lump both domestic and foreign government customers into a single group.

unidentified customers from the relationship analysis.¹⁵ We are left with 6,022 customer-supplier-year pairs with clearly identified public or private customers.

C. Measuring Environmental Risk Exposure

Current securities regulations and accounting standards that cover environmental reporting leave firms with considerable discretion. Thus, financial disclosures are often incomplete and inaccurate (Barth, McNichols, and Wilson, 1997; Schneider, 2011). We follow prior studies and rely on non-financial pollution measures from the TRI program to assess firms' exposure to environmental risk.¹⁶ Compared with environmental performance metrics created by major social raters, the TRI program offers more objective and verifiable measures of corporate environmental performance, because it is under rigorous monitoring by EPA and contains very few subjective assessments.¹⁷ In addition, the TRI data is less subject to selection biases as firms' environmental reporting is legally mandated.

The TRI program was established by the Section 313 Emergency Planning and Community Right-to-Know Act (EPCRA) of 1987. It has been expanded to contain information on over 650 toxic chemicals from more than 20,000 U.S.

¹⁵ In other words, this analysis only includes customer-supplier relationships where customers are publicly traded or privately held firms. We exclude unidentified principal customers because we cannot distinguish them from each other. Government customers are typically reported as "U.S. Government" or "U.S. domestic government," so it is unclear what levels of government or which government agencies or departments they represent.

¹⁶ Barth and McNichols (1994) and Hughes (2000) show that non-financial pollution measures, i.e., the number of Superfund sites and sulfur dioxide emissions, respectively, capture the exposure of polluting firms to future environmental liabilities. Also see, e.g., Cormier, Magnan, and Morard (1993), Clarkson, Li, and Richardson (2004), and Carroll et al. (2004). De Franco, Li, and Zhou (2013) show that TRI's toxic emissions data constitutes an important source of non-financial information for analysts to use in assessing firms' future environmental risk exposure and financial prospects.

¹⁷ To ensure the accuracy and reliability of the TRI data, EPA "*analyzes data for potential errors, contacts TRI facilities concerning potentially inaccurate submissions, provides guidance on reporting requirements, and takes enforcement actions against facilities that fail to comply with TRI requirement*".

industrial facilities. Each year, facilities are required to report to TRI the quantities of chemicals they have disposed of or released into the environment (air, water, and land), as well as those they have treated, recovered, or recycled.¹⁸ Environmental management activities, which include treatment, recovery, and recycling, reflect firms' ongoing expenditures to achieve and maintain compliance. The toxicities and quantities of chemicals released (net of those being treated, recovered, or recycled) capture firms' exposure to environmental risk. Thus, a high level of toxic chemicals released is positively associated with expenditures for compliance with future stringent environmental laws and regulations, the probability of future litigation, enforcement actions, or remediation activities arising from past and ongoing environmental contamination, as well as serious damage to human health, property, and economic activities.

Specifically, we first calculate facility-level production-related toxic chemical releases by summing all the chemicals released in a given year. To account for the inherent heterogeneity of chemicals, we multiply the mass of each chemical by its toxicity, which comes from the EPA's Risk-Screening Environmental Indicator (RSEI) model. We then aggregate the toxicity-weighted amounts of releases across facilities owned by a firm to obtain the firm-level toxicity-weighted releases, and we scale it using total sales to control for production scale.

The aggregation procedure results in many extreme values because of the enormous variation in the toxicity of TRI chemicals, which spans seven orders

¹⁸ A facility is required by law to report to the TRI program if it meets the following three criteria: 1) it has ten or more full-time employees, 2) its North American Industry Classification System (NAICS) code is covered by the TRI program, and 3) it processes, manufactures, or otherwise uses any listed toxic chemical in excess of the threshold amount.

of magnitude on a pound-for-pound basis.¹⁹ To mitigate the effects of outliers and skewness in the data, we transform the raw scaled amounts of toxicity-weighted releases to percentile ranks, which range from 0.032 (lowest environmental risk) to 1 (highest environmental risk).²⁰ We then use the percentage ranks (*EnvRisk*) as our key variable of interest in the regression analysis. Section IV.D illustrates that our results are robust to alternative measures of environmental risk exposure.

D. Control Variables

We control for a set of variables that have been shown by previous studies to influence the likelihood of having principal customers. Specifically, we include the natural log of total assets ($\ln(\text{Assets})$) to control for firm size. To account for the effect of a firm's lifecycle on its customer relationships, we use the natural log of firm age, $\ln(\text{Firm Age})$, which is the number of years that a firm has been in the CRSP database. Patatoukas (2012) documents that customer-base concentration is positively correlated with firm operating performance, and negatively correlated with selling, general, and administrative

¹⁹ For example, less toxic chemicals, such as formic acid and ethylene, have toxicities of less than 0.5; the most toxic chemicals, such as asbestos and thorium dioxide, have toxicities equal to 1 million. For chemicals with no EPA-assigned toxicity, we set toxicity equal to 0. The EPA provides two toxicity weights based on exposure path: the inhalation toxicity weight, and the oral toxicity weight. We follow the EPA's methodology and use the inhalation toxicity weight for releases (transfers) to fugitive air, stack air, and off-site incinerations. The oral toxicity weight is used for releases (transfers) to direct water and publicly owned treatment works (POTWs). If the path through which a chemical is released (transferred) is unknown, we use the higher of the two toxicity weights.

²⁰ Specifically, a percentile rank equals the cumulative frequency that corresponds to a given amount of toxicity-weighted releases scaled by total sales, for which we aim to find the percentile rank, divided by the number of observations in our sample. The same rank is assigned to values that are tied (Cox, 2002). Thus, because 1,090 firm-year observations have zero toxicity-weighted releases, the lowest percentile rank is $545.5/16,895 = 0.032$, where 545.5 is the average rank of these 1,090 observations. Setting the lowest rank equal to 0 does not affect our results. In a robustness check (untabulated), we transform the raw scaled amounts of toxicity-weighted releases to percentile ranks within each industry. Our results are qualitatively the same.

(SG&A) expenses. Thus, we include *EBITDA/Assets* and *SG&A/Assets* to capture operating performance and SG&A expenses. We also include market-to-book ratio (*M/B*) to proxy for firm-specific growth opportunities. Maksimovic and Titman (1991) and Titman (1984) argue that customers may be reluctant to conduct business with suppliers with high financial leverage or financing difficulties, which could weaken suppliers' abilities to honour implicit contracts. We therefore follow Banerjee, Dasgupta, and Kim (2008) and use the book leverage ratio (*Leverage*), defined as long-term debt divided by total assets, to measure financial leverage. To capture a company's access to bond markets, we use a debt rating indicator variable (*Debt Rating*) that equals 1 if a firm has debt ratings assigned by Standard & Poor's, and 0 otherwise. Also included is net Property, Plant, and Equipment (*PPE*) scaled by total assets (*PPE/Assets*) to account for tangibility. Moreover, because firms with high research and development (R&D) intensity are more likely to provide customers with unique and indispensable services or products (see, e.g., Bowen, DuCharme, and Shores, 1995), we include as control variables R&D expenses scaled by total assets (*R&D/Assets*), and an indicator variable (*RNDD*) that equals 1 if R&D expenses are missing, and 0 otherwise. All control variables are measured at $t-1$ in the regressions.

E. Summary Statistics

Table I reports the descriptive statistics for all supplier firms in our sample. We winsorize the variables at the top and bottom 1% of their distributions.²¹ This approach reduces the impact of extreme observations by assigning the

²¹ The only exception is *EnvRisk*, which represents percentile ranks that do not take extreme values.

cutoff values to those beyond the cutoff points. Our results (untabulated) are qualitatively the same when we truncate (rather than winsorize) the distributions.

[Insert Table I here]

The distributions of raw releases and toxicity-weighted releases are highly skewed. An average (median) firm in our sample generates 1.94 (0.07) million pounds of releases. The mean (median) value of toxicity-weighted releases is 9.05 billion (9.06 million). Our main measure of environmental risk (*EnvRisk*) is the percentile rank of scaled toxicity-weighted releases. It exhibits mean and median values equal to 0.5, and a standard deviation equal to 0.289. Note that 44.2% of our sample firms have at least one principal customer, while 6.5% have at least one government customer. We are able to identify at least one public (private) customer for 20.3% (4.4%) of firms, while 26.3% have at least one unidentified principal customer.

Table I also reports summary statistics for the control variables used in our main tests. Because our sampling approach and variable construction criteria follow the literature, the reported figures in Table I resemble those in related studies (e.g., Banerjee, Dasgupta, and Kim 2008). For the sake of brevity, we omit discussion of the descriptive statistics for control variables.

[Insert Table II here]

Table II tabulates the distribution of supplier firms with principal customers across industries classified using the two-digit SIC code. The percentage of suppliers with principal customers is highest in Electrical Equipment industries, followed by Transportation Equipment, Chemicals and Allied Products, Machinery, and Measuring, Analyzing & Controlling Instruments. Government

purchases are clustered in the Electrical Equipment, Transportation Equipment, and Measuring, Analyzing & Controlling Instruments sectors, of which Electrical Equipment and Transportation Equipment have both been identified as high polluting industries (Delmas and Toffel, 2008). Overall, the existence of principal customers exhibits a large variation across supplier industries. Because environmental risk measures tend to be industry-specific (Clarkson, Li, and Richardson, 2004), we include four-digit SIC industry fixed effects in our regression analysis to control for heterogeneity along the industry dimension.

IV. Main Results

In this section, we perform three main tests regarding the effects of environmental risk on the customer-supplier relationship. First, we examine whether a firm's environmental risk exposure affects the existence of principal customers. Second, we take principal customers' perspective, and explore whether their decisions in selecting suppliers are affected by the suppliers' environmental risk. We then examine the effects of environmental risk on the intensity and duration of the existing trading relationships. Third, we conduct various checks to ensure that our main results are robust to alternative model specifications, alternative variable definitions, and endogeneity concerns.

A. Effects of Environmental Risk Exposure on the Existence of Principal Customers

We use probit regressions to examine how the probability of having principal customers is affected by corporate environmental risk. Specifically, we estimate the model:

$$\text{Prob.}[Customer_{i,t}=1]=\Phi(\alpha+\beta EnvRisk_{i,t-1}+\gamma X_{i,t-1}+\delta Industry_{i,t}+\theta Year_i) \quad (1)$$

where the dependent variable, *Customer*, is equal to 1 if firm *i* has at least one principal customer in year *t*, and 0 otherwise. Φ denotes the normal cumulative distribution function. The key explanatory variable, *EnvRisk*, is measured one year before the supplier firms' principal customers are observed. The coefficient (β) on *EnvRisk* is expected to be negative. $X_{i,t-1}$ represents a set of predetermined control variables that are defined in section III.D and measured at *t*-1. We include four-digit SIC industry fixed effects (*Industry*) that control for heterogeneity across industries, as well as year fixed effects (*Year*) that account for macroeconomic factors that may influence demand or supply in the product market.²² The standard errors of the estimated coefficients allow for clustering of observations by firm, but our conclusions are not affected if we allow clustering by both firm and year. We report the coefficients reflecting the marginal effects that capture the impact of a one-unit change in explanatory variables on the dependent variable.

[Insert Table III here]

We estimate Equation (1) using the entire sample. The results are presented in column (1) of Table III. The estimated coefficient on *EnvRisk* is negative and statistically significant (*z*-statistics = -4.2), suggesting that high environmental risk reduces supplier firms' likelihood of having principal customers. The tabulated coefficients capture the marginal effect of a one-unit change in explanatory variables on the dependent variable. Economically, increasing *EnvRisk* from the 25th (0.25) to the 75th percentile (0.75) decreases the

²² We do not include firm fixed effects in our main specifications because both *Customer* and *EnvRisk* are highly persistent variables. The first-order autocorrelations for *Customer* and *EnvRisk* are 0.75 and 0.92, respectively. Zhou (2001) notes that the persistence of key variables can reduce the signal-to-noise ratio and lower the power of panel data estimators.

probability of having at least one principal customer by roughly 0.08, corresponding to a 17% reduction relative to the average probability (0.442) reported in Table I. The estimated coefficients of control variables indicate that small and rated supplier firms are more likely to have principal customers. Supplier firms that invest more in R&D and those with lower SG&A expenses are associated with a higher likelihood of having principal customers.

In columns (2)-(4), we group principal customers into government and firm categories, and examine the effect of environmental risk on the existence of principal customers from each category. The results reveal a negative but insignificant coefficient (z -statistics = -1.0) for *EnvRisk* in the regression explaining the likelihood of having government customers. In contrast, the negative effects of *EnvRisk* on the existence of public or private customers are both economically and statistically significant (z -statistics = -3.3 and -1.9, respectively).

The insignificant relation between *EnvRisk* and *Government* suggests a low sensitivity of government purchases to suppliers' environmental risk. This result is consistent with the key differences between government and company customers. Publicly traded or private principal customers usually use goods as inputs in their own production processes or for resale, while the government generally purchases goods for consumption (Banerjee, Dasgupta, and Kim, 2008). As a result, although environmental risk exposure may adversely affect suppliers' incentives to maintain product quality, reputational or monetary losses from poor product quality may be less important when the government is a principal customer. Furthermore, rigorous administrative controls over procurement contracts make government purchase decisions dependent

primarily on price and quality, rather than the environmental impact of the suppliers' production processes.²³

Comparing columns (3) and (4), we find that the effect of *EnvRisk* on the likelihood of having public customers is more pronounced than that on having private customers. This suggests that publicly traded companies are more concerned about their suppliers' environmental practices because of the higher level of public scrutiny they face (Michaely and Roberts, 2012).

B. Effects of Environmental Risk Exposure on Customers' Supplier Choice

The regression analysis in Table III studies supplier firms' likelihood of having principal customers. We now take the principal customers' perspective, and study whether their decisions in selecting suppliers are affected by suppliers' environmental risk exposure. This angle is worth exploring, because, in a competitive product market, unless a customer is severely distressed financially, the power to select the counterparty likely resides with the customer (Chen et al., 2014).

We perform the analysis using all principal customer-potential supplier pairs that have been constructed based on actual customer-supplier relationships. Specifically, for each actual relationship in a given year, we follow Sundaram, John, and John (1996) and identify potential suppliers (also referred as to competing suppliers) as all firms in the same four-digit SIC industry as the actual supplier, and that are covered by the TRI program.²⁴ We require at least one potential supplier (except the actual supplier) for each customer-supplier

²³ Similarly, Banerjee, Dasgupta, and Kim (2008) find that government customers are less likely to be concerned with suppliers' financial leverage.

²⁴ We exclude the customer itself from the potential suppliers if the customer and the actual supplier are in the same industry.

relationship. Furthermore, each principal customer's decision is modelled by choosing a supplier from all potential suppliers, where the choice is influenced by suppliers' environmental risk exposure and a number of other characteristics. To operationalize this, we model the probability that a customer j chooses a supplier i in year t using the following probit model.

$$\text{Prob.}[Supplier_{i,j,t}=1] = \Phi(\alpha + \beta EnvRisk_{i,t-1} + \gamma X_{i,t-1} + \rho Y_{i,t} + \delta Industry_{i,t} + \theta Year_i) \quad (2)$$

where $Supplier_{i,j,t}$ is a dummy variable equal to 1 if a potential supplier i is chosen by customer j in year t as the actual supplier, and 0 otherwise; $X_{i,t-1}$ is the set of supplier characteristics described in section III.D; and $Industry(Year)$ is supplier industry (year) fixed effects. $Y_{i,t}$ includes two relationship-specific variables: $Ln(NumSup)$, the natural logarithm of the number of potential suppliers a customer has, which we expect to be negatively correlated with the probability of a potential supplier being chosen, and $Alliance$, a dummy variable equal to 1 if any strategic alliance or joint venture was established between a principal customer and its potential supplier, and 0 otherwise.²⁵

We expect the presence of explicit alliance agreements to increase potential suppliers' chances of being chosen. As discussed in section III.B, we only consider publicly traded and privately held customers for which we can meaningfully identify potential suppliers. As a result, we perform the analysis using 42,210 customer-potential supplier-year pairs, of which 5,518 are actual customer-supplier relationships.

[Insert Table IV here]

The result in column (1) of Table IV shows a negative and significant coefficient on $EnvRisk$, implying that a higher level of environmental risk

²⁵ We obtain information on alliances and joint ventures from the Securities Data Corporation (SDC) strategic alliance database.

exposure lowers a supplier firm's probability of being chosen by its potential customer relative to its industry peers. The economic magnitude would equal a 15% decrease over and above the unconditional probability ($5,518/42,210 = 0.131$) if *EnvRisk* increases from the 25th (0.25) to the 75th percentile (0.75).

Ln(NumSup) and *Alliance* are found to be negatively and positively correlated, respectively, with the probability of a supplier being chosen. The estimated coefficients of other control variables are generally consistent with those reported in Table III. In a robustness check (untabulated), we augment Equation (2) by including customer fixed effects to account for the influence of time-invariant customer characteristics. We obtain qualitatively similar results.²⁶ Columns (2) and (3) of Table IV illustrate the choices of public and private customers, respectively. The results suggest that *EnvRisk* affects public customers' supplier choices more than that of private customers, which is analogous to the findings in Table III.

C. Effects of Environmental Risk Exposure on the Intensity and Durability of the Customer-Supplier Relationship

We now focus on actual principal customer-supplier relationships, and examine the effect of supplier environmental risk exposure on the intensity and durability of the trading relationship. Each actual customer-supplier-year is treated as a single observation in the regression analysis. We define *Intensity* as the fraction of a supplier's sales that are made to the principal customer. By definition, this variable is censored both from below (by 10%) and above (by

²⁶ After including customer fixed effects, the estimated coefficient of *EnvRisk* becomes -0.042, with a z-statistic = -3.44.

100%). We thus estimate the following equation using a tobit regression with double censoring:²⁷

$$Intensity_{i,j,t} = \alpha + \beta EnvRisk_{i,t-1} + \gamma X_{i,t-1} + \rho Y_{i,j,t} + \delta Industry_{i,t} + \theta Year_i + \varepsilon_{i,j,t} \quad (3)$$

where $X_{i,t-1}$ is the set of supplier characteristics described in section III.D, and $Y_{i,j,t}$ represents the two relationship-specific control variables, $Ln(NumSup)$ and $Alliance$.

[Insert Table V here]

The results in column (1) of Table V show that the coefficient on *EnvRisk* is negative and significant at the 5% level (z -statistic = -2.0), suggesting that the percentage of sales to principal customers decreases with suppliers' environmental risk. Other things being equal, if *EnvRisk* increases from the 25th (0.25) to the 75th percentile (0.75), the fraction of sales made to a principal customer would decrease by 1.2%, or 7% of the average fraction of sales made to principal customers in our sample (18%).

Next, we use a Cox proportional hazard model to examine the effect of environmental risk exposure on the duration of the customer-supplier relationship:²⁸

$$h(t)_{i,j} = h_0(t)_{i,j} \exp(\alpha + \beta EnvRisk_i + \gamma X_i + \rho Y_{i,t} + \delta Industry_i + \theta Year_i + \varepsilon_{i,j}) \quad (4)$$

²⁷ According to our definition, if the fraction of sales made to a customer drops below 10% in year t , the customer is no longer classified as a principal customer. However, the customer-supplier relationship may actually continue in year t , with the fraction of sales made to the customer being any number between 0% and 10%. Thus, to account for relationship deterioration potentially caused by high environmental risk, we assume that the fraction of sales to a principal customer decreases to 10% in year t if the customer had been a principal customer until $t-1$ but ceased to be one in year t . Assuming a reduction to 0% or 5% in year t generates similar results.

²⁸ In our model, the hazard, i.e., the probability of relationship termination, is assumed to depend on a set of explanatory variables (covariates). Proportional hazard refers to the assumption that the hazard for any firm is constant across time and is a constant proportion of the baseline hazard. Following common practice, when estimating Equation (1), we adjust for delayed entry any relationships that existed in the first year of our sample. Durations not completed at the end of the sample period are treated as right censored.

where $h(t)_{i,j}$ represents supplier firm i 's hazard (probability) at time t that the relationship with its principal customer j will be terminated within an interval of time, given that the relationship has survived until the beginning of the interval. $h_0(t)_{i,j}$ is the baseline hazard function in the absence of explanatory variables. For explanatory variables, we follow prior studies (e.g., Fee, Hadlock, and Thomas, 2006; Raman and Shahrur, 2008) and use average *EnvRisk* over the duration of the relationship, while setting the values of supplier characteristics (X) and relationship-specific variables (Y) to their values in the first year that the relationship was observed during the sample period.

As Raman and Shahrur (2008) suggest, we include *Intensity* in Y as an additional explanatory variable. Because the estimation of Equation (4) is based on the hazard function, a positive coefficient on an explanatory variable implies that an increase in the variable will result in a shorter relationship length. Each principal customer-supplier relationship is treated as a single observation in the regression. That is, Equation (4) is estimated using data arranged at the relationship level, rather than at the relationship-year level, so the number of observations is 1,820.

Column (2) of Table V reports the regression results for Equation (4). We find that the coefficient on $\overline{EnvRisk}$ is positive and significant at the 5% level, indicating that higher environmental risk exposures of supplier firms are associated with less durable business relationships with their principal customers. Economically, increasing $\overline{EnvRisk}$ from the 25th (0.21) to the 75th percentile (0.66) increases the hazard of relationship termination by 10.4%.²⁹ In addition, we find that the hazard of relationship termination is negatively

²⁹ Specifically, the percentage change in the hazard is $100\% \times [\exp(0.232 \times (0.66 - 0.21))] = 10.4\%$.

correlated with *intensity* and supplier size, but positively correlated with supplier age.³⁰

To complement the duration analysis with the Cox proportional hazard model, we estimate the following probit model that examines whether environmental risk adversely affects the likelihood of relationship continuation.³¹

$$\text{Prob.}[Continue_{i,j,t}=1]=\Phi(\alpha+\beta EnvRisk_{i,t}+\gamma X_{i,t-1}+\rho Y_{i,j,t}+\delta Industry_{i,t}+\theta Year_i) \quad (5)$$

where $Continue_{i,j,t}$ is a dummy variable that equals 1 if a principal customer-supplier relationship continues in year t , and 0 otherwise. The results in column (3) of Table V reveal that higher environmental risk exposures significantly lower the probability of customer-supplier relationship continuation. Specifically, the likelihood that a principal customer stays in year t declines by 2.1% if *EnvRisk* increases from the 25th (0.25) to the 75th percentile (0.75).

Taken together, the results in Table V indicate that suppliers' ongoing environmental risk exposure adversely influences the subsequent evolution of the trading relationship and significantly weakens their bonds with principal customers. Furthermore, we repeat the analysis in Table VI for relationships with public and private customers separately, and, not surprisingly, find more pronounced results for public customer relationships. Note that these results are not tabulated for the sake of brevity.

³⁰ We obtain similar results (untabulated) if we 1) exclude *Intensity* as an explanatory variable, 2) include *intensity*² as an additional explanatory variable to account for the possible non-linear relationship between the hazard of relationship termination and *Intensity* (as per Fee, Hadlock, and Thomas, 2006), or 3) conduct the duration analysis using the Weibull model, where the length of the relationship for each supplier-customer pair is assumed to follow a Weibull distribution.

³¹ Similarly to the intensity analysis, we account for relationship deterioration potentially caused by high environmental risk by assuming that the fraction of sales to a principal customer decreases to 10% in year t if the customer has been a principal customer until $t-1$, but ceases to be one in year t .

We perform a number of additional tests to ensure that our main results, as reported in Tables III-V, are robust to alternative model specifications and different variable definitions. To save space, results are not tabulated but are available upon request. Specifically, our results hold when 1) scaling *Weighted Releases* by the costs of goods sold or total assets when computing percentile ranks, 2) defining environmental risk as $\ln(\text{Weighted Releases})/\text{Sales}$, 3) defining environmental risk as $(\text{Raw Releases})/\text{Sales}$, or 4) ranking $(\text{Weighted Releases})/\text{Sales}$ by year or by industry.

D. Endogeneity Issues

We have documented a robust relation between suppliers' environmental risk exposure and the customer-supplier relationship, but its causal interpretation remains hypothetical. The abovementioned results are potentially subject to two types of endogeneity. The first type is the omitted variables bias. While we have controlled for a standard set of variables in the regressions, our main findings may be spurious if our models omit any variables that affect both suppliers' environmental risk exposure and their relationships with principal customers.

The second type is reverse causality running from the trading relationship with principal customers to suppliers' environmental risk. For example, the existence of a principal customer may encourage suppliers to make relationship-specific investments related to pollution control and prevention activities, thereby reducing suppliers' environmental risk exposure. In both cases, the coefficient estimates in Tables III-V can be biased and inconsistent.

We perform a battery of tests to alleviate these concerns. The results are in Table VI. While all control variables in Equations (1)-(5) are still included in these new tests, we only report the coefficients of *EnvRisk* and the newly added variables for brevity.

[Insert Table VI here]

Panels A-C of Table VI give the results from additional tests that address issues related to omitted variables that may affect both suppliers' environmental risk exposure and the customer-supplier relationship. Hong, Kubik, and Scheinkman (2012) show that firms behave in a more socially responsible manner when they have more financial slack. To the extent that customer firms prefer to conduct business with financially healthy supplier firms, the link between suppliers' environmental risk exposure and the customer-supplier relationship may be driven by the suppliers' financial strength or constraints. To mitigate this concern, we include additional control variables to account for the effects of financial slack, investment needs, and stock performance. Hadlock and Pierce's (2010) index of financial constraints, the cash-to-assets ratio, the capital expenditure divided by total assets, the cost of goods sold divided by sales, and annual stock returns.³² As panel A of Table VI shows, our main results appear unaffected.

Lev, Petrovits, and Radhakrishnan (2010) find that corporate charitable contributions stimulate sales growth via enhanced consumer satisfaction. However, if firms that make more charitable contributions are also more likely to engage in environmental management activities, then our findings may just

³² Hadlock and Pierce's (2010) index is defined as $-0.737 \times \ln(Assets) + 0.043 \times \ln(Assets)^2 + 0.04 \times Firm\ Age$. *Firm Age* is the number of years that elapsed since a firm entered the CRSP database. We find qualitatively similar results using the alternative financial constraints classifications suggested by Kaplan and Zingales (1997), Cleary (1999), and Whited and Wu (2006).

be capturing the effects of suppliers' giving decisions. To rule out this possibility, we augment our model by including *Charity*, a dummy variable that is equal to 1 if a supplier has at least one strength in the three charity-related categories evaluated by Kinder, Lydenberg, and Domini (KLD) Research & Analytics.³³ As panel B of Table VI reveals, our results remain qualitatively the same.

In panel C, we use $EnvRisk_{t-3}$, instead of $EnvRisk_{t-1}$, as the key explanatory variable, because more distantly lagged values of *EnvRisk* should be correlated less with *current* omitted firm characteristics. We again obtain similar results. In panel D, we explicitly control for environmental management activities (*EnvRisk_RRT*) and pollution prevention activities (*Prevention*) to mitigate reverse causality concerns. To measure *EnvRisk_RRT*, we compute the toxicity-weighted and log-transformed amount of waste that is treated, recovered, and recycled, and scale the measure by sales. Because firms do not typically disclose the amount of chemicals reduced by pollution prevention activities, we follow Doshi, Dowell, and Toffel (2013), and extrapolate that amount using the production ratio reported by the TRI database.³⁴ We then define *Prevention* as the toxicity-weighted and log-transformed amount of waste reduced by pollution prevention activities, scaled by sales. The results indicate that *EnvRisk* remains economically and statistically significant in our regressions, alleviating

³³ Our charitable giving data comes from the KLD database. KLD evaluates corporate philanthropy in three categories, including whether the firm has donated over 1.5% of trailing three-year net earnings before taxes to charity, whether it supports non-profit organizations, and whether it makes charitable contributions abroad. In addition, to account for missing values of *Charity*, we include an indicator variable (*CharityDum*) as an additional control, which equals 1 if *Charity* is missing, and 0 otherwise.

³⁴ Specifically, the production ratio of a facility is the production level in the current year divided by the production level in the previous year (Berrone and Gomez-Mejia, 2009). We predict waste levels generated in a given year by multiplying the production ratio by the total waste generated in the previous year, and then subtract actual waste from predicted waste to obtain the amount of waste reduced by pollution prevention.

the concern that our results are driven by principal customers encouraging suppliers to reduce environmental risk through environmental management and pollution control activities.

Finally, we use a two-step bootstrapping approach to further mitigate endogeneity concerns. In particular, we predict the level of environmental risk exposure based on a set of possible determinants of environmental risk in the first step, and we use the predicted *EnvRisk* in the second step for trading relationship regressions. We follow Chang, Dasgupta, and Hilary (2006), and bootstrap the two-step system 500 times to obtain consistent standard errors, on which we construct and report the 95% confidence intervals.

In selecting the determinants of environmental risk, we begin by introducing three instrumental variables in the first-stage estimation. The first instrument, $\ln(1+DisPro)$, is the log of the weighted average geographic distance between the regional EPA offices and a firm's facilities. We first calculate the geographic distance for each facility-regional EPA office pair, and then weight the distance using the amount of toxicity-weighted waste generated by each facility.³⁵ To the extent that information asymmetries and monitoring costs increase with the physical distance from regional EPA offices, we find they would be less effective at inducing more remote firms to reduce their environmental risk exposure. This implies a positive relation between $\ln(1+DisPro)$ and *EnvRisk*.

The second instrumental variable, *PopDensity*, is the average population density within 100 kilometres around the census tracts in which a firm's

³⁵ We use Coval and Moskowitz's (1999) formula to calculate physical distance for every facility-regional EPA office pair. The geographic coordinates of reported facilities are provided by the TRI database. The coordinates of the regional EPA offices are based on zip codes from the EPA's website.

facilities operate, weighted by the toxicity-weighted waste generated by each facility. Kassinis and Vafeas (2006) document that communities with higher population densities exert more pressure on firms to reduce their emissions. We therefore expect *PopDensity* to be negatively correlated with *EnvRisk*.

As the third instrument, we take the natural log of the number of facilities reporting non-zero toxicity-weighted waste to the TRI program, $\ln(1 + \text{NumFac})$. Firms with a larger number of facilities processing toxic chemicals are expected to have a higher level of environmental risk exposure. These three instrumental variables, however, are not expected to directly influence the trading relationship, other than affecting it through suppliers' environmental risk exposure.³⁶

Furthermore, we include a number of company characteristics proposed by previous studies (e.g., McWilliams and Siegel, 2000; Clarkson et al., 2011) as additional determinants of environmental risk. We include production scale ($\ln(\text{Sales})$), profitability ($\text{EBITDA}/\text{Assets}$), and growth opportunities (M/B) because large firms, firms with fewer growth opportunities, and firms with higher profitability are more willing to engage in pollution control and prevention to reduce environmental risk. We include $R\&D/\text{Assets}$ and $RNDD$ because firms with higher R&D investments are more capable of reducing their production process pollution. We also include capital expenditures scaled by gross PPE (CAPEX/PPE), because firms may increase investments to reduce pollution. Moreover, we use the percentage of revenues from foreign markets

³⁶ One possible concern is that *NumFac* is strongly correlated with firm size, and may thus have a direct effect on the existence of principal customers. However, ex ante, the correlation between *NumFac* and firm size is weak. A facility is covered by the TRI program as long as it has ten or more employees. In addition, if *NumFac* captures the effect of firm size, this should work against us finding a negative relationship between environmental risk and trading relationships, because larger firms typically have lower environmental risk exposure (Ioannou and Serafeim, 2012) and a lower likelihood of having principal customers (Table III).

(*Foreign*) to account for the effect of foreign operations. We also add *Leverage*, because Chang et al. (2014) document that firms' leverage ratios are negatively correlated with the amount of toxic chemicals released. Finally, we also include four-digit SIC industry, headquarter state, and year fixed-effects.³⁷

The results of the first-step regression are reported in Appendix A. As expected, $\ln(1+NumFac)$ and $\ln(1+DisPro)$ are significantly and positively associated with *EnvRisk* (*t*-statistics are 23.2 and 6.0, respectively). *PopDensity* is significantly and negatively related to *EnvRisk* (*t*-statistic = -3.8). The coefficients of other explanatory variables are generally consistent with those reported in previous studies.

More importantly, we report the results of the second-step regressions in panel E of Table VI. Columns (1)-(3) reveal that the bootstrapped 95% confidence intervals for the coefficients of the predicted *EnvRisk* do not span zero, suggesting that the effects of *EnvRisk* are significantly different from zero at less than the 5% level. In column (4), we perform the duration analysis using $\overline{EnvRisk}$ computed based on predicted *EnvRisk*. The 95% confidence interval does not span zero, suggesting that the coefficient estimate on $\overline{EnvRisk}$ is significant at the 5% level.³⁸

³⁷ We obtain firm headquarter states from the Compact Disclosure Database and Compustat.

³⁸ Instead of bootstrapping the two-step system, we use the standard two-stage instrumental variable approach for columns (1)-(3), with $\ln(1+DisPro)$, *PopDensity*, and $\ln(1+NumFac)$ being the instrumental variables. The instruments pass the relevance test, as the *F*-statistics from the joint test of excluded instruments are significant at the 1% level. The *p*-values of the overidentification tests are insignificantly different from zero, thereby confirming the validity of the instrumental variables. The second-stage regression results are consistent with those obtained using the bootstrapping approach. The standard instrumental variable approach, however, cannot be applied to the duration analysis in column (4), because its second stage involves estimating the Cox proportional hazard model.

V. Further Analysis

In this section, we first partition our sample to examine whether our results vary across supplier firms depending on customers' environmental risk exposure. We then experiment with an alternative environmental risk measure constructed using Kinder, Lydenberg, and Domini (KLD) Research & Analytics data.

A. Customers' Environmental Risk

To examine how customers' environmental risk exposure affects our findings, we partition our sample into two groups according to the median values of customers' environmental risk exposure each year. We then re-estimate Equations (2) and (3) for the two groups, respectively. For the duration analysis, we divide our sample based on the average customer environmental risk over the duration of the relationship, and re-estimate Equation (4) for both subsamples. We include all control variables from Equations (2)-(4) in these tests, but report only the coefficients of *EnvRisk* for the sake of brevity. The results, reported in Table VII, indicate that our results are more pronounced in the subsample where customers have lower environmental risk exposures. These findings indicate that suppliers' environmental risk exposure is more damaging for trading relationships with greener principal customers.

[Insert Table VII here]

B. An Alternative Measure of Environmental Risk Exposure

One potential concern with our analysis is that our main measure of environmental risk only captures exposures associated with a specific set of

toxic chemicals, and thus may not be able to provide a comprehensive picture of a firm's environmental risk. To address the issue, we rely on an alternative data source, namely, KLD Research & Analytics. The KLD database has been widely used in prior studies of corporate social responsibility. It provides binary ratings for approximately eighty factors in seven CSR areas based on data from various sources, including company disclosures, media reports, data from government and non-government agencies, and company dialogues.³⁹

We focus on the area that contains ratings for seven environmental concern items, and seven environmental strength items. KLD sets the rating equal to 1 for each item if a firm has the strength or the concern, and 0 otherwise. The seven strength items are: *Pollution Prevention*, *Recycling*, *Clean Energy*, *Property Plant and Equipment*, *Beneficial Products and Service*, *Communications*, and *Other Strength*. The seven concern items are: *Hazardous Waste*, *Regulation Problems*, *Ozone Depleting Chemicals*, *Substantial Emissions*, *Agricultural Chemicals*, *Climate Change*, and *Other Concern*. Each concern adds one point to firms' environmental risk exposure, while each strength reduces it by one point. Our alternative measure of environmental risk, *EnvRisk_KLD*, is a net measure of environmental concerns, defined as the number of environmental concerns minus the number of environmental strengths. By construction, a higher value of *EnvRisk_KLD* indicates a higher level of environmental risk exposure. After merging the KLD database with Compustat, our sample consists of 10,010 firm-years from 1992 through 2009.

[Insert Table VIII here]

³⁹ See, among others, El Ghoul et al. (2011), Kim, Park, and Wier (2012), Deng, Kang, and Low (2013), and Di Giuli and Kostovetsky (2014). The seven areas are environment, corporate governance, community, diversity, employee relations, human rights, and product. Each area has a set of strength factors and a set of concern factors.

Table VIII reports results obtained by estimating Equations (1)-(4) using KLD data. Consistent with the main results using the TRI data, we find that *EnvRisk_KLD* is negatively and significantly correlated with the existence of principal customers, and the intensity and duration of the trading relationship. In unreported tests, we jointly include all environmental concerns and strengths of suppliers in regressions, and find that suppliers' hazardous waste, regulation problems, substantial emissions, and other concerns all have negative and significant impacts on the trading relationship.

VI. Conclusion

This paper explores the implications of corporate environmental risk for customer-supplier relationships. Using a large sample of firms covered by both Compustat and the TRI program between 1988 and 2009, we document a negative and significant relation between suppliers' environmental risk exposure and the probability of having principal customers. Consistent with this finding, we also provide evidence that customers are more likely to favour firms with low environmental risk relative to their competitors. Moreover, we examine how suppliers' environmental risk adversely affects their ongoing relationships with principal customers. We find that higher environmental risk leads to a significant decline in the proportion of sales to customers, and to shorter relationship durations. These results are robust to using environmental data from the KLD database to define the measure of environmental risk and controlling for endogeneity issues. Further analyses show that the effects of environmental risk on customer-supplier relationships are more pronounced when the customer's production process is more environmentally responsible. This is consistent with the notion that environmentally conscious customers are

more likely to be concerned about potential disruptions caused by suppliers' environmental risk factors.

Taken together, our results indicate that environmental risk weakens supplier firms' abilities to initiate and maintain valuable trading relationships with principal customers. This reveals an important channel through which environmental responsibility increases firm value.

Appendix A Determinants of corporate environmental risk

This table reports the results of the determinants of environmental risk. The dependent variable is *EnvRisk* at $t-1$, the percentile ranks of *Weighted Releases/Sales*. *DisPro* is the weighted average physical distance between the regional EPA office and the firm's facility. *PopDensity* is defined as the weighted average population density (thousands) within 100 kilometres of the census tract in which a firm's facility operates. *NumFac* is the number of facilities who report non-zero toxicity-weighted waste to TRI. *Sales* is net sales. *M/B* is $(Assets + \text{Market value of equity} - \text{Book value of equity})/Assets$. *EBITDA/Assets* is earnings before interest, taxes, depreciation, and amortization scaled by *Assets*. *R&D/Assets* is R&D expenses scaled by *Assets*. *RNDD* is a dummy variable equal to 1 if R&D expenses are missing, and 0 otherwise. *CAPEX/PPE* is capital expenditures scaled by gross property, plant, and equipment (*PPE*). *Foreign* is the percentage of revenues from foreign markets. *Leverage* is long-term debt/*Assets*. Dollar values are converted into 2005 constant dollars using the GDP deflator. All explanatory variables are lagged one year relative to the dependent variable. Constant terms, year fixed effects, four-digit SIC industry fixed effects, and headquarter state fixed effects are included in all regressions, but their coefficients are not reported. The t -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedasticity-consistent errors, which are also corrected for correlation across observations for a given firm. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	<i>EnvRisk</i> _{$t-1$}
<i>Ln(1+DisPro)</i>	0.017*** (6.0)
<i>PopDensity</i>	-0.069*** (-3.8)
<i>Ln(1+NumFac)</i>	0.165*** (23.2)
<i>Ln(Sales)</i>	-0.034*** (-8.1)
<i>M/B</i>	0.006 (1.1)
<i>EBITDA/Assets</i>	-0.075 (-1.5)
<i>R&D/Assets</i>	-0.173 (-1.2)
<i>RNDD</i>	0.007 (0.5)
<i>CAPEX/PPE</i>	-0.000*** (-2.8)
<i>Foreign</i>	0.030 (1.3)
<i>Leverage</i>	0.015 (0.6)
Industry and year fixed effects	Y
State fixed effects	Y
N/R ²	14,286/0.58

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Table I Summary statistics

Our sample consists of manufacturing firms that were covered jointly in Compustat and the TRI program between 1988 and 2009. *Raw Releases* is in millions of pounds, and is measured as the amount of chemicals released in a given year. *Weighted Releases* is in millions, and is obtained by multiplying the mass of each chemical by its toxicity. *EnvRisk* is the percentile ranks of *Weighted Releases/Sales*. *Sales* is net sales. *Customer* is a dummy variable that equals 1 if the firm has at least one principal customer, and 0 otherwise. *Government* is a dummy variable equal to 1 if the firm has at least one principal government customer, and 0 otherwise. *Public (Private)* is a dummy variable that equals 1 if the firm has at least one principal public (private) customer, and 0 otherwise. *Unidentified* is a dummy variable that equals 1 if the firm has at least one unidentified customer, and 0 otherwise. *Assets* is the book value of total assets. *Firm Age* is the number of years that has elapsed since a firm entered the CRSP database. *EBITDA/Assets* is earnings before interest, taxes, depreciation, and amortization scaled by *Assets*. *SG&A/Assets* is SG&A expenses scaled by *Assets*. *M/B* is the market-to-book ratio defined as $(\text{Assets} + \text{Market value of equity} - \text{Book value of equity})/\text{Assets}$. *Leverage* is long-term debt/*Assets*. *Debt Rating* is a dummy variable equal to 1 if the firm has a debt rating assigned by Standard & Poor's, and 0 otherwise. *Tangibility* is net PPE over *Assets*. *R&D/Assets* is R&D expenses scaled by *Assets*. *RNDD* is a dummy variable equal to 1 if R&D expenses are missing, and 0 otherwise. Dollar values are converted into 2005 constant dollars using the GDP deflator. Q1 and Q3 stand for the 25th and 75th percentiles of the distribution, respectively. All variables are winsorized at the top and bottom 1% of their distributions.

Variables	Mean	Standard Deviation	Minimum	Q1	Median	Q3	Maximum
<i>Raw Releases (millions pounds)</i>	1.941	14.19	0.000	0.008	0.070	0.515	1080.3
<i>Weighted Releases (millions)</i>	9052.3	78389.9	0.000	0.207	9.058	442.2	3558079.0
<i>Weighted Release/Sales</i>	4.914	56.79	0.000	0.001	0.015	0.308	4011.5
<i>EnvRisk</i>	0.500	0.289	0.032	0.250	0.500	0.750	1.000
<i>Customer</i>	0.442	0.497	0.000	0.000	0.000	1.000	1.000
<i>Government</i>	0.065	0.246	0.000	0.000	0.000	0.000	1.000
<i>Public</i>	0.203	0.402	0.000	0.000	0.000	0.000	1.000
<i>Private</i>	0.044	0.205	0.000	0.000	0.000	0.000	1.000
<i>Unidentified</i>	0.263	0.440	0.000	0.000	0.000	1.000	1.000
<i>Assets (\$millions)</i>	3988.1	10146.2	9.194	201.1	714.8	2754.8	77195.2
<i>Ln(Assets)</i>	6.636	1.882	2.219	5.304	6.572	7.921	11.25
<i>Firm Age (years)</i>	25.65	15.63	1.000	11.00	25.00	39.00	54.00
<i>EBITDA/Assets</i>	0.094	0.083	-0.236	0.054	0.095	0.140	0.315
<i>SG&A/Assets</i>	0.223	0.148	0.000	0.114	0.197	0.297	0.797
<i>M/B</i>	1.639	0.871	0.678	1.096	1.374	1.865	5.692
<i>Leverage</i>	0.205	0.162	0.000	0.075	0.185	0.300	0.761
<i>Debt Rating</i>	0.455	0.498	0.000	0.000	0.000	1.000	1.000
<i>Tangibility</i>	0.315	0.160	0.040	0.195	0.289	0.408	0.804
<i>R&D/Assets</i>	0.027	0.037	0.000	0.000	0.013	0.036	0.179
<i>RNDD</i>	0.309	0.462	0.000	0.000	0.000	1.000	1.000

Table II Distribution across industries of supplier firms with principal customers

The sample consists of manufacturing firms covered jointly in Compustat and the TRI program between 1988 and 2009. In column (1), *N* is the number of supplier firms with principal customers in a two-digit SIC industry. % represents the number of supplier firms with principal customers in a two-digit SIC industry, divided by the total number of supplier firms with principal customers. Columns (2)-(5) report the numbers and percentages of supplier firms with government, public, private, and unidentified principal customers, respectively.

Two-Digit SIC	Industry Name	(1) <i>Customer</i>		(2) <i>Government</i>		(3) <i>Public</i>		(4) <i>Private</i>		(5) <i>Unidentified</i>	
		<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%	<i>N</i>	%
20	Food & Kindred Products	264	3.53	0	0.00	138	4.02	13	1.76	197	4.44
21	Tobacco Products	27	0.36	0	0.00	25	0.73	0	0.00	4	0.09
22	Textile Mill Products	173	2.32	2	0.18	70	2.04	20	2.70	105	2.37
23	Apparel & Other Finished Products	40	0.54	2	0.18	37	1.08	2	0.27	19	0.43
24	Lumber & Wood Products, Except Furniture	74	0.99	2	0.18	23	0.67	9	1.22	59	1.33
25	Furniture & Fixtures	146	1.95	9	0.82	81	2.36	3	0.41	91	2.05
26	Paper & Allied Products	200	2.68	0	0.00	89	2.59	10	1.35	148	3.33
27	Printing, Publishing, & Allied Products	88	1.18	0	0.00	42	1.22	15	2.03	63	1.42
28	Chemicals & Allied Products	974	13.0	59	5.41	398	11.60	112	15.1	603	13.6
29	Petroleum Refining & Related Industries	107	1.43	10	0.92	40	1.17	19	2.57	63	1.42
30	Rubber & Miscellaneous Plastics Products	270	3.61	1	0.09	142	4.14	23	3.11	181	4.08
31	Leather & Leather Products	26	0.35	9	0.82	5	0.15	5	0.68	12	0.27
32	Stone, Clay, Glass, & Concrete Products	129	1.73	12	1.10	63	1.84	11	1.49	86	1.94
33	Primary Metal Industries	500	6.69	34	3.12	171	4.98	61	8.24	379	8.54
34	Fabricated Metal Products, Except Machinery & Transportation Equipment	429	5.74	67	6.14	181	5.28	51	6.89	267	6.02
35	Industrial & Commercial Machinery & Computer Equipment	657	8.79	47	4.31	269	7.84	71	9.59	415	9.35
36	Electronic & Other Electrical Equipment & Components, Except Computer Equipment	1,589	21.3	244	22.4	802	23.4	139	18.8	998	22.5
37	Transportation Equipment	1,000	13.4	386	35.4	579	16.9	115	15.5	326	7.35
38	Measuring, Analyzing, & Controlling Instruments; Photographic, Medical & Optical Goods; Watches & Clocks	620	8.30	206	18.9	180	5.25	44	5.95	344	7.75
39	Miscellaneous Manufacturing Industries	160	2.14	1	0.09	96	2.80	17	2.30	78	1.76
Total		7,473	100	1,091	100	3,431	100	740	100	4,438	100

Table III Effects of environmental risk on the existence of principal customers

This sample consists of manufacturing firms covered jointly in Compustat and the TRI program between 1988 and 2009. We estimate probit models to capture the effects of environmental risk on the existence of principal customers. *Customer* is a dummy variable that equals 1 if the firm has at least one principal customer, and 0 otherwise. *Government* is a dummy variable that equals 1 if the firm has at least one principal government customer, and 0 otherwise. *Public* (*Private*) is a dummy variable that equals 1 if the firm has at least one principal public (private) customer, and 0 otherwise. *EnvRisk* is percentile ranks of *Weighted Releases/Sales*. *Weighted Releases* is obtained by multiplying the mass of each chemical by its toxicity. *Assets* is the book value of total assets. *Firm Age* is the number of years that elapsed since a firm entered the CRSP database. *EBITDA/Assets* is earnings before interest, taxes, depreciation, and amortization scaled by *Assets*. *SG&A/Assets* is SG&A expenses scaled by *Assets*. *M/B* is the market-to-book ratio defined as (*Assets* + Market value of equity - Book value of equity)/*Assets*. *Leverage* is long-term debt/*Assets*. *Debt Rating* is a dummy variable equal to 1 if the firm has a debt rating assigned by Standard & Poor's, and 0 otherwise. *Tangibility* is net PPE over *Assets*. *R&D/Assets* is R&D expenses scaled by *Assets*. *RNDD* is a dummy variable that equals 1 if R&D expenses are missing, and 0 otherwise. All explanatory variables are measured one year before supplier firms' principal customers are observed. Constant terms, year fixed effects, and four-digit SIC industry fixed effects are included in all regressions, but their coefficients are not reported. Reported coefficients reflect the marginal effects that capture the impact of a one-unit change in explanatory variables on the dependent variable. The z-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedasticity-consistent errors, which are also corrected for correlation across observations for a given firm. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Var.	<i>Customer</i> (1)	<i>Government</i> (2)	<i>Public</i> (3)	<i>Private</i> (4)
<i>EnvRisk</i>	-0.154*** (-4.2)	-0.003 (-1.0)	-0.082*** (-3.3)	-0.004* (-1.9)
<i>Ln(Assets)</i>	-0.090*** (-10.7)	-0.004*** (-5.6)	-0.043*** (-7.7)	-0.005*** (-8.8)
<i>Ln(Firm Age)</i>	-0.014 (-1.4)	0.004*** (4.0)	-0.019*** (-2.9)	-0.000 (-0.5)
<i>EBITDA/Assets</i>	0.126 (1.3)	-0.001 (-0.2)	0.139** (2.2)	0.003 (0.6)
<i>SG&A/Assets</i>	-0.756*** (-8.5)	-0.046*** (-6.1)	-0.307*** (-5.1)	-0.045*** (-6.6)
<i>M/B</i>	0.021* (1.9)	-0.001 (-1.0)	-0.002 (-0.3)	0.000 (0.1)
<i>Leverage</i>	0.017 (0.3)	-0.001 (-0.2)	0.043 (1.3)	-0.000 (-0.0)
<i>Debt Rating</i>	0.075*** (2.8)	0.003 (1.4)	0.035** (2.0)	0.002 (0.9)
<i>Tangibility</i>	-0.000 (-0.0)	-0.020*** (-3.1)	0.044 (0.9)	0.010** (2.1)
<i>R&D/Assets</i>	0.938** (2.5)	0.032 (1.1)	0.683*** (3.0)	0.058*** (2.8)
<i>RNDD</i>	-0.049* (-1.7)	-0.005** (-2.3)	-0.037** (-2.0)	-0.001 (-0.5)
Industry and year fixed effects	Y	Y	Y	Y
N/Pseudo R ²	16,895/0.23	16,895/0.47	16,895/0.23	16,895/0.29

Table IV Effects of environmental risk on customers' supplier choices

This analysis is performed using all customer-potential supplier pairs that are constructed based on actual customer-supplier relationships. For each actual relationship in a given year, we identify potential suppliers as all firms in the same four-digit SIC industry as the actual supplier, and that were covered by the TRI program. We estimate probit models to capture the effects of environmental risk on customers' decisions to choose a supplier among all potential suppliers. The dependent variable, *Supplier*, is a dummy variable that equals 1 if a potential supplier is chosen by a customer as the actual supplier, and 0 otherwise. *EnvRisk* is percentile ranks of *Weighted Releases/Sales*. *Weighted Releases* is obtained by multiplying the mass of each chemical by its toxicity. *Ln(NumSup)* is the log of the number of potential suppliers each customer has. *Alliance* is a dummy variable that equals 1 if any strategic alliance or joint venture was established between the customer and its potential supplier, and 0 otherwise. Other variable definitions are in the legend of Table III. All explanatory variables are measured one year before supplier firms' principal customers are observed. Constant terms, year fixed effects, and four-digit SIC industry fixed effects are included in all regressions, but their coefficients are not reported. Column (1) gives the decisions of both public and private customers. Columns (2) and (3) provide the choices of public and private customers, respectively. Reported coefficients reflect the marginal effects that capture the impact of a one-unit change in explanatory variables on the dependent variable. The *z*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedasticity-consistent errors, which are also corrected for correlation across observations for a given relationship. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Var. = <i>Supplier</i>	Public and Private Customers (1)	Public Customers (2)	Private Customers (3)
<i>EnvRisk</i>	-0.040*** (-3.0)	-0.043*** (-2.7)	-0.029* (-1.9)
<i>Ln(Assets)</i>	-0.030*** (-10.4)	-0.026*** (-7.4)	-0.038*** (-9.9)
<i>Ln(Firm Age)</i>	-0.014*** (-4.0)	-0.018*** (-4.3)	-0.000 (-0.1)
<i>EBITDA/Assets</i>	0.088*** (2.8)	0.129*** (3.3)	0.023 (0.6)
<i>SG&A/Assets</i>	-0.293*** (-8.9)	-0.259*** (-6.7)	-0.369*** (-6.8)
<i>M/B</i>	-0.003 (-0.8)	-0.006 (-1.5)	-0.001 (-0.2)
<i>Leverage</i>	0.031 (1.6)	0.037 (1.6)	0.026 (1.0)
<i>Debt Rating</i>	0.013 (1.5)	0.012 (1.1)	0.006 (0.5)
<i>Tangibility</i>	0.027 (1.0)	0.004 (0.1)	0.090*** (2.6)
<i>R&D/Assets</i>	0.356*** (3.5)	0.342*** (2.8)	0.461*** (3.3)
<i>RNDD</i>	-0.026*** (-2.7)	-0.028** (-2.4)	-0.013 (-1.3)
<i>Ln(NumSup)</i>	-0.103*** (-10.1)	-0.109*** (-8.9)	-0.072*** (-5.0)
<i>Alliance</i>	0.284*** (7.1)	0.272*** (6.4)	0.235*** (2.6)
Industry and year fixed effects	Y	Y	Y
N/Pseudo R ²	42,210/0.13	32,802/0.12	9,408/0.22

Table V Effects of environmental risk on the customer-supplier relationship

This analysis is performed on the basis of actual customer-supplier relationships where customers are public or private firms. *EnvRisk* is percentile ranks of *Weighted Releases/Sales*. *Weighted Releases* is obtained by multiplying the mass of each chemical by its toxicity. Other variable definitions are in the legends of Tables III and IV. In column (1), we estimate Tobit regressions with double censoring, where the dependent variable, *Intensity*, is the fraction of a supplier's sales that are made to the principal customer. Column (2) presents results obtained using the Cox proportional hazard model to examine the effect of environmental risk on the duration of customer-supplier relationships. $\overline{EnvRisk}$ is average *EnvRisk* over the duration of the relationship. Column (3) reports results from the probit model investigating whether environmental risk adversely affects the likelihood of relationship continuation. *Continue* is a dummy variable that equals 1 if a principal customer-supplier relationship continues in year *t*, and 0 otherwise. Constant terms, year fixed effects, and four-digit SIC industry fixed effects are included in all regressions, but their coefficients are not reported. The *z*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedasticity-consistent errors, which are also corrected for correlation across observations for a given relationship. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Var.	(1) Tobit <i>Intensity</i>	(2) Cox	(3) Probit <i>Continue</i>
<i>EnvRisk</i>	-0.024** (-2.0)		-0.041** (-2.0)
$\overline{EnvRisk}$		0.232** (2.1)	
<i>Ln(Assets)</i>	-0.015*** (-5.4)	-0.099*** (-4.1)	0.011** (2.4)
<i>Ln(Firm Age)</i>	-0.010*** (-2.7)	0.111*** (4.2)	-0.000 (-0.1)
<i>EBITDA/Assets</i>	0.030 (1.0)	-1.011*** (-4.5)	0.125** (2.3)
<i>SG&A/Assets</i>	-0.103*** (-3.1)	-0.450* (-1.8)	0.117** (2.1)
<i>M/B</i>	0.006 (1.4)	0.010 (0.4)	0.002 (0.3)
<i>Leverage</i>	-0.022 (-1.3)	-0.241 (-1.5)	0.040 (1.3)
<i>Debt Rating</i>	0.011 (1.3)	-0.075 (-1.0)	0.012 (0.8)
<i>Tangibility</i>	0.067** (2.1)	-0.078 (-0.4)	0.055 (1.4)
<i>R&D/Assets</i>	0.220* (1.9)	1.230** (2.0)	-0.115 (-0.7)
<i>RNDD</i>	0.005 (0.7)	0.130** (2.0)	0.008 (0.6)
<i>Ln(NumSup)</i>	-0.007 (-0.9)	0.125 (1.5)	0.007 (0.5)
<i>Alliance</i>	0.056*** (3.8)	0.004 (0.0)	-0.043 (-1.4)
<i>Intensity</i>		-1.815*** (-8.2)	-0.058* (-1.8)
Industry and year fixed effects	Y	Y	Y
N/Log-likelihood	7,318/5659.5	1,820/-9897.4	6,826/-2924.0

Table VI Endogeneity tests

All regressions include the same control variables as in Tables III-VI, but their coefficients are not tabulated. *Customer* is a dummy variable that equals 1 if the firm has at least one principal customer, and 0 otherwise. *Supplier* is a dummy variable that equals 1 if a potential supplier is chosen by a customer as the actual supplier, and 0 otherwise. *Intensity* is the fraction of a supplier's sales that are made to the principal customer. Column (4) presents results obtained using the Cox proportional hazard model to examine the effect of environmental risk on the duration of customer-supplier relationships. $\overline{EnvRisk}$ is average *EnvRisk* over the duration of the relationship. *Cash/Assets* is the cash-to-assets ratio. *HP* index is $-0.737 \times \ln(Assets) + 0.043 \times \ln(Assets)^2 - 0.04 \times Firm\ Age$. *CAPEX/Sales* is capital expenditure by sales. *COGS/Sales* is costs of goods sold scaled by sales. *Stkrtn* is compounded monthly stock returns calculated over the year. *Charity* is a dummy variable that equals 1 if a firm has at least one strength in the KLD charity-related categories. *CharityDum* is a dummy variable that equals 1 if *Charity* is missing, and 0 otherwise. $EnvRisk_{t-3}$ is percentile ranks of *Weighted Releases/Sales* at $t-3$. $EnvRisk_RRT$ is the toxicity-weighted and log-transformed amount of waste that is treated, recovered, and recycled, scaled by *Sales*. *Prevention* is the toxicity-weighted and log-transformed amount of waste reduced by pollution prevention activities, scaled by *Sales*. In panel E, *EnvRisk* is predicted by the model in appendix A, while $\overline{EnvRisk}$ is calculated based on predicted *EnvRisk*. The z-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedasticity-consistent errors, which are also corrected for correlation across observations for a given firm (column (1)) and a given relationship (columns (2)-(4)). ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively. In panel E, 95% confidence intervals in square brackets are calculated from 500 bootstrap replications of the two-step estimation based on resampling from the dataset with replacement of clusters.

Dependent Var.	Column (1) of Table III (1) Probit	Column (1) of Table IV (2) Probit	Column (1) of Table V (3) Tobit	Column (2) of Table V (4) Cox
	<i>Customer</i>	<i>Supplier</i>	<i>Intensity</i>	
<i>Panel A: Controlling for financial constraints and cash holdings</i>				
<i>EnvRisk</i>	-0.155*** (-4.1)	-0.036*** (-2.7)	-0.022* (-1.8)	
$\overline{EnvRisk}$				0.195* (1.7)
<i>Cash/Assets</i>	-0.159** (-1.9)	-0.003 (-0.1)	0.006 (0.2)	0.213 (1.1)
<i>HP</i> index	0.114** (2.2)	0.006 (0.3)	0.044* (1.9)	-0.036 (-0.2)
<i>CAPEX/Sales</i>	-0.110** (-2.5)	-0.010 (-0.81)	0.047* (1.9)	0.030 (0.1)
<i>COGS/Sales</i>	0.014 (0.6)	-0.005 (-0.96)	0.028 (1.2)	-0.073 (-0.6)
<i>Stkrtn</i>	-0.015 (-1.6)	-0.000 (-0.2)	0.000 (0.2)	0.045 (1.1)
N	16,440	40,917	7,157	1,772
<i>Panel B: Controlling for charitable contribution</i>				
<i>EnvRisk</i>	-0.178*** (-4.5)	-0.048*** (-3.6)	-0.022* (-1.8)	
$\overline{EnvRisk}$				0.206* (1.7)
<i>Charity</i>	-0.013 (-0.3)	0.014 (0.8)	0.005 (0.5)	0.088 (0.4)
<i>CharityDum</i>	-0.000 (-0.0)	-0.011 (-1.3)	-0.000 (-0.1)	0.152* (1.7)
N	13,686	37,375	6,440	1,587
<i>Panel C: Replacing $EnvRisk_{t-1}$ by $EnvRisk_{t-3}$</i>				
$EnvRisk_{t-3}$	-0.141*** (-3.5)	-0.032** (-2.3)	-0.039*** (-3.0)	
$\overline{EnvRisk}_{t-3}$				0.210* (1.7)
N	14,195	36,878	6,171	1,539
<i>Panel D: Controlling for environmental management and pollution prevention activities</i>				
<i>EnvRisk</i>	-0.154*** (-4.1)	-0.037*** (-2.8)	-0.023* (-1.9)	

$\overline{EnvRisk}$				0.240**
				(2.0)
$EnvRisk_RRT$	0.018	-0.013	0.020	0.088
	(0.3)	(-0.7)	(0.8)	(1.3)
$Prevention$	-0.041	-0.020	-0.020	-0.089
	(-0.6)	(-0.9)	(-0.8)	(-1.2)
N	16,895	42,210	7,318	1,656
<i>Panel E: Employing a two-step bootstrapping approach</i>				
$EnvRisk$	-0.239	-0.161	-0.030	
	[-.417,-.061]	[-.303,-.019]	[-.055,-.004]	
				0.742
$\overline{EnvRisk}$				[.168,1.31]

Table VII Cross-sectional differences in the effects of environmental risk on customer-supplier relationships

This table divides firms into subsamples and re-estimates Equations (2)-(4). All regressions include the same control variables as in Tables III-VI, but their coefficients are not tabulated. *Supplier* is a dummy variable that equals 1 if a potential supplier is chosen by a customer as the actual supplier, and 0 otherwise. *Intensity* is the fraction of a supplier's sales that are made to the principal customer. Columns (5)-(6) present results obtained using the Cox proportional hazard model to examine the effect of environmental risk on the duration of customer-supplier relationships. $\overline{EnvRisk}$ is average *EnvRisk* over the duration of the relationship. In columns (1)-(4), a firm is classified as having customers with high (low) environmental risk if their customers' environmental risk is above (below) the sample median. In columns (5)-(6), a firm is classified as having customers with high (low) environmental risk if their customers' environmental risk over the duration of the relationship is above (below) the sample median. The *z*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedasticity-consistent errors, which are also corrected for correlation across observations for a given relationship. ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Var.	Column (1) of Table IV		Column (1) of Table V		Column (2) of Table V	
	(1) Probit	(2) Probit	(3) Tobit	(4) Tobit	(5)	(6)
	<i>Supplier</i>	<i>Supplier</i>	<i>Intensity</i>	<i>Intensity</i>	Cox	Cox
	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>	<i>Low</i>	<i>High</i>
<i>EnvRisk</i>	-0.047** (-2.0)	0.017 (0.5)	-0.067*** (-2.8)	0.028 (1.1)		
$\overline{EnvRisk}$					0.446* (1.7)	0.176 (0.6)
N	8,455	9,175	1,445	1,642	425	425

Table VIII Alternative measure of environmental risk

This sample consists of manufacturing firms covered jointly in Compustat and the KLD database between 1992 and 2009. The net score of KLD environmental rating (*EnvRisk_KLD*) is used as an alternative measure of environmental risk. *EnvRisk_KLD* is defined as total environmental concerns minus total environmental strengths. *Customer* is a dummy variable that equals 1 if the firm has at least one principal customer, and 0 otherwise. *Supplier* is a dummy variable that equals 1 if a potential supplier is chosen by a customer as the actual supplier, and 0 otherwise. *Intensity* is the fraction of a supplier's sales that are made to the principal customer. Column (4) presents results obtained using the Cox proportional hazard model to examine the effect of environmental risk on the duration of customer-supplier relationships. *EnvRisk_KLD_Dum* is a dummy variable that equals 1 if the average *EnvRisk_KLD* over the duration is greater than or equal to 0, and 0 otherwise. Other variable definitions are in the legends of Tables III and IV. All regressions include year and industry fixed effects, defined based on two-digit SIC code. The z-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedasticity-consistent errors, which are also corrected for correlation across observations for a given firm (column (1)) and a given relationship (columns (2)-(4)). ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Var.	(1) Probit <i>Customer</i>	(2) Probit <i>Supplier</i>	(3) Tobit <i>Intensity</i>	(4) Cox
<i>EnvRisk_KLD</i>	-0.031** (-2.1)	-0.007*** (-3.0)	-0.007* (-1.8)	
<i>EnvRisk_KLD_Dum</i>				0.238* (1.8)
<i>Ln(Assets)</i>	-0.039*** (-3.5)	-0.003** (-2.3)	-0.006** (-2.2)	-0.045 (-1.4)
<i>Ln(Firm Age)</i>	-0.025** (-2.0)	-0.005*** (-3.4)	-0.009** (-2.6)	0.029 (0.9)
<i>EBITDA/Assets</i>	0.479*** (5.5)	0.048*** (4.9)	-0.044* (-1.8)	-0.591*** (-3.2)
<i>SG&A/Assets</i>	-0.247*** (-3.7)	-0.005 (-0.7)	-0.107*** (-5.1)	-0.706*** (-4.3)
<i>M/B</i>	-0.018** (-2.5)	-0.002*** (-2.7)	-0.000 (-0.1)	-0.004 (-0.2)
<i>Leverage</i>	0.016 (0.2)	0.018** (2.4)	-0.016 (-0.9)	-0.158 (-0.9)
<i>Debt Rating</i>	0.024 (0.8)	-0.005 (-1.3)	-0.002 (-0.2)	-0.107 (-1.4)
<i>Tangibility</i>	-0.240*** (-2.8)	-0.015 (-1.2)	0.017 (0.5)	-0.103 (-0.5)
<i>R&D/Assets</i>	0.205 (1.2)	0.032* (1.9)	0.203*** (4.0)	0.264 (0.7)
<i>RNDD</i>	-0.057* (-1.7)	-0.005 (-0.8)	0.001 (0.1)	-0.193** (-2.0)
<i>Ln(NumSup)</i>		-0.044*** (-8.6)	-0.001 (-0.4)	0.074** (2.5)
<i>Alliance</i>		0.107*** (7.0)	0.068*** (5.0)	0.109 (1.0)
<i>Intensity</i>				-1.309*** (-5.5)
Industry and year fixed effects	Y	Y	Y	Y
N/Log-likelihood	10,010/-5919.9	68,388/-13179.0	5,877/1481.9	1,836/-7993.4

Essay Two:

Corporate Environmental Liabilities and Capital Structure

Abstract

We investigate the capital structure implications of corporate environmental liabilities, which are captured using the amount of firms' toxic production-related waste. We document that firms with higher environmental liabilities maintain lower financial leverage ratios, suggesting that environmental liabilities work as a substitute for financial liabilities. The substitution effect is more pronounced for larger firms, firms covered by more analysts, firms that have higher sales to principal customers, and firms with greater community concerns. Further analysis shows that less environmentally responsible firms have a lower fraction of bank debt in total debt, all else equal, consistent with the notion that banks are more environmentally sensitive than other lenders. Overall, our findings imply that being environmentally responsible can enhance firms' debt capacity and improve the availability of bank credit.

“Dirty Secrets - Companies may be burying billions more in environmental liabilities than their financial statements show...But few investors understand the true magnitude of the threat that toxic liabilities - environmental liabilities, that is - pose to the financial health of some U.S. businesses.”

CFO Magazine (2009)

I. Introduction

The U.S. Environmental Protection Agency (EPA hereafter) define environmental liabilities as “*legal obligations to make future expenditures due to the past or ongoing manufacture, use, release, or threaten release of a particular substance, or other activities that adversely affect the environment*” (EPA 1996). Both anecdotal evidence and empirical studies suggest that environmental liabilities are staggering. For instance, according to a study by the United Nations, the annual global environmental expenses are around US\$6 trillion in 2010, which amounts to 11% of the global GDP. Barth and McNichols (1994) estimate firms’ environmental liabilities under Superfund and find that the average amount of unrecognized environmental liabilities is roughly 28.6% of the market valuation of equity.⁴⁰

Given the sheer magnitude of corporate environmental liabilities and the drastically increasing attention that environmental issues have received, we aim to examine the capital structure implications of corporate environmental liabilities. In particular, we ask, while companies keep most of environmental liabilities as off-balance-sheet liabilities, do they treat environmental liabilities

⁴⁰The United Nations study is described at <http://www.environmentalleader.com/2010/10/05/un-estimates-annual-global-environmental-costs-equal-6-trillion/>. As additional firm-level evidence, Exxon Mobil spent \$5.5 billion on environmental expenditures for pollution controls and made a provision of additional environmental liabilities of \$391 million in 2012. The sum of the two expenses accounts for 13% of the net income of \$44.8 billion. Clarkson, Li, and Richardson (2004) study the future pollution abatement obligations of firms in the pulp and paper industry and document that the average unbooked liabilities for high-polluting firms are approximately 16.6% of the market capitalization. Carroll et al. (2004) examine the claims for injuries from asbestos litigations and state that the estimated costs range from \$200 to \$265 billion.

as a substitute for financial on-balance-sheet liabilities?⁴¹ Do companies' observed financial leverage ratios vary according to their environmental liabilities?

Environmental liabilities are legally binding obligations and share important characteristics of financial debt. Firms with substantial environmental liabilities make regular and legally mandated outlays to achieve and maintain compliance with environmental laws and regulations. Similar to interest expense on financial debt, environment-related expenses and investments are tax-deductible. Failure to demonstrate compliance may lead to substantial non-compliance induced environmental liabilities and can even trigger bankruptcy.⁴² Based on these debt-like features and building on the trade-off theory of capital structure, we expect environmental liabilities to be negatively related to the use of financial debt for four reasons.

First, environmental outlays reduce taxable income, thereby lowering firms' marginal tax rates, which are defined as the present value of the tax obligation from earning an extra dollar today. DeAngelo and Masulis (1980) argue that each firm has an optimal amount of total tax deductions and that non-debt tax shields (NDTS) substitute for interest tax deductions. Thus, to the extent that environment-related outlays are an important source of tax savings, firms with higher environmental liabilities should have weaker tax incentives to use financial debt, all else equal. Second, environmental outlays reduce the amount of cash flows available to service financial debt obligations, thus lower firms'

⁴¹ We discuss the accounting treatment of environmental liabilities in Section II.B.

⁴² For example, asbestos liability, a typical non-compliance induced environmental liability, is treated as a special type of debt in the sense that it is a fixed non-equity claim on the firm's assets with bankruptcy priority (Hadlock and Sonti 2011). Eighty-five firms have filed for bankruptcy due to asbestos liabilities at the end of 2002 (White 2002). Solutia Inc. and Tronox Inc. filed for bankruptcy in 2003 and 2009, respectively, due to significant unbooked environmental liabilities.

capacity for financial debt.

Third, environmental liabilities increase firms' business risk. Environmental liabilities imposed through violations are unpredictable, substantial, and highly impactful (Barth and McNichols 1994; White 2002; Clarkson et al. 2011; Schneider 2011; Li, Simunic, and Ye 2014). Clarkson et al. (2011) and Flammer (2013) show that poor environmental performance contributes significantly to firms' future operational risk and poor financial performance. Facing increasingly more stringent environmental regulations, firms with high environmental liabilities are inevitably subject to more uncertainties arising from market demand due to damaged reputation, operating costs associated with waste management and future compliance, future litigation and enforcement activities, and the cost of external financing (e.g., Gormley and Matsa 2011; Chava 2014; Li, Simunic, and Ye 2014), all of which would increase firms' likelihood of financial distress and bankruptcy, thereby reducing their use of financial debt.

Finally, supply side factors may also play a role. Environmentally sensitive lending has increased markedly over the last two decades. A large number of banks, which account for about 80% of the global lending volume, have adopted the Equator Principles (<http://www.equator-principles.com/>) and agreed to consider social and environmental issues in their lending decisions (Chava 2014).⁴³ Chava (2014) also argues that when lending to firms with environmental concerns, lenders face multiple risks, which include borrowers' credit risk caused by environmental regulations and compliance, litigation risk under lender liability laws, and reputation risk arising from association with

⁴³ Cogan (2008) reports that many large and publicly traded banks around the globe use reducing greenhouse gas emissions as a target and emphasize clean and renewable energy in their lending portfolios.

polluting firms.⁴⁴ Accordingly, he documents that lenders charge a significantly higher interest rate on the bank loans issued to firms with higher environmental liabilities and avoid lending to firms with severe environmental concerns. We thus expect that firms' environmental liabilities hamper credit supply, especially that from large and highly visible banks. In sum, the preceding four arguments all suggest that firms with higher environmental liabilities should have lower debt ratios, all other things being equal.

We quantify environmental liabilities using non-financial measures provided by the EPA's Toxic Release Inventory (TRI) program, which collects data on release and management of over 650 toxic chemicals by thousands of facilities in the United States. The database is by far the most comprehensive database about waste production and releases by operating facilities in the United States. We compute a firm's total waste produced (in pounds) in all facilities. To account for the differences in toxicity across chemicals, in calculating the total waste produced, the amounts of individual chemicals produced are weighted by their respective toxicity defined by the EPA. Our main proxy for environmental liabilities is then defined at the firm-year level as the natural log of toxicity weighted production waste scaled by total sales.

Using a large panel of US firms that are covered by both the Compustat database and the TRI program over the period of 1992-2013, we find that firms with higher environmental liabilities maintain lower financial leverage ratios. A one-standard deviation increase (0.175) in environmental liabilities

⁴⁴ Chava (2014) points out that lenders are potentially liable for environmental damage caused by borrowers under the terms of the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) and its Superfund Amendments, the Resource Conservation and Recovery Act, the Clean Water Act, the Clean Air Act, and the Toxic Substance Control Act, among others. He also gives several examples illustrating that lenders' reputation can be adversely affected by the bad publicity and social attitudes of polluting borrowers.

decreases the leverage ratio by 7.5% from its mean value (0.255). This economic impact on the leverage ratio is similar to that of the market-to-book ratio, which has been shown by previous studies (e.g., Rajan and Zingales 1995) as one of the most important determinants of capital structure.

The negative relation between environmental liabilities and financial leverage is robust to alternative model specifications and different variable definitions. Furthermore, we perform several tests to mitigate endogeneity concerns caused by omitted variables and reverse causality. Among these tests, we employ an instrumental variable approach using two instrumental variables, i.e., (1) the weighted-average physical distance between EPA regional office and the firm's facility, and (2) the weighted average unemployment rate of the state in which a firm's facility operates. The main results still hold, supporting a causal relation between environmental liability and firms' capital structure.

To further substantiate our main findings, we employ several alternative measures of environmental liabilities. The first one is a dollarized measure of environmental liabilities capturing the financial expenses incurred by firms in complying with environmental laws and regulations. It is obtained by estimating the functional relation between the amount of toxic production-related waste and the sum of the cost of goods sold and capital expenditure. The second measure is from the Enforcement and Compliance Historical Online (ECHO) database that provides information about "compliance and enforcement information for approximately 800,000 EPA-regulated facilities". From the ECHO database, we calculate the total cost imposed by the EPA or courts on firms for violating environmental regulations. Moreover, we rely on four alternative environmental data sources, namely, KLD Research &

Analytics (KLD), Newsweek Green Rankings, Thomson Reuters Asset4, and Trucost to construct the environmental liability measures that capture not only toxic chemicals generated, but also various potential environmental damage costs and poor environmental policies and reputations. Our findings are robust to these alternative measures of environmental liabilities although sample size varies drastically.

Further analysis shows that the negative effect of environmental liabilities on financial leverage varies across firms and over time. In particular, the effect is more pronounced for firms with greater visibility, i.e., larger firms and firms covered by more analysts. We also find that the effect becomes stronger after the Financial Accounting Standards Board (FASB) enacted FIN 47 in 2005, which improves corporate environmental disclosure and increases recognition of environmental liabilities. In addition, firms that rely more heavily on principal customers and those with greater community concerns are found to exhibit a stronger substitution between environmental liabilities and financial liabilities.

Finally, we find that firms with higher environmental liabilities have a lower fraction of bank debt in total debt after controlling for the difference in financial leverage across firms. This finding is consistent with banks being more concerned about reputation risk and litigation risk in their lending decisions because their identities are more easily identified than other lenders, such as corporate bond holders (e.g., Chava 2014).

Our paper contributes to the corporate social responsibility (CSR hereafter) literature that examines the relation between CSR and various corporate

policies.⁴⁵ In particular, we present empirical evidence on the effects of environmental liabilities on capital structure. Prior studies have documented that CSR or corporate environmental performance affects the *absolute* levels of the cost of equity and the cost of debt (e.g., Bauer and Hann 2010; Schneider 2011; El Ghouli et al. 2011; Dhaliwal et al. 2011; Chava 2014; El Ghouli et al. 2014). We complement these studies by investigating the leverage ratio, which is determined by firms' choice between debt and equity and captures the *relative* importance of the effects of environmental liabilities on the cost of debt and the cost of equity. In addition, to the best of our knowledge, we are among the first to empirically show that corporate environmental liabilities influence the fraction of bank debt in total debt. Furthermore, while a number of studies suggest that companies can do well (in terms of firm value and operating performance) by doing good for the environment and society (e.g., Orlitzky, Schmidt, and Rynes 2003, Guenster et al. 2011), few studies have examined the specific channels through which being socially responsible brings economic benefits. Our findings imply that being environmentally responsible can enhance firms' debt capacity and improve the availability of bank credit.

Our analysis also contributes to the capital structure literature. By showing environmental liabilities as an important determinant of capital structure, our study adds to the stakeholder theory of capital structure and reveals the importance of society stakeholders in influencing firms' financing decisions.⁴⁶

⁴⁵ For example, firms with irresponsible CSR activities are more aggressive in avoiding taxes (Hoi, Wu, and Zhang 2013) and manipulating earnings (Kim, Park, and Wier 2012). Deng, Kang, and Low (2013) provide evidence that acquirers' CSR has a positive effect on the investment quality and post-merger long-term performance. Albuquerque, Durnev, and Koskinen (2014) show that CSR lowers consumers' price elasticity and decreases systematic risk. Gao, Lisic, and Zhang (2014) document a negative association between CSR and insider trading profits.

⁴⁶ Maksimovic and Titman (1991) argue that employees and other stakeholders of a firm are reluctant to do business with a highly levered firm because of the concern about the highly-

Moreover, while the bulk of capital structure research has focused on explaining the leverage choice as it is reported on the balance sheet, several studies have shown that off-balance-sheet liabilities, such as operating leases and pension liabilities, work as substitutes for on-balance-sheet financial debt (e.g., Graham, Lemmon, and Schallheim 1998; Shivdasani and Stefanesco 2011). We extend this literature by documenting the substituting effect of environmental liabilities on financial debt. Finally, our results help explain why firms appear to be underleveraged from a tax perspective (Graham 2000) - firms' debt policy should be less conservative in their capital structure decisions than has been previously thought, once environmental liabilities are accounted for.

The remainder of the paper is organized as follows. Section II discusses the important features of environmental liabilities and reviews the relevant literature briefly. We discuss our sample, variables, and summary statistics in Section III. Section IV presents our main empirical results regarding the effect of environmental liabilities on financial leverage. Section V reports additional analysis. Section VI concludes.

II. Institutional Features of Environmental Liabilities and the Literature Review

A. Debt Features of Environmental Liabilities

Environmental liabilities, according to the EPA's definition outlined in

levered firm's ability to honor its obligations, explicit or implicit. Banerjee, Dasgupta, and Kim (2008) and Bae, Kang, and Wang (2011) provide empirical evidence in support of the predictions of Maksimovic and Titman's (1991) model. While the extant literature on nonfinancial stakeholders is mainly from the perspective of customer-supplier relations and the workforce, our study provides evidence on the role of the environment, an important society stakeholder, in a firm's financing decisions.

Section I, are the legal obligations governed by various environmental laws or regulations at federal, state and local levels, or even by the common law. Given their diverse sources, environmental liabilities can be further divided into six broad categories: (1) obligations to achieve and maintain compliance with environmental regulations and laws; (2) obligations imposed by pollution remediation or clean up laws; (3) obligations to pay civil and criminal fines and penalties for noncompliance; (4) obligations to compensate private parties for injury to human health, property and economic activity; (5) obligations to pay punitive damages for remiss conduct; (6) obligations to compensate governments for damages to natural resources (Barth and McNichols 1994; EPA 1996). Unlike the first category of environmental liabilities, categories (2)-(5) are conditional on firms' failure to demonstrate compliance and are often associated with accidents or uncontrollable events. These categories of liabilities are enforced either by public agencies or through private parties' suits. Though occasionally imposed, non-compliance induced environmental liabilities also entail a series of regular outlays over a long period of time until the violations are entirely corrected.⁴⁷

Environmental liabilities have several key characteristics in common with financial debt. First, to achieve and maintain compliance with environmental laws and regulations, companies incur environmental operating expenses for environmental management activities, which are necessary for properly treating, recycling, recovering, and disposing pollutants prior to direct releases into the environment. In addition, capital expenditures are often made to purchase

⁴⁷ In particular, remediation liabilities require initial capital expenditures, followed by ongoing operating, maintenance, and monitoring expenses for more than 30 years (Barth and McNichols 1994). Also, compensation liabilities, such as asbestos liabilities, have long-lived nature due to the long-running mass tort litigations (Hadlock and Sonti 2011).

pollution control equipment and achieve pollution prevention through technology innovation, raw material substitution, or process modification.⁴⁸ These environmental outlays are regularly incurred on a long-term basis because environmental standards are constantly revised and new obligations are continuously imposed, and also because it usually takes years for firms to fully comply with new environmental regulations or laws. Thus, environmental liabilities are legally binding obligations that result in substantial and continuous outlays on a regular basis.⁴⁹ Second, environmental outlays are tax deductible, much like interest expenses on financial debt. Third, failure to comply with environmental obligations can lead to substantial penalties, compliance costs, operation shutdowns, or even bankruptcy. The possible claimants include governments at different levels, communities, and individuals. In terms of priority, the claims are junior to secured debt but senior to unsecured debt (e.g., Rogers 2005).

However there are also important differences between environmental liabilities and financial debt. For instance, unlike financial debt, most environmental liabilities have no pre-specified maturity date. The principal value of environmental liabilities may fluctuate drastically in response to the development of environmental technologies and the changes in environmental regulations over time, and thus is nearly impossible to precisely estimate in

⁴⁸ For example, according to a report provided by the American Petroleum Institute, the petroleum industry has invested more than \$148 billion toward improving the environmental performance of its operations and facilities during 1990–2005. In 2005, the environmental outlays hit \$12.4 billion. While \$1.7 billion was spent for “research and development, corporate environmental programs, and spill remediation”, \$10.7 billion was spent to “implement technologies, create cleaner fuels, and finance environmental initiatives”.

⁴⁹ For instance, the EPA introduces four new environmental regulations to the electric power sector in 2011. The initial deadline falls between 2013 and 2018. Apart from maintaining the current compliance, firms in the industry need to invest approximately \$10 billion annually to meet the emerging standards. Furthermore, firms make continuous environmental expenditures to enhance environmental reputation capital, which reduces litigations risk (Boone and Uysal 2012) and strengthens relationships with stakeholders (e.g., Jones 1995; Chang et al. 2014).

dollar terms. In addition, firms have the flexibility to incur more environmental outlays in high marginal tax states of the world to maximize the tax benefits, a feature not present with financial debt. As a result, environmental liabilities and financial debt are unlikely to be *perfect* substitutes.

B. Financial Accounting for Environmental Liabilities

The Financial Accounting Standards Board (FASB) established FAS 5/FIN 14 in 1975 as the underlying framework for the accounting and disclosure of environmental liabilities. FAS 5/FIN 14 requires that environmental costs must be “reasonably estimable” in order to be accrued. Moreover, FAS 5 pertains only to losses or asset impairments up to the end of the accounting period. Future commitments, such as modifying production processes to prevent or reduce pollution, generally are not considered (Roberts 1995). Firms are also allowed to avoid the accrual of environmental liabilities if they can demonstrate that the liabilities do not exceed the low recognition threshold specified by FAS 5. Thus, several third-party investigations conducted in the 1990s reveal that FAS 5/FIN 14 results in disparate and inconsistent accounting practices and widespread underreporting of environmental liabilities (Lee and Trabucchi 2008).

FAS 143 was issued in 2003 by FASB to directly address the accounting of environmental liabilities. It mandates that environmental liabilities should be accounted for using the fair-value cost estimation methodology, which considers multiple cost estimate scenarios and probabilities instead of using the minimum allowed under FAS 5. FIN 47 further clarified FAS 143 and became effective in 2005. It requires the recognition of the fair value of environmental

liabilities in the period in which they are incurred, even if the liabilities are conditional on future events such as the timing and method of settlement of the obligations. The effect of FIN 47 has been the immediate recognition of previously unrecorded environmental liabilities and the reevaluation of previously recorded liabilities (Lee and Trabucchi 2008).

Despite positive changes in accounting standards in recent years, most of the environmental liabilities are off the books over our sample period (1992-2013) because most companies have not established rigorous procedures that consistently identify, measure, and report environmental liabilities associated with properties and facilities owned and operated by them. Our empirical analysis thus mainly relies on non-financial measures that are supposed to be highly correlated with the magnitude of environmental liabilities.

C. A Brief Review of Relevant Literature

Our paper is closely related to recent studies examining how corporate social responsibility impacts companies' costs of financing. Bauer and Hann (2010) document that environmental performance affects the solvency of borrowing firm and that environmental concerns are associated with a higher cost of debt financing and lower credit ratings. Schneider (2011) finds that corporate environmental performance negatively affects bond yields in the paper and pulp and the chemical industries. El Ghouli et al. (2014) find that firms with higher corporate environmental responsibility have cheaper equity financing. Dhaliwal et al. (2011) show that firms with superior CSR performance are more likely to voluntarily disclose their CSR strategies, thereby reducing information asymmetry and enjoying a lower cost of equity capital. Cheng, Ioannou, Serafeim (2014) document that firms with better CSR

performance face significantly lower capital constraints through enhanced stakeholder engagement and increased transparency. Chava (2014) shows that firms with more environmental concerns have higher costs of equity and debt capital. While these recent studies have documented that CSR or corporate environmental performance affects both the cost of equity and the cost of debt, by looking at the effects of environmental liabilities on the financial leverage ratio, we essentially investigate the choice between debt and equity and evaluate the cost of equity relative to the cost of debt, instead of trying to evaluate the absolute cost of equity or debt.

Our study also complements the literature on off-balance-sheet liabilities. Several studies show that firms have sizable liabilities that are not recorded on the balance sheet, and that these liabilities are negatively related to the amount of on-balance-sheet debt used by firms. For example, Graham, Lemmon, and Schallheim (1998) study operating leases as an off-balance-sheet liability and find that firms with low marginal tax rates use more operating leases and have lower levels of financial debt. Shivdasani and Stefanescu (2011) consider pension liabilities and show that one percentage point increase in the pension liability to total assets ratio is associated with a 0.36 percentage point decrease in the financial leverage ratio. We are among the first to provide evidence that environmental liabilities also have a partial substitution effect on financial debt.

Another closely related strand of the capital structure literature aims to understand why firms appear to be underleveraged from a tax perspective. Graham (2000) shows that firms are generally very conservative in their capital structure. The typical firm in his study could double tax benefit by issuing more financial debt until the marginal tax benefit begins to decline. This

conservatism is often thought to be puzzling because tax benefits are a highly important determinant of financing decisions to most CFOs surveyed by Graham and Harvey (2001). To explain the debt conservatism puzzle, recent studies have suggested a number of factors, which include supply side constraints faced by lenders (Faulkender and Petersen 2006), distress risk premia (Almeida and Philippon 2007), depreciation and tax credits (Schallheim and Wells 2006), employee stock option expenses (Graham, Lang, and Shackelford 2004), the tax shield provided by defined benefit pension contributions (Shivdasani and Stefanescu 2011), the CEO and governance characteristics (Strebulaev and Yang 2013), and the risk of losing intellectual property to rivals (Klasa et al. 2014). As discussed in Section II.A, environmental outlays are substantial, provide a source of valuable tax shields, and may be timed to lower the marginal tax rate and tax benefits for financial debt. Once environmental liabilities are taken into account, firms should be less conservative in their choice of leverage than what they report on the balance sheet. Thus, our findings complement the existing explanation for debt conservatism.

III. Data, Variables, Models, and Summary Statistics

A. Data and Sample

Our sample consists of all firms that are included in the Compustat database and have at least one facility that reports to the EPA's TRI program at any point between 1992 and 2013. To measure environmental liabilities, we mainly rely on toxic waste data reported by firms under the TRI program. Financial data are from the Compustat Industrial Annual files. The amount of

bank debt is collected from the Capital IQ database. Data on stock prices and returns are retrieved from the Center for Research in Security Prices (CRSP) files. Dollar values are converted into 2005 constant dollars using the GDP deflator.

We start the sample period in 1992 since the Pollution Prevention Act (PPA), which requires firms to provide detailed information about facility-level waste management and source reduction activities, took effect in 1991 and we use one-year lagged value of environmental liability measures in regressions so that they are available when firms make financing decisions in a given year. Following standard practice, we exclude financial, insurance, and real estate companies (SIC codes 6000–6900) because their capital structures are likely to be significantly different from the industrial companies in our sample.⁵⁰ Also discarded are firms with missing values for environmental liability and for the variables employed in our regression analysis. These restrictions lead to an unbalanced panel that consists of 18,070 firm-year observations from 1,698 firms. To the best of our knowledge, the size of our sample is larger than those in previous studies that use the EPA’s TRI data.⁵¹

B. Measuring Environmental Liabilities

As the current securities regulations and accounting standards leave firms considerable discretion in their environmental reporting, the environmental

⁵⁰ Some previous studies on capital structure (e.g., Frank and Goyal 2003) exclude regulated utilities (SIC codes 4900–4999) because their financial policies are governed by regulatory requirements. We keep utilities companies in the analysis because utilities are among the most important heavily-polluting industrial sectors covered by the TRI database (Delmas and Toffel 2008). Our results (untabulated), however, remain qualitatively the same if we discard regulated utilities firms.

⁵¹ Previous studies either limit their samples to certain industries (e.g., Clarkson, Li, and Richardson 2004; Schneider 2011) or use TRI data from third parties which cover a subset of companies (e.g., Al-Tuwaijri, Christensen, and Hughes II 2004; and Chatterji and Toffel 2010).

disclosure made by firms are often incomplete and inaccurate (Barth, McNichols, and Wilson 1997; Schneider 2011). We thus follow prior studies and rely on nonfinancial pollution measures from the TRI program to assess firms' environmental liabilities.⁵² Compared with environmental performance metrics created by major social raters, the TRI program offers more objective and verifiable measures of corporate environmental performance, because it is under rigorous monitoring by EPA and contains very few subjective assessments.⁵³ In addition, the TRI data is less subject to selection biases as firms' environmental reporting is legally mandated.

The TRI program was established by the Section 313 Emergency Planning and Community Right-to-Know Act (EPCRA) of 1987 and has been expanded to contain information on over 650 toxic chemicals from more than 20,000 U.S. industrial facilities. Each year, facilities are required to report to TRI the quantities of chemicals disposed or released into the environment (air, water, and land) and those that are treated, recycled, and recovered.⁵⁴ As our study mainly focuses on the on-going and future environmental liabilities caused by continuous production activities, chemicals released into the environment as a result of one-time accidents or catastrophic events are excluded when calculating the facility-level waste. Unreported robustness checks show that including releases caused by one-time accidents or catastrophic events has no

⁵² Barth and McNichols (1994) and Hughes (2000) show that nonfinancial pollution measures, i.e., the number of Superfund sites and sulfur dioxide emissions, respectively, capture the exposure of polluting firms to future environmental liabilities. Also see among others, Cormier, Magnan, and Morand (1993), Clarkson, Li, and Richardson (2004), and Carroll et al. (2004).

⁵³ To ensure the accuracy and reliability of the TRI data, EPA “*analyzes data for potential errors, contacts TRI facilities concerning potentially inaccurate submissions, provides guidance on reporting requirements, and takes enforcement actions against facilities that fail to comply with TRI requirement*”.

⁵⁴ A facility is required by law to report to the TRI program if it meets the following three criteria: (1) it has 10 or more full-time employees, (2) its North American Industry Classification System (NAICS) code is covered by the TRI program, and (3) it processes, manufactures, or otherwise uses any listed toxic chemical in excess of the threshold amount.

material impact on our results.

We assume that firms are liable for the total amount of toxic waste, which is defined as the sum of toxic chemicals that are released, treated, recycled, and recovered. Environmental management activities, which include treatment, recovering, and recycling, reflect firms' on-going expenditures for compliance with current environmental laws and regulations, and for meeting self-set environmental performance standards. They are long-term and recurring obligations so long as a firm's production continues to generate any environmentally unfriendly substances. More importantly, the quantity of chemicals released are positively associated with firms' expenditures for compliance with future stringent environmental laws and regulations, the probability of future litigations, enforcement actions, and remediation activities arising from past and on-going environmental contamination as well as serious damages to human health, property, and economic activities. De Franco, Li, and Zhou (2013) show that the TRI's toxic emission data constitutes an important source of non-financial information for analysts to assess firms' future environmental risk exposure and financial prospect.

Specifically, we first calculate the facility-level production-related waste by summing up all the chemical waste in a given year. To account for the inherent heterogeneity of chemicals, we multiply the mass of each chemical by its toxicity, which is taken from the EPA's Risk-Screening Environmental indicator (RSEI) model. EPA provides two toxicity weights based on the exposure path: the inhalation toxicity weight and the oral toxicity weight. We follow EPA's methodology and use the inhalation toxicity weight for releases (transfers) to fugitive air, stack air, and off-site incinerations. The oral toxicity

weight is used for releases (transfers) to direct water and publicly-owned treatment works (POTWs). If the path through which a chemical is released (transferred) is unknown, the higher of the two toxicity weights is used. For chemicals that have no assigned toxicity by EPA, we set toxicity equal to zero.

We then aggregate the toxicity-weighted amounts of waste across facilities owned by the firm to obtain the firm-level toxicity-weighted waste. The aggregation procedure gives rise to many extreme values because of the enormous variation in the toxicity of TRI chemicals, which spans seven orders of magnitude on a pound-for-pound basis. For instance, less-toxic chemicals, such as Formic acid and Ethylene, have toxicity less than 0.5, while the most toxic chemicals, such as, Asbestos and Thorium dioxide, have toxicity equal to 1,000,000. We then log-transform the firm-level toxicity-weighted waste to mitigate the effect of skewness and achieve normality (e.g., Berrone and Gomez-Mejia 2009; Delmas and Toffel 2008), and scale it using total sales to control for production scale. The resulting measure (*EnvLiab*) is our key variable of interest in the regression analysis, with higher values indicating higher environmental liabilities.

We acknowledge that *EnvLiab* offers an incomplete picture of a firm's environmental liabilities since it primarily focuses on toxic production-related waste. This limitation would work against finding a significant relation between environmental liabilities and capital structure. In Section IV.C, we show that our results are robust to alternative definitions and measures of environmental liabilities, which capture various aspects of environmental liabilities.

C. Other Variables

We measure capital structure using the leverage ratio (*Leverage*), which is defined as the ratio of total debt over total assets. The fraction of bank debt in total debt, BD/D , is computed as the amount of bank debt divided by total debt.

In our regression analysis, we control for a set of control variables that have been shown by previous studies as important determinants of financing decisions (e.g., Frank and Goyal 2003; Chang, Hilary, and Dasgupta 2006). Specifically, we include the natural log of total assets ($Ln(Assets)$) to control for firm size. To account for the effect of a firm's life cycle on its financial leverage, we employ the natural log of firm age, $Ln(Firm\ Age)$, which is defined as the number of years elapsed since a firm enters the CRSP database. We use the market-to-book ratio (M/B) to proxy for growth opportunities and use $EBITDA/Assets$ to capture profitability. As companies having more tangible assets are expected to support more debt as these assets can be pledged as collateral, we include the net Property, Plant, and Equipment scaled by total assets ($PPE/Assets$) to account for asset tangibility. Research and development expenses scaled by assets ($R\&D/Assets$) can proxy for a variety of company characteristics, such as the uniqueness of the product (Titman 1984), information asymmetry, or growth potential. We also include an $R\&D$ indicator variable ($RNDD$) that equals one if R&D expenses are missing, and zero otherwise. To control for the risk and financial constraints faced by companies, we include a dividend payout indicator (*Dividend Payer*), Altman's (1968) unleveraged Z -score, and earnings volatility ($\sigma(Earnings)$). We expect that the incentive to take on debt increases with the company's marginal tax rate because of the tax deductibility of interest expenses. Thus, we include the corporate marginal tax rate (MTR) based on the operating income after interest

expenses according to Graham (1996). Faulkender and Petersen (2006) document that companies having access to public bond markets, as measured by having a debt rating, take on more debt. We thus include a debt rating indicator variable (*Debt Rating*), which equals one if a company has a debt rating assigned by Standard & Poor's, and zero otherwise, to capture companies' access to corporate bond markets. Chang, Dasgupta, and Hilary (2006) show that companies with greater analyst coverage have lower leverage. Hence, we control for analyst following by including the maximum number of analysts that make annual earnings forecasts any month over a 12-month period (*NbrAnal*).

D. Summary Statistics

Table I reports the descriptive statistics for all firms in our sample. We winsorize the variables at the top and bottom 1% of their distributions. This approach reduces the impact of extreme observations by assigning the cutoff values to those that are beyond the cutoff points. Our results (untabulated) are qualitatively the same when we truncate (rather than winsorize) the distributions.

[Insert Table I here]

The distributions of raw waste and toxicity-weighted waste are highly skewed. An average (a median) firm in our sample generates 13.6 (0.4) million pounds of waste. The mean (median) value of toxicity-weighted waste is 43.3 billion (378.8 million). Our main measure of environmental liabilities (*EnvLiab*), after log transformation and being scaled by sales, has the mean value equal to 0.063 and has the standard deviation equal to 0.175.

The average (median) firm in our sample has leverage equal to 0.255 (0.245). Table I also reports summary statistics for the control variables described above. Since our sampling approach and variable construction criteria follow the literature, in the interest of brevity, we omit discussion of the descriptive statistics for control variables.

Appendix A tabulates the distribution of firms across industries classified using the two-digit SIC code. The highest fraction of firms is from Electrical Equipment industries (SIC = 36), followed by Chemicals and Allied Products (SIC = 28), Industrial and Commercial Machinery and Computer Equipment (SIC = 35), and Transportation Equipment (SIC = 37). Overall, the firm presence exhibits a large variation across industries. As environmental liability measures tend to be industry-specific (Clarkson, Li, and Richardson 2004), we include two-digit SIC industry fixed effects in our regression analysis to control for heterogeneity along the industry dimension.

IV. The Effect of Environmental Liabilities on Financial Leverage

A. Baseline Results

To study the effect of environmental liabilities on the leverage ratio, we estimate the model

$$Leverage_{i,t} = \alpha + \beta EnvLiab_{i,t-1} + \gamma X_{i,t-1} + \delta Industry_{i,t} + \theta Year_i + \varepsilon_{i,t} \quad (1)$$

where the key explanatory variable, *EnvLiab*, is measured one year before the leverage ratio is observed. The coefficient (β) on *EnvLiab* is expected to be negative. We include the two-digit SIC industry fixed effects (*Industry*) that control for heterogeneity across industries. Also included are year fixed effects (*Year*), which account for macro-economic factors that influence corporate

capital structure.⁵⁵ The standard errors of the estimated coefficients allow for clustering of observations by firm but our conclusions are not affected if we allow clustering by both firm and year.

[Insert Table II here]

Column (1) of Table II presents our baseline results obtained by estimating equations (1). The coefficient estimate on *EnvLiab* is negative and statistically significant (t -statistic = -5.4), indicating that high environmental liabilities reduce firms' financial leverage. Economically, a one-standard deviation increase (0.175) in *EnvLiab* decreases the leverage ratio by 0.019 ($= -0.109 \times 0.175$), which amounts to roughly 7.5% of the average leverage ratio (0.255). To put it into perspective, the market-to-book ratio (M/B), which has been suggested by previous studies to be one of the most important determinants of financial leverage, exhibits similar economic significance. A one-standard deviation increase (0.869) in M/B decreases the leverage ratio by 0.019 ($= -0.022 \times 0.869$). The other control variables generally have signs consistent with those in prior literature (e.g., Frank and Goyal 2003; Chang, Dasgupta, and Hilary 2006). For example, companies that are younger, less profitable, or followed by more analysts have lower financial leverage. In contrast, firms that have credit ratings or make less investment in R&D use more debt in their capital structure. Robustness checks (untabulated) show that qualitatively similar results are obtained if we define *EnvLiab* without log-transforming the firm-level toxicity-weighted waste or if we defining *EnvLiab*

⁵⁵ We do not include firm fixed effects in our main specifications because both *Leverage* and *EnvLiab* are highly persistent variables. The first order autocorrelations for *Leverage* and *EnvLiab* are 0.90 and 0.95, respectively. Zhou (2001) points out that the persistence of key variables can reduce the signal-to-noise ratio and lower the power of panel data estimators. Nevertheless, as we show in robustness checks described below, our main results hold when firm fixed effects are included.

as percentile ranks of the firm-level toxicity-weighted waste scaled by sales.

In columns (2)-(4) of Table II, we show that our baseline results are robust to alternative model specifications and variable definitions. In particular, in column (2) we estimate equation (1) using the Fama-MacBeth (1973) procedure that corrects standard errors for cross-sectional correlations. In column (3) we estimate equations (1) with firm fixed effects that account for unidentified time-invariant firm characteristics. In column (4) we measure financial leverage using total debt divided by the quasi-market value of assets (total assets minus book value of equity plus market value of equity). The coefficients of *EnvLiab* remain both economically and statistically significant.

Taken together, our baseline results in Table II suggest that firms with higher environmental liabilities use less financial debt. These results are consistent with our view that the environmental liabilities lower firms' capacity for financial debt, reduce the tax benefits of debt, and increase firms' business risk.

B. Tests for Endogeneity

We have documented a robust relation between our measure of environmental liabilities and financial leverage, but its causal interpretation remains hypothetical. Our main results are potentially subject to two types of endogeneity. The first type is omitted variable bias. While we have controlled for a standard set of variables that have been shown by previous studies to affect capital structure, the relation that we observe may be spurious if our models omit any variables that affect both capital structure and environmental liabilities. The other possible endogeneity issue is reverse causality running

from capital structure decisions to environmental liabilities. For example, firms may issue debt to finance expenditures on pollution control and prevention activities, resulting in a negative relation between current financial leverage and the total amount of toxic chemical waste. In both cases, the coefficient estimates in Tables II can be biased and inconsistent.

[Insert Table III here]

We perform several tests to alleviate endogeneity concerns, and tabulate the results in Table III. First, we explicitly control for past debt issues (*PastDebt*) and pollution control and prevention activities (*Prevention*). To measure *PastDebt*, we compute the volume of net debt issued over the past three years, and scale it using the book value of assets at $t-1$. Because firms do not disclose the amount of chemicals reduced by pollution prevention activities, we follow Doshi, Dowell, and Toffel (2013) and extrapolate the amount using the production ratio reported by the TRI database.⁵⁶ *Prevention* is then defined as the toxicity-weighted and log-transformed amount of waste reduced by pollution prevention activities and scaled by sales. The results reported in column (1) of Table III indicate that *EnvLiab* remains economically and statistically significant in the leverage regression, suggesting that our results are not driven by omitting pollution prevention activities financed by past debt issues.

In column (2), we use *EnvLiab* _{$t-3$} , instead of *EnvLiab* _{$t-1$} , as the key explanatory variable, because more distantly lagged values of *EnvLiab* should be less correlated with *current* omitted firm characteristics. Similar results are

⁵⁶Specifically, the production ratio of a facility is the production level in the current year divided by the production level in the previous year (Berrone and Gomez-Mejia 2009). We predict the waste level generated in a given year by multiplying the production ratio by the total waste generated in the previous year, and then subtract the actual waste from the predicted waste to obtain the amount of waste that is reduced by pollution prevention.

obtained. In column (3) we employ an instrumental variable approach to further mitigate endogeneity concerns. Specifically, we use two instrumental variables that are likely to satisfy both the relevant and exclusion criteria. The first instrument, $\ln(1+DisPro)$, is the log of one plus the weighted average geographical distance between EPA regional offices and a firm's facilities. We first calculate the geographical distance for each facility-EPA regional office pair, and then weight the distance using the log-transformed toxicity-weighted waste generated by each facility scaled by sales. To the extent that information asymmetries and monitoring costs increase with the physical distance from EPA regional offices, EPA regional offices would be less effective in making more remote firms reduce environmental liability, implying a positive relation between and *EnvLiab*. We use Coval and Moskowitz's (1999) formula to calculate the geographical distance for every facility-EPA regional office pair. The geographic coordinates of reported facilities are provided by the TRI database. The coordinates of EPA's regional offices are based on zip codes from EPA's website.

The second instrument variable, *Unemployment*, is the average unemployment rate among all the states in which a firm's facilities operate, weighted by the log-transformed toxicity-weighted waste generated by each facility scaled by sales.⁵⁷ Kah and Kotchen (2010) document that higher state unemployment rates are associated with fewer public environmental concerns, thereby leading to higher corporate environmental liabilities. These two instrumental variables, however, are not expected to directly influence financial leverage, rather than affecting it through environmental liabilities.

⁵⁷ The state-level unemployment rate data are collected from the U.S. Bureau of Labor Statistics.

We take the instrumental variable approach in the framework of a two-stage least squares (2SLS) regression. The results of the first-stage regression are reported in column (1) of Appendix B. $\ln(1+DisPro)$, and *Unemployment* are found to be significantly and positively related to *EnvLiab* (t -statistics are 4.0 and 10.0, respectively). The instruments pass the relevance test as the F -statistics from the joint test of excluded instruments are significant at the 1% level. The p -values of the over-identification tests are insignificantly different from zero, thereby confirming the validity of these instrumental variables. The results of the second-stage regression, which are reported in column (3) of Table III, reveal that the *EnvLiab* remains economically and statistically significant in leverage regression, implying a causal relation going from environmental liabilities to financial leverage.

C. *Alternative Measures of Environmental Liabilities*

In the section we experiment with several alternative measures of environmental liabilities that are constructed using various data sources. We first measure environmental liabilities using toxic waste that is released into the environment (air, water, and land). We also scale the toxicity-weighted and log-transformed amount of releases by sales. The resulting measure is denoted by *EnvLiab_Release*. Compared with waste recycled, recovered, and treated, waste released is more likely to be related to *future* environmental regulations, litigations, and enforcement actions. The results reported in column (1) of Table IV reveal that *EnvLiab_Release* is negatively and significantly related to *Leverage*.

[Insert Table IV here]

Our main measure of environmental liabilities (*EnvLiab*) is a nonfinancial measure from the TRI program of EPA. By capturing the amount of waste complemented by toxicity information, *EnvLiab* should be highly correlated with, but is certainly not equivalent to the actual *financial* expenses paid by polluters to cope with the toxic waste in the present and in the future. To address this concern, we estimate the dollar amounts of environmental liabilities in several ways as follows.

First, we run the following regression to establish a functional relation between *EnvLiab* and the financial expenses incurred by firms in complying with environmental laws and regulations.

$$(COGS+CAPEX)/Sales_{i,t}=\alpha+\sum_{j=1}^N\beta_jWaste_{ij,t}+\gamma X_{i,t-1}+\delta Firm_i+\theta Year_i+\varepsilon_{i,t} \quad (2)$$

where the dependent variable is the sum of operating expenses, which are measured by the cost of goods sold (*COGS*), and capital expenditure (*CAPEX*) scaled by sales. *Waste* is the amount of chemical *j* (in pounds) deflated by sales. Totally 549 chemicals ($N = 549$) are included in the regression. The underlying assumption of this equation is that *COGS* and *CAPEX* contain respectively current expenses and capital expenditures related to waste management. β_j captures the functional relation between environmental costs and each chemical that a firm reports. *X* represents the control variables included in equation (1). Firm and year fixed effects are added to account for unmodeled firm heterogeneity and unmodeled macroeconomic effects that affect operating expenses and capital expenditure. In addition, by including firm fixed effects, the estimated coefficient β_j captures the sensitivity of current operating expenses and capital expenditures to within-firm variations in the amount of toxic waste.

The results obtained by estimating equation (2) are reported in Appendix C. To save space, the coefficients of 549 chemicals are not tabulated. The dollarized amount of environmental liabilities is then computed as $\sum_{j=1}^N \beta_j Waste_{i,j,t}$ for each year based on all kinds of production-related waste that a firm reports. We then re-estimate equation (1) after replacing *EnvLiab* with $\sum_{j=1}^N \beta_j Waste_{i,j,t}$. The results reported in column (2) of Table IV illustrate that the negative effect of this dollarized proxy for environmental liabilities on financial leverage is significant at the 5% level.

Second, we then focus on a monetized part of environmental liabilities that arises from violations of environmental regulations and laws. EPA's ECHO (Enforcement and Compliance History Online) database contains facilities' compliance records, which include the occurrence of monitoring activities, the determination of violations, enforcement actions to address violations, and the costs associated with enforcement actions between 1992 and 2013.⁵⁸ Since most facilities resolve violations within a year, environmental obligations induced by violations and enforcement actions can be viewed as short-term liabilities. We compute the dollar amount of costs associated with the enforcement actions by summing up penalties, the compliance cost, recovery cost, and the supplemental project cost, and scale the sum by sales.⁵⁹ The resulting measure,

⁵⁸ The examples of violations include excessive pollutants release or failure to meet the toxic chemical handling requirements. EPA catches violations mainly through regular facility inspections and facilities' self-reporting. Once a violation is observed, federal and state governments will work together to force facilities to take actions and assure that these facilities will eventually return to compliance. EPA's ECHO focuses on facilities that violates Clean Air Act (CAA), Clean Water Act (CWA), Resource Conservation and Recovery Act (RCRA), and Safe Drinking Water Act (SDWA), however, it does not contain information on criminal enforcement actions.

⁵⁹ A supplemental environmental project (SEP) is an environmental and public health beneficial project which a violator voluntarily agrees to perform. In return, the project costs can be used to

EnvLiab_ECHO, is then used in the leverage ratio regression. After removing firm-years that are not covered by the ECHO database, the number of observations for this test reduces to 2,890. Nevertheless, the results reported in column (3) of Table IV show that *EnvLiab_ECHO* is negatively and significantly related to *Leverage*.

A potential concern with our analysis is that our main measure of environmental liabilities only captures liabilities associated with a set of toxic chemicals specified by the EPA, and thus is unable to provide a comprehensive picture of a firm's environmental liabilities. To address the issue, we rely on four alternative data sources, namely, Kinder, Lydenberg, and Domini (KLD) Research & Analytics, Newsweek Green Rankings, Thomson Reuters Asset4, and Trucost.

The KLD database has been widely used in prior studies of corporate social responsibility. It provides binary ratings to approximately 80 factors in seven CSR areas based on data from various sources, including company disclosures, media reports, data from government and non-government agencies, and dialogs with companies.⁶⁰ We use the ratings in the environmental concern category to measure corporate environmental liabilities. We first sum up environmental concern items to calculate raw environmental concern scores.⁶¹

offset penalties.

⁶⁰ See among others, El Ghouli et al. (2011), Kim, Park, and Wier (2012), Deng, Kang, and Low (2013), and Di Giuli and Kostovetsky (2014). The seven areas include environment, corporate governance, community, diversity, employee relations, human rights, and product. Each area has a set of strength factors and concern factors.

⁶¹ KLD began to provide a number of environmental concern ratings in 1991, including hazardous waste, regulation problems, ozone depleting chemicals, substantial emissions, agricultural chemicals, and other concerns. In 1999, climate change was added as an additional environmental concern. In 2009, KLD was acquired by RiskMetrics which was subsequently acquired by MSCI in 2010. While hazardous waste, ozone depleting chemicals, and agricultural chemicals were dropped, impact of products & services, biodiversity & land use, and operational waste were added. In 2012, MSCI expanded the environmental concern category by including supply chain management and water management.

To address the concern that the number of environmental concerns varies across the sample period, we follow Deng, Kang, and Low (2013) and create an adjusted measure by dividing the raw environmental scores by the number of environmental concern indicators. The resulting measure is denoted by *EnvLiab_KLD*. By construction, a higher value of *EnvLiab_KLD* indicates a higher level of environmental liabilities. We identify 23,163 firm-year observations that are jointly covered by the KLD database and Compustat between 1992 and 2013.⁶² Column (4) of Table IV presents the results obtained using *EnvLiab_KLD* as a proxy for environmental liabilities. Consistent with the main results using the TRI data, we find that *EnvLiab_KLD* is negatively and significantly associated with the leverage ratio (t -statistic = -5.4), indicating that firms with more environmental concerns maintain lower leverage ratios.

Next, we use Newsweek's green rankings compiled via collaborating with three agencies (i.e., Trucost, KLD Research & Analytics, and CorporateRegister.com) for 500 largest US companies from 2008 onwards. The green ranking is based on three components: the environmental impact score from Trucost, the green policy score derived from KLD, and the reputation score based on data collected by CorporateRegister.com. The three component scores are converted into standardized values called Z-scores. The overall green score is calculated as the weighted sums of the three Z-scores using the weights 45%, 45%, and 10%, respectively.⁶³ We converted the overall green score into

⁶² To be consistent with the analysis using the TRI data, we excluded financial, insurance, and real estate firms and firms with missing values for *EnvLiab_KLD* and for control variables employed in the regressions. Similar results are obtained if we use the raw environmental concern scores.

⁶³ The green scores are retrieved from Newsweek's official website. The background information of the three agencies and the methodology can be found at <http://www.newsweek.com/newsweek-green-rankings-2012-full-methodology-65325>. In 2011, Newsweek changed its data sources and methodology in several ways. First, Sustainalytics,

percentile ranks ranging from 1 (best performing) to 100 (worst performing) and denote the resulting measure by *EnvLiab_Newsweek*. Firms with high potential environmental damage costs and poor environmental policies and reputations are assumed to have high values of *EnvLiab_Newsweek*. The sample size for this test reduces to 1,680 firm-year observations that are jointly covered in the Newsweek Green Rankings and Compustat between 2009 and 2012. Column (5) of Table IV shows that the coefficient on *EnvLiab_Newsweek* remains negative and significant (t -statistic = -1.9), suggesting that firms that are more environmentally responsible have higher financial leverage.

Our third alternative measure of environmental liabilities is the environmental score provided by the Thomson Reuters Asset4 database, which has been widely used by prior studies (e.g., Cheng, Ioannou, Serafeim, 2014; Lys, Naughton, and Wang, 2013). Asset4 provides comprehensive data on the environmental impact of Russell 1000 firms from 2002. To the extent that a firm's environmental scores is directly related to its environmental expenditure, a high environmental score (*EnvLiab_Asset4*) indicates higher environmental liabilities (Lys, Naughton, and Wang, 2013). After matching with the

another ESG research group, replaced KLD Research & Analytics to offer a new environmental management score. Second, a new environmental disclosure score also replaced the old reputation score to incorporate the breadth and quality of corporate reporting of environmental impacts and involvement in key transparency initiatives. Third, Newsweek drop the Z-score method but calculate the green score by weighing the environmental impact score, the new environmental management score, and the new environmental disclosure score using the proportions 45%, 45% and 10%, respectively. Newsweek states that the new weighting scheme not only improves the transparency of the score calculation, but also makes the scores in different years comparable. Finally, Newsweek redefined the industry classification and increased the number of industries from fifteen to nineteen. Nevertheless, the new methodology could affect the distribution of the green score. To examine the changes in the properties of the green score across two regimes, we compare the simple statistics of the green score in 2009 and 2010 versus those in 2011 and 2012. We find that the standard deviations of the green score are about the same in two regimes (10.3 in 2011 and 2012 versus 10.6 in 2009 and 2010) but the average score is much lower in 2011 and 2012 (52.4 versus 70.5). We also examine simple correlations in green score in consecutive years and find that the correlation between 2009 (2011) and 2010 (2012) is 0.89 (0.96) and that between 2010 and 2011 is 0.72. Therefore, though the methodology was changed in 2011, the relative green scores across firms are not very much affected. Newsweek green rankings were not published in 2013.

Compustat database, we obtain a sample of 6,097 firm-year observations between 2003 and 2013. The results, reported in column (6) of Table IV, show that the estimated coefficient on *EnvLiab_Asset4* is negative and significant (t -statistic = -2.6), indicating that firms with higher level of environmental expenditures maintain low leverage ratio.

Finally, we collect information on corporate environmental cost from the Trucost database. Trucost uses a unique methodology to estimate corporate environmental costs based on an input-output model, and is currently the only data source that provides the environmental cost of firms in dollar amount. We identify 6,070 firm-year observations jointly covered by the Trucost and Compustat database between 2002 and 2013. The results are reported in column (7) of Table IV. Environmental cost (*EnvLiab_Trucost*) is negatively and significantly related to leverage ratio (t -statistic = -2.2). Taken together, our main findings are robust to using alternative measures of environmental liabilities from various data sources.

V. Further Analysis

In this section we first examine how our main results vary across time and across firms depending on various firm-specific characteristics. We then study the effect of environmental liabilities on the use of bank debt.

A. *Heterogeneity in the Effect of Environmental Liabilities on Financial Leverage*

To examine how the relation between environmental liabilities and financial leverage varies across firms and over time, we interact *EnvLiab* with several

variables in the leverage ratio regressions. First, while generally there is a lack of consistency and accuracy in environmental reporting, the impact of environmental liabilities should be more likely to be properly recognized when firms are more visible. Moreover, firms with greater visibility are more subject to public scrutiny and have higher reputation risk and litigation risk, thus their financial policy should be more sensitive to environmental liabilities. In other words, we expect the effect of environmental liabilities to be more pronounced for firms with high visibility. We use firm size (Miller 2006) and analyst coverage (Mehran and Peristiani 2010) to measure firms' visibility. We then interact *EnvLiab* with *Ln(Assets)* and *NbrAnal* separately and report the results in columns (1) and (2) of Table V. The interaction terms are negative and significant for both regressions, consistent with our expectations.

[Insert Table V here]

Second, Maksimovic and Titman (1991) and Titman (1984) argue that customers may be reluctant to conduct business with suppliers with high financial leverage or financing difficulties, which weakens suppliers' ability to honour implicit contracts. To the extent that environmental liabilities lower firms' capacity for financial debt and increase firms' business risk, the effect of environmental liabilities on leverage is expected to be stronger for firms that rely heavily on large customers. Thus, we interact the fraction of sales to principal customers (*PriCus*) with *EnvLiab* and report the results in column (3) of Table V.⁶⁴ The interaction term is negative and significant, implying that

⁶⁴ We identify principal customers using the Business Segment File of Compustat. Following Banerjee, Dasgupta, and Kim (2008), we define principal customers as those accounting for 10% or more of a firm's reported sales.

firms with higher environmental liabilities are more likely to maintain lower leverage ratios to mitigate large customers' concerns about their financial health.

Third, local communities, as an important external stakeholder group, can exert pressure on companies via voting in elections, activism within environmental nongovernment organizations, and citizen lawsuits (Delmas and Toffel 2004). Firms with higher environmental liabilities tend to face more pressure on environmental performance and experience more uncertainty about their future financial performance and operations when they have poor relationships with communities. Thus, we expect that the negative impact of *EnvLiab* on *Leverage* will be more pronounced for firms with poorer community relations. To examine how community relations affect our findings, we use the Kinder, Lydenberg, and Domini's (KLD) community rating to measure a firm's community relations (*ComCon*).⁶⁵ We then interact *EnvLiab* with *ComCon* and report the results in column (4) of Table V. The interaction term is negative and significant, suggesting that firms with poor community relations reduce their financial debt more given the increased business risk caused by environmental liabilities.

Last, the FASB's FIN 47 became effective in 2005. Given that its effect has been the immediate recognition of previously unrecorded environmental liabilities and the re-evaluation of previously recorded liabilities (Lee and Trabucchi 2008), we conjecture that the effect of environmental liabilities on capital structure is stronger post-FIN 47. To explore this possibility, we

⁶⁵ Our community relation data is from the KLD database. *ComCon* covers the concern in four categories, namely, investment controversies, negative economic impact, tax disputes, and other concern. A higher value of *ComCon* indicates poorer relations with communities. In addition, to account for missing values of *ComCon*, we include an additional control (*ComConDum*), which equals one if *ComCon* is missing, and zero otherwise. Similar results (untabulated) are obtained if we drop firms with missing values of *ComCon* in the regression.

introduce the indicator variable *Post_FIN47*, which equals one if the observation is in 2005 or later, and zero otherwise. We then augment equation (1) by including *Post_FIN47* and *EnvLiab*×*Post_FIN47* and run the regression without year fixed effects. The results are reported in column (5) of Table V. Consistent with our conjecture, the interaction term is negative and significant, suggesting that the substitution between environmental liabilities and financial liabilities becomes stronger after FIN47 improves corporate environmental disclosure and increases recognition of environmental liabilities.

B. The Effect of Environmental Liabilities on the Use of Bank Debt

We then examine the effect of environmental liabilities on the fraction of bank debt in total debt. We expect that compared with other creditors (e.g., corporate bond holders), banks are more sensitive to borrowers' environmental liabilities, since they are more identifiable and more likely to be held responsible for environmental damages caused by borrowers. We employ the following model to study the relation between environmental liabilities and the use of bank debt in total debt.

$$(BD/D)_{i,t} = \alpha + \beta EnvLiab_{i,t-1} + \gamma Leverage_{i,t-1} + \rho Z_{i,t-1} + \delta Industry_{i,t} + \theta Year_i + \varepsilon_{i,t} \quad (3)$$

where we include *Leverage* as a control variable as previous studies document a negative relation between the use of bank debt and leverage (Houston and James 1996; Denis and Mihov 2003). Our bank debt sample starts from 1994 as Capital IQ has been collecting detailed information on debt structure from 1994. We exclude firm-years with missing or zero total debt. The number of observations is reduced to 14,831.⁶⁶

⁶⁶ The number of observations is reduced as the coverage by Capital IQ is comprehensive only

[Insert Table VI here]

The results reported in column (1) of Table VI show that *EnvLiab* attracts a negative and statistically significant coefficient (t -statistic = -6.8), suggesting that firms with high environmental liabilities rely less on bank debt. Economically, a one standard deviation increase (0.175) in *EnvLiab* reduces the ratio of bank debt to total debt by 0.038 ($= -0.219 \times 0.175$), which amounts to roughly 21% of the average bank debt to total debt ratio (0.184). Consistent with previous studies (Houston and James 1996; Denis and Mihov 2003), we find that larger firms, more profitable firms, firms with higher leverage, and firms with credit ratings tend to have a lower proportion of bank financing in debt structure.

Columns (2)-(4) report the results obtained using alternative specifications. In column (2) we estimate equation (3) using the Fama-MacBeth (1973) procedure that corrects standard errors for cross-sectional correlations. In column (3) equation (3) is estimated with firm fixed effects (rather than industry fixed effects). In column (4) we report the second-stage of the 2SLS regression, which involve using $\ln(1+DisPro)$ and *Unemployment* as instruments for *EnvLiab*. The results of the first-stage regression are reported in column (2) of Appendix B. The effects of environmental liabilities remain significant across all alternative specifications, suggesting a robust and causal relation running from environmental liabilities to the use of bank debt. In untabulated tests, we interact *EnvLiab* with several variables described in Section V.A that proxy for firm visibility, the reliance on principal customers, and community concerns, respectively. We find that the interaction terms are

from 2002 onwards. Moreover, the coverage of the Capital IQ database is also different from that of the Compustat database. As a robustness check, we re-estimate the model using firms in our main sample that also exist in Capital IQ, and find similar results (untabulated).

statistically insignificant in the bank debt regressions, suggesting the effect of environmental liabilities on the use of bank debt does not vary significantly across the firms in our sample according to these characteristics.

VI. Conclusions

In recent years, environmental issues have increasing impacts on corporate decisions in light of global increasing awareness on corporate environmental impacts. Although environmental liabilities have been staggering and become an increasingly important issue for investors and corporate managers, relatively few previous studies examine the impact environmental liabilities on corporate financing decisions, capital structure decisions in particular. The study fills this gap in the literature.

Using a large sample of firms covered by the TRI database and the Compustat between 1992 and 2013, we investigate how environmental liability affect two important aspects of corporate capital structure, namely the leverage ratio and the use of bank debt. We find that firms with high environmental liability maintain low leverage ratios and have a higher fraction of bank debt in total debt. Our results are robust to a variety of tests on variable definitions, endogeneity issues, and alternative measures of environmental liabilities.

Appendix A Industry distribution

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. N is the number of firms in a two-digit SIC industry.

Two-digit SIC	Industry Name	N
1	Agricultural Production Crops	17
7	Agricultural Services	1
10	Metal Mining	179
12	Coal Mining	77
13	Oil & Gas Extraction	180
14	Mining & Quarrying of Nonmetallic Minerals, Except Fuels	100
16	Heavy Construction Other Than Building Construction Contractors	40
17	Construction Special Trade Contractors	35
20	Food & Kindred Products	912
21	Tobacco Products	46
22	Textile Mill Products	264
23	Apparel & other finished products	51
24	Lumber & Wood Products, Except Furniture	211
25	Furniture & Fixtures	402
26	Paper & Allied Products	650
27	Printing Publishing & Allied Products	195
28	Chemicals & Allied Products	2,345
29	Petroleum Refining & Related Industries	436
30	Rubber & Miscellaneous Plastics Products	474
31	Leather & Leather Products	60
32	Stone, Clay, Glass, & Concrete Products	366
33	Primary Metal Industries	1,028
34	Fabricated Metal Products, Except Machinery & Transportation Equipment	925
35	Industrial & Commercial Machinery & Computer Equipment	1,776
36	Electronic & Other Electrical Equipment & Components, Except Computer Equipment	2,438
37	Transportation Equipment	1,304
38	Measuring, Analyzing, & Controlling Instruments; Photographic, Medical & Optical Goods; Watches & Clocks	1,286
39	Miscellaneous Manufacturing Industries	306
40	Railroad Transportation	3
42	Motor Freight Transportation & Warehousing	3
44	Water Transportation	16
45	Transportation by Air	12
46	Pipelines, Except Natural Gas	2
47	Transportation Services	20
48	Communications	36
49	Electric, Gas, & Sanitary Services	868
50	Wholesale Trade-durable Goods	308
51	Wholesale Trade-non-durable Goods	152
52	Building Materials, Hardware, Garden Supply, & Mobile Home Dealers	9
53	General Merchandise Stores	10
54	Food Stores	114
55	Automotive Dealers & Gasoline Service Stations	16
56	Apparel & Accessory Stores	18
57	Home Furniture, Furnishings, & Equipment Stores	17
58	Eating & Drinking Places	31
59	Miscellaneous Retail	17
70	Hotels, Rooming Houses, Camps, & Other Lodging Places	12
72	Personal Services	21
73	Business Services	127
75	Automotive Repair, Services, & Parking	6
76	Miscellaneous Repair Services	1
79	Amusement & Recreation Services	20
80	Health Services	7
82	Educational Services	5
87	Engineering, Accounting, Research, Management, & Related Services	36
99	Nonclassifiable Establishments	79
Sum		18,070

Appendix B Instrumental variable approach – First stage regressions

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. *EnvLiab* is $\ln(1 + \text{Weighted Waste})/\text{Sales}$. *Weighted Waste* is obtained by multiplying the mass of each chemical by its toxicity. *DisPro* is the weighted average geographical distance between EPA regional offices and a firm's facilities. *Unemployment* is the weighted average unemployment rate among all the states in which a firm's facilities operate. Other variable definitions are in the legend of Table I. Constant terms, year fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable: <i>EnvLiab</i>	(1)	(2)
<i>Ln(1+DisPro)</i>	0.051*** (4.0)	0.051*** (3.1)
<i>Unemployment</i>	0.027*** (10.0)	0.023*** (9.1)
<i>Leverage</i>		-0.093*** (-4.8)
<i>Ln(Assets)</i>	-0.050*** (-11.2)	-0.048*** (-10.5)
<i>Ln(Firm Age)</i>	0.007** (2.6)	0.009*** (3.0)
<i>M/B</i>	0.037*** (4.6)	0.031*** (3.2)
<i>EBITDA/Assets</i>	-0.334*** (-4.7)	-0.230*** (-3.2)
<i>PPE/Assets</i>	-0.057*** (-2.7)	-0.025 (-1.2)
<i>R&D/Assets</i>	-0.030 (-0.3)	-0.054 (-0.4)
<i>RNDD</i>	-0.004 (-0.6)	-0.001 (-0.2)
<i>Dividend Payer</i>	0.016*** (3.0)	0.010** (2.1)
<i>Z-score</i>	-0.036*** (-6.9)	-0.041*** (-7.1)
$\sigma(\text{Earnings})$	0.259*** (3.4)	0.216*** (3.0)
<i>MTR</i>	-0.007 (-0.2)	0.005 (0.2)
<i>Debt Rating</i>	0.013** (2.4)	0.015*** (2.7)
<i>NbrAnal</i>	0.003*** (5.3)	0.003*** (5.5)
Year and Industry Fixed Effects	Y	Y
Joint test of excluded instruments	Prob > <i>F</i> = 0.00	Prob > <i>F</i> = 0.00
J-Statistics (p-value)	0.66	0.42
N	18,068	14,829
R ²	0.51	0.50

Appendix C Functional relation between environmental liabilities and financial expenses

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. $(COGS + CAPEX)/Sales$ is cost of goods sold ($COGS$), and capital expenditure ($CAPEX$) scaled by sales. $Waste_j$ is the amount of chemical j (in pounds) deflated by sales. Other variable definitions are in the legend of Table I. $Waste_j$, constant terms, year fixed effects, and firm fixed effects are included in all regressions but their coefficients are not reported. The t -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable:	$(COGS + CAPEX)/Sales$
$Waste_j$	Y
$Ln(Assets)$	0.012** (2.0)
$Ln(Firm\ Age)$	-0.007 (-1.3)
M/B	0.007 (1.4)
$EBITDA/Assets$	-0.348*** (-5.8)
$PPE/Assets$	0.022 (0.8)
$R\&D/Assets$	-0.668*** (-3.0)
$RNDD$	-0.020* (-1.7)
$Dividend\ Payer$	-0.005 (-0.9)
$Z\text{-}score$	0.029*** (4.3)
$\sigma(Earnings)$	0.164** (2.5)
MTR	0.010 (0.6)
$Debt\ Rating$	-0.016** (-2.2)
$NbrAnal$	-0.002*** (-2.8)
Year & Firm Fixed Effects	Y
N	16,587
R ²	0.83

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Table I Summary statistics

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. *Raw Waste* is the amount of chemicals generated in a given year. *Weighted Waste* is obtained by multiplying the mass of each chemical by its toxicity. *EnvLiab* is $\ln(1 + \text{Weighted Waste})/\text{Sales}$. *Leverage* is the ratio of total debt over total assets. *BD/D* is the amount of bank debt divided by total debt. *Sales* is net sales. *Assets* is the book value of total assets. *Firm Age* is the number of years elapsed since a firm enters the CRSP database. *M/B* is the market-to-book ratio defined as $(\text{Assets} + \text{Market value of equity} - \text{Book value of equity})/\text{Assets}$. *EBITDA/Assets* is earnings before interest, taxes, depreciation and amortization scaled by *Assets*. *PPE/Assets* is net Property, Plant, and Equipment (*PPE*) scaled by *Assets*. *R&D/Assets* is R&D expenses scaled by *Assets*. *RNDD* is a dummy variable that equals one if R&D expenses are missing, and zero otherwise. *Dividend Payer* is a dummy variable that equals one if company paid dividends, and zero otherwise. *Z-score* is $(3.3 \times \text{pretax income} + \text{Sales} + 1.4 \times \text{retained earnings} + 1.2 \times (\text{current assets} - \text{current liabilities}))/\text{Assets}$. $\sigma(\text{Earnings})$ is the historical standard deviation (using available data during the previous 5 years) of the ratio of *EBITDA/Assets*. *MTR* is the simulated marginal tax rate after interest expenses obtained from John Graham's Web site. *Debt Rating* is a dummy variable equal to one if the firm has a debt rating assigned by Standard & Poor's and zero otherwise. *NbrAnal* is the maximum number of analysts making annual earnings forecast any month over a 12-month period. Dollar values are converted into 2005 constant dollars using the GDP deflator. Q1 and Q3 stand for the 25th and 75th percentiles of the distribution, respectively. All variables are winsorized at the top and bottom 1% of their distributions.

Variables	Mean	Standard Deviation	Q1	Median	Q3
<i>Raw Waste (million pounds)</i>	13.63	49.82	0.047	0.398	3.602
<i>Weighted Waste (millions)</i>	43261.9	187092.5	4.485	378.8	10192.3
<i>EnvLiab</i>	0.063	0.175	0.004	0.015	0.048
<i>Leverage</i>	0.255	0.172	0.128	0.245	0.359
<i>BD/D</i>	0.184	0.316	0.000	0.000	0.238
<i>Assets(\$millions)</i>	5721.4	13975.3	292.3	1044.3	4176.2
<i>Ln(Assets)</i>	7.013	1.906	5.681	6.952	8.337
<i>Firm Age (years)</i>	26.40	20.13	10.00	22.00	37.00
<i>M/B</i>	1.660	0.869	1.121	1.399	1.890
<i>EBITDA/Assets.</i>	0.089	0.083	0.051	0.090	0.133
<i>PPE/Assets</i>	0.324	0.180	0.185	0.287	0.429
<i>R&D/Assets</i>	0.024	0.036	0.000	0.009	0.031
<i>RNDD</i>	0.355	0.478	0.000	0.000	1.000
<i>Dividend Payer</i>	0.590	0.492	0.000	1.000	1.000
<i>Z-score</i>	1.987	1.099	1.401	2.034	2.662
$\sigma(\text{Earnings})$	0.049	0.047	0.020	0.035	0.060
<i>MTR</i>	0.312	0.085	0.329	0.350	0.351
<i>Debt Rating</i>	0.509	0.500	0.000	1.000	1.000
<i>NbrAnal</i>	7.218	7.137	1.500	5.000	11.00

Table II The effect of environmental liabilities on financial leverage

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. The dependent variable, *Leverage*, is the ratio of total debt over total assets. *EnvLiab* is $\ln(1 + \text{Weighted Waste})/\text{Sales}$. *Weighted Waste* is in millions and obtained by multiplying the mass of each chemical by its toxicity. *Sales* is net sales. *Assets* is the book value of total assets. Other explanatory variables are defined in the legend of Table I. All explanatory variables are lagged one period relative to the dependent variable. Constant terms are included in all regressions but their coefficients are not reported. In column (1), year and two-digit SIC industry fixed effects are included in the regression. Column (2) reports the results obtained using the Fama-MacBeth (1973) procedure. Column (3) includes both year and firm fixed effects. In column (4), the dependent variable (*Leverage_M*) is computed as total debt divided by the quasi-market value of assets (total assets minus book value of equity plus market value of equity). The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable:	(1) <i>Leverage</i> Industry Fixed Effects	(2) <i>Leverage</i> Fama-MacBeth	(3) <i>Leverage</i> Firm Fixed Effects	(4) <i>Leverage_M</i> Industry Fixed Effects
<i>EnvLiab</i>	-0.109*** (-5.4)	-0.125*** (-11.9)	-0.107*** (-3.8)	-0.077*** (-4.2)
<i>Ln(Assets)</i>	-0.005 (-1.5)	-0.006*** (-5.2)	0.019*** (3.7)	-0.002 (-1.0)
<i>Ln(Firm Age)</i>	-0.008*** (-2.7)	-0.007*** (-3.7)	-0.003 (-0.7)	-0.008*** (-3.6)
<i>M/B</i>	-0.022*** (-6.5)	-0.016*** (-3.5)	-0.015*** (-4.9)	-0.051*** (-20.5)
<i>EBITDA/Assets</i>	0.330*** (6.4)	0.347*** (10.7)	0.130*** (2.6)	0.128*** (3.5)
<i>PPE/Assets</i>	0.034* (1.7)	0.037*** (4.4)	0.069** (2.4)	0.039** (2.5)
<i>R&D/Assets</i>	-0.665*** (-7.2)	-0.627*** (-13.5)	-0.084 (-0.6)	-0.506*** (-7.7)
<i>RNDD</i>	0.023*** (3.1)	0.025*** (11.0)	0.001 (0.1)	0.030*** (5.0)
<i>Dividend Payer</i>	-0.030*** (-4.9)	-0.029*** (-10.0)	0.006 (0.9)	-0.033*** (-6.7)
<i>Z-score</i>	-0.067*** (-13.6)	-0.069*** (-20.1)	-0.057*** (-9.6)	-0.043*** (-12.2)
$\sigma(\text{Earnings})$	-0.023 (-0.4)	-0.099** (-2.4)	0.070 (1.2)	-0.010 (-0.2)
<i>MTR</i>	0.023 (1.0)	0.029 (1.3)	0.004 (0.2)	0.032* (1.7)
<i>Debt Rating</i>	0.080*** (10.2)	0.075*** (31.2)	0.038*** (4.5)	0.053*** (9.0)
<i>NbrAnal</i>	-0.001*** (-2.8)	-0.001* (-2.0)	-0.002*** (-3.7)	-0.002*** (-3.7)
N	18,070	18,070	18,070	18,033
R ²	0.33	0.29	0.70	0.42

Table III Tests for endogeneity

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. The dependent variable, *Leverage*, is the ratio of total debt over total assets. *EnvLiab* is $\ln(1 + \text{Weighted Waste})/\text{Sales}$. *Weighted Waste* is obtained by multiplying the mass of each chemical by its toxicity. *PastDebt* is the sum of debt issues over the past three years divided by *Assets* at $t-1$. *Prevention* is the toxicity-weighted and log-transformed amount of waste reduced by pollution prevention activities scaled by *Sales*. Other variable definitions are in the legend of Table I. All explanatory variables are lagged one period relative to the dependent variable. Constant terms, year fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. In column (1) we add past debt issues and pollution prevention activities as additional controls. Column (2) uses *EnvLiab* _{$t-3$} as the key independent variable. Column (3) reports the second stage of the 2SLS regression. The t -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable:	(1)	(2)	(3)
	<i>Leverage</i>		
<i>EnvLiab</i> _{$t-1$}	-0.067*** (-3.3)		-0.118** (-2.1)
<i>PastDebt</i>	0.058*** (10.2)		
<i>Prevention</i>	-0.114*** (-4.2)		
<i>EnvLiab</i> _{$t-3$}		-0.091*** (-4.4)	
<i>Ln(Assets)</i>	-0.006** (-2.0)	-0.005 (-1.5)	-0.007 (-1.5)
<i>Ln(Firm Age)</i>	-0.006* (-1.8)	-0.010*** (-2.9)	-0.009*** (-2.9)
<i>M/B</i>	-0.021*** (-6.3)	-0.020*** (-5.4)	-0.023*** (-5.7)
<i>EBITDA/Assets</i>	0.334*** (6.6)	0.352*** (6.3)	0.311*** (5.7)
<i>PPE/Assets</i>	0.051*** (2.6)	0.022 (1.0)	0.010 (0.5)
<i>R&D/Assets</i>	-0.591*** (-6.5)	-0.654*** (-6.2)	-0.645*** (-7.0)
<i>RNDD</i>	0.023*** (3.1)	0.023*** (2.9)	0.021*** (2.8)
<i>Dividend Payer</i>	-0.030*** (-5.0)	-0.028*** (-4.3)	-0.031*** (-5.0)
<i>Z-score</i>	-0.063*** (-13.1)	-0.066*** (-12.3)	-0.064*** (-11.7)
$\sigma(\text{Earnings})$	-0.181*** (-3.3)	-0.016 (-0.3)	-0.068 (-1.2)
<i>MTR</i>	0.002 (0.1)	0.025 (1.0)	0.022 (0.9)
<i>Debt Rating</i>	0.080*** (10.5)	0.080*** (9.5)	0.082*** (10.3)
<i>NbrAnal</i>	-0.002*** (-3.1)	-0.001** (-2.0)	-0.001** (-2.1)
N	17,412	15,227	18,068
R ²	0.36	0.33	0.32

Table IV Alternative measures of environmental liabilities

The dependent variable *Leverage* is the ratio of total debt over total assets. *EnvLiab_Release* is the toxicity-weighted and log-transformed amount of releases scaled by sales. $\sum_{j=1}^{549} \beta_j Waste_j$ is computed by summing up $\beta_j Waste_j$ where *Waste_j* is the amount of chemical *j* (in pounds) deflated by *Sales* and β_j is estimated using equation (2) for chemical *j* that a firm reports. *EnvLiab_ECHO* is the summation of penalties, compliance cost, recovery cost, and supplemental project cost scaled by *Sales*. *EnvLiab_KLD* is defined as the total environmental concerns divided by the number of concerns in that year. *EnvLiab_Newsweek* is computed based on the green scores retrieved from Newsweek's website. *EnvLiab_Asset4* is the environmental score extracted from Thomson Reuters Asset4 database. *EnvLiab_Trucost* is the environmental cost from the Trucost database. Other variable definitions are defined in the legend of Table I. All explanatory variables are lagged one period relative to the dependent variable. Constant terms, year fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable:	(1)	(2)	(3)	(4)	(5)	(6)	(7)
<i>Leverage</i>							
<i>EnvLiab_Release</i>	-0.126*** (-5.1)						
$\sum_{j=1}^{549} \beta_j Waste_j$		-0.093** (-2.1)					
<i>EnvLiab_ECHO</i>			-1.429*** (-2.81)				
<i>EnvLiab_KLD</i>				-0.094*** (-5.4)			
<i>EnvLiab_Newsweek</i>					-0.089* (-1.9)		
<i>EnvLiab_Asset4</i>						-0.035*** (-2.6)	
<i>EnvLiab_Trucost</i>							-0.126** (-2.2)
<i>Ln(Assets)</i>	-0.004 (-1.4)	0.002 (0.7)	-0.002 (-0.45)	0.025*** (9.6)	-0.011* (-1.8)	0.012** (2.1)	0.000 (0.0)
<i>Ln(Firm Age)</i>	-0.008*** (-2.7)	-0.009*** (-3.0)	-0.017*** (-3.17)	-0.013*** (-4.8)	-0.007 (-1.1)	-0.010* (-1.7)	-0.011** (-2.0)
<i>M/B</i>	-0.022*** (-6.6)	-0.026*** (-7.7)	-0.019** (-2.38)	-0.007*** (-4.0)	-0.012* (-1.7)	0.004 (1.2)	-0.003 (-0.6)
<i>EBITDA/Assets</i>	0.334*** (6.5)	0.367*** (6.8)	0.338*** (3.32)	0.111*** (3.6)	0.497*** (4.8)	-0.112* (-1.8)	0.373*** (4.8)
<i>PPE/Assets</i>	0.035* (1.8)	0.036* (1.8)	-0.013 (-0.37)	0.135*** (8.6)	0.186*** (6.0)	0.171*** (5.5)	0.160*** (5.2)
<i>R&D/Assets</i>	-0.668*** (-7.3)	-0.642*** (-6.8)	-0.585*** (-2.59)	-0.232*** (-5.0)	-0.652*** (-3.8)	-0.398*** (-3.7)	-0.513*** (-3.3)
<i>RNDD</i>	0.023*** (3.0)	0.023*** (3.0)	0.035*** (2.92)	0.033*** (5.1)	-0.006 (-0.4)	0.034** (2.4)	0.026* (1.8)
<i>Dividend Payer</i>	-0.030*** (-4.9)	-0.033*** (-5.3)	-0.020* (-1.80)	-0.020*** (-3.8)	-0.032** (-2.2)	-0.015 (-1.5)	-0.028** (-2.6)
<i>Z-score</i>	-0.066*** (-13.6)	-0.062*** (-13.3)	-0.061*** (-7.18)	-0.027*** (-9.4)	-0.055*** (-8.7)	-0.005 (-1.4)	-0.057*** (-9.2)
<i>σ(Earnings)</i>	-0.032 (-0.6)	-0.058 (-1.1)	0.115 (0.77)	-0.073*** (-2.9)	-0.413*** (-3.0)	-0.059 (-0.9)	-0.238** (-2.4)
<i>MTR</i>	0.022 (1.0)	0.025 (1.1)	0.033 (0.67)	-0.080*** (-3.6)	-0.135* (-1.9)	-0.111*** (-2.9)	-0.075* (-2.0)
<i>Debt Rating</i>	0.079*** (10.2)	0.078*** (10.1)	0.066*** (4.83)	0.093*** (15.0)	0.094*** (5.3)	0.084*** (6.3)	0.094*** (6.7)
<i>NbrAnal</i>	-0.001*** (-2.8)	-0.002*** (-3.4)	-0.000 (-0.48)	-0.004*** (-9.1)	-0.003*** (-2.8)	-0.003*** (-3.1)	-0.003*** (-3.8)
N	18,070	17,949	2,890	23,163	1,680	6,097	6,070
R ²	0.33	0.33	0.30	0.38	0.42	0.37	0.40

Table V Variations in the effect of environmental liabilities on financial leverage

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. The dependent variable (*Leverage*) and control variables are defined in the legend of Table I. *PriCus* is the fraction of sales to all principal customers. *ComCon* is formed by summing up the KLD ratings on community concerns. *ComConDum* is a dummy variable that equals one if *ComCon* is missing, and zero otherwise. *Post_FIN47* is a dummy variable that equals one if the observation is in 2005 or later, and zero otherwise. All explanatory variables are lagged one period relative to the dependent variable. In columns (1)-(4), constant terms, year fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. Column (5) does not include year fixed effects. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable: <i>Leverage</i>	(1)	(2)	(3)	(4)	(5)
<i>EnvLiab</i>	0.033 (0.5)	-0.096*** (-4.7)	-0.094*** (-4.2)	-0.110*** (-5.4)	-0.092*** (-4.1)
<i>EnvLiab</i> × <i>Ln(Assets)</i>	-0.050** (-2.5)				
<i>EnvLiab</i> × <i>NbrAnal</i>		-0.025** (-2.1)			
<i>EnvLiab</i> × <i>PriCus</i>			-0.075* (-2.0)		
<i>EnvLiab</i> × <i>ComCon</i>				-1.059** (-2.2)	
<i>EnvLiab</i> × <i>Post_FIN47</i>					-0.084*** (-2.9)
<i>Ln(Assets)</i>	-0.006* (-1.8)	-0.005* (-1.7)	-0.005 (-1.5)	-0.004 (-1.3)	-0.006** (-2.0)
<i>Ln(Firm Age)</i>	-0.008*** (-2.7)	-0.009*** (-2.9)	-0.008*** (-2.6)	-0.007** (-2.3)	-0.009*** (-2.9)
<i>M/B</i>	-0.021*** (-6.5)	-0.020*** (-6.1)	-0.021*** (-6.3)	-0.021*** (-6.3)	-0.021*** (-6.4)
<i>EBITDA/Assets</i>	0.323*** (6.3)	0.320*** (6.2)	0.330*** (6.4)	0.328*** (6.4)	0.356*** (6.9)
<i>PPE/Assets</i>	0.034* (1.7)	0.035* (1.7)	0.036* (1.8)	0.034* (1.7)	0.042** (2.1)
<i>R&D/Assets</i>	-0.649*** (-7.1)	-0.648*** (-7.0)	-0.676*** (-7.4)	-0.669*** (-7.3)	-0.655*** (-7.1)
<i>RNDD</i>	0.023*** (3.1)	0.023*** (3.1)	0.022*** (3.0)	0.022*** (3.0)	0.024*** (3.2)
<i>Dividend Payer</i>	-0.030*** (-4.9)	-0.030*** (-4.9)	-0.030*** (-4.9)	-0.029*** (-4.7)	-0.028*** (-4.6)
<i>Z-score</i>	-0.068*** (-13.6)	-0.067*** (-13.6)	-0.067*** (-13.6)	-0.066*** (-13.5)	-0.068*** (-13.7)
<i>σ(Earnings)</i>	-0.024 (-0.4)	-0.019 (-0.3)	-0.020 (-0.4)	-0.022 (-0.4)	-0.019 (-0.4)
<i>MTR</i>	0.025 (1.1)	0.023 (1.0)	0.025 (1.1)	0.023 (1.0)	0.031 (1.3)
<i>Debt Rating</i>	0.077*** (10.0)	0.078*** (10.1)	0.079*** (10.2)	0.080*** (10.3)	0.078*** (10.0)
<i>NbrAnal</i>	-0.001*** (-2.9)	-0.001** (-2.3)	-0.001*** (-2.7)	-0.001** (-2.2)	-0.001** (-2.3)
<i>PriCus</i>			-0.001 (-0.1)		
<i>ComCon</i>				-0.007 (-0.9)	
<i>ComConDum</i>				0.015*** (2.6)	
<i>Post_FIN47</i>					-0.040*** (-8.5)
N	18,070	18,070	18,070	18,070	18,070
R ²	0.33	0.33	0.33	0.33	0.32

Table VI Effect of environmental liabilities on the use of bank debt

The sample consists of firm-years jointly covered in Compustat and the TRI program between 1992 and 2013. *BD/D* is the amount of bank debt divided by total debt. *EnvLiab* is $\ln(1 + \text{Weighted Waste})/\text{Sales}$. *Weighted Waste* is obtained by multiplying the mass of each chemical by its toxicity. Other variable definitions are in the legend of Table I. All explanatory variables are lagged one period relative to the dependent variable. Constant terms, year fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	(1) Industry Fixed Effects	(2) Fama-MacBeth	(3) Firm Fixed Effects	(4) 2 nd stage of 2SLS
Dependent Variable: <i>BD/D</i>				
<i>EnvLiab</i>	-0.219*** (-6.8)	-0.155*** (-5.8)	-0.314*** (-4.4)	-0.170* (-2.0)
<i>Leverage</i>	-0.055* (-1.7)	-0.035 (-1.3)	-0.109*** (-2.7)	-0.045 (-1.3)
<i>Ln(Assets)</i>	-0.047*** (-8.0)	-0.036*** (-4.8)	-0.047*** (-4.1)	-0.044*** (-6.0)
<i>Ln(Firm Age)</i>	-0.009* (-1.8)	-0.025*** (-5.5)	0.044*** (3.4)	-0.010* (-1.9)
<i>M/B</i>	-0.002 (-0.3)	-0.008 (-1.4)	0.020*** (3.0)	-0.004 (-0.5)
<i>EBITDA/Assets</i>	0.124 (1.6)	0.262*** (3.7)	0.015 (0.2)	0.129 (1.6)
<i>PPE/Assets</i>	0.043 (1.3)	0.012 (0.8)	0.012 (0.2)	0.037 (1.1)
<i>R&D/Assets</i>	-0.612*** (-4.0)	-0.546*** (-5.3)	0.119 (0.4)	-0.596*** (-3.9)
<i>RNDD</i>	0.001 (0.1)	0.004 (0.6)	0.023 (1.0)	0.000 (0.0)
<i>Dividend Payer</i>	-0.025** (-2.2)	-0.029*** (-4.2)	-0.019 (-1.2)	-0.026** (-2.3)
<i>Z-score</i>	-0.020*** (-2.7)	-0.014*** (-4.3)	-0.033*** (-3.0)	-0.017** (-2.0)
$\sigma(\text{Earnings})$	-0.013 (-0.1)	0.117 (1.3)	0.063 (0.5)	-0.035 (-0.3)
<i>MTR</i>	0.061 (1.4)	0.056** (2.6)	0.026 (0.7)	0.060 (1.4)
<i>Debt Rating</i>	-0.066*** (-4.6)	-0.085*** (-6.0)	-0.043** (-2.2)	-0.067*** (-4.7)
<i>NbrAnal</i>	-0.001 (-0.6)	-0.004*** (-6.1)	0.004*** (3.0)	-0.001 (-0.7)
N	14,831	14,831	14,831	14,829
R ²	0.33	0.07	0.59	0.33

Essay Three: Options Trading and Corporate Financing Decisions

Abstract

We provide evidence that options trading affects firms' financing decisions. We find that firms with exchange-listed options are more likely to issue equity as opposed to debt. They issue equity more frequently but in smaller amounts and maintain low leverage ratios. The effect of options trading on financing decisions is more pronounced for firms with larger options trading volume, higher information asymmetry, and greater short-sale constraints. Further analysis shows that optioned firms attract more short-term institutional investors, have greater analyst coverage, and experience higher abnormal returns at seasoned equity offerings announcements. These findings are consistent with the notion that options trading reduces firms' information asymmetry, which makes equity financing more favourable.

“In certain circumstances, financial markets can affect the so-called fundamentals which they are supposed to reflect.”

--- Testimony by George Soros before Congress in 1994

I. Introduction

The U.S. equity options market has experienced tremendous growth over the past few decades. According to the Options Clearing Corporation (OCC), the number of options contracts traded increased from 5.7 million in 1974 to over 3.7 billion in 2013. Given the surge in exchange-listed options in recent history, a number of studies have explored how options trading affect corporate announcements (Jennings and Starks, 1986; Skinner, 1990; Ho, 1993; Cao, Chen, and Griffin, 2005; Chern et al., 2008), stock liquidity and price discovery (Kumar, Sarin, and Shastri, 1998; Chakravarty, Gulen, and Mayhew, 2004), market valuation (Roll, Schwartz, and Subrahmanyam, 2009), and cost of equity capital (Naiker, Navissi, and Truong, 2013). Nevertheless, these studies mainly focus on how options trading affects the market conditions of the underlying stock. Little is known about whether options trading has any impact on firm decision making. We fill this apparent gap by investigating the effect of options trading on firm financing decisions.

The options market is a typical secondary market in that the issuance and trading of options contracts occur among the investors. There is no cash flowing into or out of the firms along with options trading. Therefore, the options market seems to merely reflect – but not have any impact on – firm decision making. However, the options market is not just a sideshow: it might affect firm decision making by changing firms’ information environment.

Because of the low costs and high leverage inherent in options trading, options are ideal securities for informed investors with private information (Black, 1975). Cao (1999) demonstrates that informed trading in the options market reveals private information acquired by informed investors, thereby enhancing the price informativeness of the underlying assets. Options trading also alleviates the short-sale constraints on the stock, which reduces the underweighting of negative information in the market and improves the price discovery of the underlying stock (Diamond and Verrecchia, 1987; Figlewski and Webb, 1993; Phillips, 2011). In addition, options are an effective tool for investors to hedge their positions in the underlying stock (Hu, 2014). This makes stocks with exchange-listed options more attractive to investors. With more attention from investors and an enlarged shareholder-base, firms with exchange-listed options enjoy greater information production from both buy- and sell-side of the market. This further enhances firms' information environment.

Prior studies (e.g., Axelson, 2007; Demarzo and Duffie, 1999; Fulghieri and Lukin, 2001; Myers and Majluf, 1984) demonstrate that information asymmetry among firm insiders and outside investors is an important determinant of firms' security issuance decisions. Since options trading is related to firms' information environment, we investigate whether the availability of stock-traded options impacts firm financing decisions. Specifically, we look at the debt versus equity choice and the size of equity issues.

To examine the effect of options trading on financing decisions, we employ a large panel of U.S. firms covered by Compustat, CRSP, and OptionMetrics over the period of 1996-2012. We find strong evidence that optioned firms are

more likely to issue equity as opposed to debt. In our full sample, the probability of issuing equity is 6.1% higher for optioned firms than non-optioned firms. We further find that conditional on equity issuance, optioned firms issue smaller amounts of equity. The size of issuance is 3.4% lower for optioned firms as compared to non-optioned firms. Lastly, we find that optioned firms have lower leverage ratios, suggesting that the impact of options trading on the firm's financing choices accumulated and reflected in its leverage. Ceteris paribus, these firms have leverage ratios that are 1.8% lower than those of non-optioned firms.

To alleviate endogeneity concerns, we adopt a propensity-score matching approach to match optioned firms with non-optioned firms based on key firm characteristics. Our results hold in the propensity-score matched samples. In addition, we perform a difference-in-difference analysis using a sample of firms with options listed for the first time during our sample period. For each of the options listing firms, we select a matching firm from the pool of firms without listed options. We find a significant increase in the probability of equity issuance for firms with listed options in the period following an options listing, as compared to their non-optioned counterparts. Option listing firms also exhibit a larger reduction in leverage ratio following the initiation of options listing.

We then examine how the effect of options trading on corporate financing decisions varies across firms. First, we find that the effect is stronger for firms with high options trading volume than for firms with low options trading volume. The findings suggest that an active options trading market among optioned firms is essential for firm financing decisions. Second, we document

that the effect is more prominent for firms facing greater information asymmetry. The findings provide further support for our argument that options trading reduces firms' information asymmetry which alters firms' preferences between debt and equity issuance. Lastly, we show that the effect is stronger for firms with higher short-sale constraints, which is consistent with the argument that options trading improves price discovery by alleviating short-sale constraints.

We also provide direct evidence that options trading attracts investors and financial analysts that are able to enhance the information environment of the firm. We show that short-term institutional ownership and sell-side analyst coverage increase significantly following an options listing. Since short-term institutional investors are backed by buy-side analysts, the findings suggest that options trading increases the coverage by both buy- and sell-side analysts, which further improves firms' information environment. In the last test, we examine a specific corporate financing decision, seasoned equity offerings (SEOs), and show that optioned firms experience higher abnormal returns at SEO announcements. Therefore, the results confirm our findings with regard to the effect of options trading on firm financing using a highly visible and important corporate financing event.

Our paper contributes to the extant literature as follows. Unlike the stock market, the options market is a pure secondary market in that both the issuance and trading of options contracts are among the investors and there is no cash flowing into or out of the firms. Therefore, prior literature mainly focuses on the impact of options trading on the stock market and largely neglects its impact on firm decision making. Our study fills this gap by showing that options

trading has a significant impact on firm financing decisions, suggesting that the derivatives market has real effects on firm fundamentals. Our findings also support the call for further research on the feedback effects of financial markets on real economic activities by Bond, Edmans, and Goldstein (2012).

The remainder of the paper proceeds as follows. Section II reviews the literature and develops our hypotheses. We discuss our sample and variables in Section III. We present our main empirical results in Section IV and report additional results in Section V. Section VI concludes.

II. Literature Review and Hypotheses

In this section, we review prior literature about the impact of options trading on the informational efficiency of stock prices. We then develop hypotheses about how options trading affects the pattern of firms' debt and equity issuances based on this perspective.

A. Options Trading and Informational Efficiency of Stock Prices

In Black and Scholes (1973), options are redundant assets in a complete market as they can be replicated by a portfolio of the underlying assets and a bond. This implies that options trading should not have any effect on the pricing of the underlying assets. Nevertheless, Ross (1976) and Figlewski (1989) point out that in incomplete markets, it is not possible to perfectly replicate an option. As a result, certain investors may prefer to trade one type of security over another, causing options to potentially play a non-redundant role in price discovery. Black (1975) argues that because of the low costs and high leverage in options trading, options are ideal securities for informed investors with

private information. Subsequent studies provide supporting evidence by showing that option prices (Manaster and Rendleman, 1982), trading volume (Pan and Poteshman, 2006; Roll, Schwartz, and Subrahmanyam, 2010), and implied volatility (Cremers and Weinbaum, 2010) have predictive power of future stock returns.

Cao (1999) demonstrates that informed trading in the options market reveals private information acquired by informed investors. This results in increased price informativeness of the underlying assets. A number of empirical studies find supporting evidence for this argument. Skinner (1990) and Ho (1993) show that the stock price reaction to earnings announcements is reduced for optioned stocks as compared to non-optioned stocks, suggesting that part of the information is revealed to the public prior to the earnings announcements for optioned firms. There is also evidence that stock prices of non-optioned stocks take sufficiently longer to adjust to earnings announcements (Jennings and Starks, 1986), takeover announcements (Cao, Chen, and Griffin, 2005), and stock split announcements (Chern et al., 2008).

Further, Kumar, Sarin, and Shastri (1998) suggest that options listings have a beneficial impact on the quality of the market for the underlying stock in terms of higher liquidity, lower information asymmetry, and greater pricing efficiency. Chakravarty, Gulen, and Mayhew (2004) document that price discovery tends to be greater when options volume is greater than stock volume and when effective bid-ask spread is lower in the options market relative to the stock market. Roll, Schwartz, and Subrahmanyam (2009) show that options trading improves market valuation of the underlying stock by completing markets and stimulating the acquisition of private information by informed

traders. Naiker, Navissi, and Truong (2013) find that optioned firms have lower implied cost of capital than non-optioned firms, which is consistent with the view that options trading improves the precision of information and reduces information asymmetry problems.

Options trading can also improve the informational efficiency of stock prices by alleviating the short-sale constraints on the stock. Trading options can help mitigate the short sale constraints by enabling investors to synthetically short the stock by purchasing puts and writing calls. Diamond and Verrecchia (1987) show that the introduction of options trading allows for more rapid incorporation of negative private information into stock prices. Figlewski and Webb (1993) show that options trading allows investors to bypass short-sale constraints, which reduces the under-weighting of negative information in the market and improves the price efficiency of the underlying stock. Phillips (2011) reports that options on short-sale constrained stocks can alleviate up to 79% of the price adjustment to negative news, as compared to unconstrained stocks. These findings imply that the options market plays a positive role in price discovery by allowing the incorporation of negative views into stock prices.

Despite the vast literature on the information role of options trading, there are several studies contending that options trading does not reveal any new information to the market. For example, Stephan and Whaley (1990) find that the stock market leads the options market by as much as fifteen minutes. Muravyev, Pearson, and Broussard (2013) show that option price quotes do not contain economically significant information about future stock prices beyond what is already reflected in current stock prices. Further, Bris, Goetzmann, and Zhu (2007) show that put options do not offer a viable substitute for short sales.

Grundy, Lim, and Verwijmeren (2012) find a significant diminution in options volumes and a significant increase in options bid-ask spreads for banned stock relative to unbanned stock during the September 2008 short-sale ban, suggesting that bearish options strategies are not perfect substitutes for short sales.

B. Hypothesis Development

The above discussion suggests that options trading shapes a firm's information environment via several channels. First, options trading attracts informed trading, which facilitates the disclosure of private information acquired by informed investors (e.g., Cao, 1999; Cao, Chen, and Griffin, 2005; Kumar, Sarin, and Shastri, 1998). Second, options trading alleviates the short-sale constraints on stock by enabling investors to trade on bad news. This reduces the under-weighting of negative information in the market, which improves the price discovery of the underlying stock (Figlewski and Webb, 1993; Phillips, 2011). Third, stocks with exchange-listed options are more attractive to investors because options are an effective tool for investors to hedge their positions in the underlying stocks (Hu, 2014). This increases shareholders' attention and enlarges a firm's shareholder-base. Damodaran and Lim (1991) and Ho (1993) find that analyst following and institutional holdings increase after an options listing. Therefore, options trading stimulates information production from both the buy- and sell-sides of the market.

Building on prior literature, we expect firms with exchange-listed options to be more likely to issue equity as opposed to debt for two reasons.

First, equity, the price of which is sensitive to information, is preferred when firms have better information environments. Myers and Majluf (1984) demonstrate that the equity of firms with greater information asymmetry is more likely to suffer from unfavourable market misevaluation due to the adverse selection cost. Fulghieri and Lukin (2001) and Axelson (2007) document that firms are more likely to issue equity when investors are able to produce information on the quality of the underlying securities, as the chance that the issue will fail is reduced and the underpricing is lower. To the extent that options trading enhances the information efficiency of underlying stocks, firms with options trading are expected to rely more on equity.

Second, Jensen (1986) states that debt serves as the disciplinary mechanism that prevents managers with large cash flows from overinvesting. By improving firms' information environment, options trading can improve corporate resource allocation and help expose the misconduct of firms (Roll, Schwartz, and Subrahmanyam, 2009; Karpoff and Lou, 2010; Massa, Zhang, and Zhang, 2015). Therefore, options trading reduces firms' incentive to issue debt.

When determining the size of the equity issue, firms trade off the gain from issuing overvalued equity against the cost of issuing too much equity (Chang, Dasgupta, and Hilary, 2006). Firms with greater information asymmetry tend to seize "windows of opportunity" and issue large amounts of equity to rebalance the capital structure, as such firms might be overlevered due to too much reliance on debt financing at other times. They may also make large equity issuances to build debt capacity to obtain higher financial flexibility in security issuances in the future. In contrast, firms with options trading are more flexible

in issuing equity and able to issue equity more frequently. We therefore expect the average size of equity issues to be smaller for firms with options trading.

While prior studies have used special corporate events to study the information content of options trading (Skinner, 1990; Ho, 1993; Cao, Chen, and Griffin, 2005; Chern et al., 2008), we highlight the role of options trading in improving firms' information environments by investigating the effect of options trading on corporate policies. Our study adds to the on-going debate on whether options trading contains economically significant information by showing that options trading does affect corporate financing decisions. Furthermore, our study suggests that the derivatives market has real effects on firm fundamentals and supports the call made by Bond, Edmans, and Goldstein (2012) for further research on the feedback effects of financial markets on real economic activities.

III. Data, Variables, and Summary Statistics

A. Data and Sample

We obtain data on options trading from Ivy DB OptionMetrics, which covers all the options traded on U.S. listed equity between 1996 and 2012. This data set contains the information for each individual put and call option on a daily basis, including the number of contracts traded, the closing bid and ask prices, implied volatility, and other characteristics of equity options. Data on stock prices and returns are retrieved from the Center for Research in Security Prices (CRSP) files. Institutional ownership data are from Thomson Financial's CDA Spectrum database, which collects and reports stock holdings of institutional investors for each firm on a quarterly basis. Following Gompers

and Metrick (2001), if a firm in Compustat does not exist in the CDA Spectrum database, we set its institutional ownership to zero. The data on analyst coverage are obtained from the I/B/E/S Historical Summary file. Similarly, we assume that firms not covered by I/B/E/S have no analyst coverage.

We begin our analysis with the universe of all U.S. firms listed in the Compustat Quarterly files at any point between 1996 and 2013. Our sample ends in the first quarter of 2013 as the latest period in OptionMetrics data is December 2012. Following common practice in the literature, we exclude firms in financial and utility industries (SIC codes: 6000–6999 and 4900–4999, respectively) because their capital structures are likely to be significantly different from the industrial companies in our sample. Also excluded are firms with missing values for variables employed in the regressions. These restrictions yield an unbalanced panel that consists of 275,435 firm-quarter observations from 10,532 firms.

B. Options Trading and Options Trading Volume

Our measure of options trading is *OptList*, an indicator that equals one if a firm has positive options trading volume in a particular quarter, and zero otherwise. We follow the methodology of Roll, Schwartz, and Subrahmanyam (2009) when computing the options trading volume. Specifically, we calculate the total daily trading volume for each option by multiplying the total number of contracts traded and the midpoint between daily closing bid and ask prices for that option. *OptVol* is the sum of this value across all trading days and all types of options for each firm-quarter. Following Roll, Schwartz, and

Subrahmanyam (2009), if a firm in Compustat is not covered by OptoinMetrics for a particular quarter, we set the option volume for that quarter to zero.

C. Financing Decision Variables

We define leverage ratio (*Leverage*) as total debt divided by total assets. Equity and debt issues are defined using quarterly cash flow statement data of Compustat. Equity issues (ΔE) equal to the sale of common stock minus the purchase of common stock, and debt issues (ΔD) equal to long-term debt issuance minus long-term debt reduction plus changes in current debt. The issue size is the net amount issued deflated by the book value of assets at the beginning of the fiscal quarter. We classify firms as issuing debt or equity when the corresponding issue size exceeds 3%. McKeon (2011) suggests that failure to control for internal equity issuances (e.g., exercise of employee stock options) can result in flawed inference in empirical studies of financing choices. We thus screen out internal equity issuances using the 3% threshold and focus on external issuances, which reflect more about the firm's active choice of debt vs. equity. However, all our results hold if we use a 5% cutoff for issue size, as in Hovakimian, Opler, and Titman (2001).

D. Control Variables

In regressions we control for a set of variables that have been shown in the prior literature to influence a firm's financing decisions. We include the log of the book value of assets, $Ln(Assets)$, as a proxy for firm size. We also control for firm maturity by including the log of the firm's age, $Ln(Firm\ age)$, which is the number of years elapsed since a firm enters the CRSP database. Firms

having more tangible assets are expected to support more debt as these assets can be pledged as collateral. We use the net Property, Plant, and Equipment (PPE) scaled by assets ($PPE/Assets$) to account for the tangibility of the firm's assets. Various capital structure theories suggest that leverage is related to profitability. For example, it could be argued that profitability is a proxy for debt capacity, and there should therefore be a positive association between profitability and leverage. We use return on assets ($EBITDA/Assets$) as a proxy for profitability. We expect that the incentive to take on debt increases with the company's marginal tax rate because of the tax deductibility of interest expenses. Thus, we include the simulated corporate marginal tax rate based on the operating income after interest expenses from Graham (1996). We also control for net operating loss carryforwards (*Net operating loss*) since it reduces a firm's marginal tax rate and thus increases the likelihood of a firm issuing equity as opposed to debt (Graham, 1996). Following Hovakimian, Opler, and Titman (2001), we control for the effect that an equity issue may dilute a firm's earning per share by including an indicator variable (*Earnings dilution*) which equals one for firms with the earnings-to-price ratio exceeds their estimated after-tax borrowing cost. We employ the market-to-book ratio (M/B) as a control for growth opportunities. Most previous studies document a positive relation between the market-to-book ratio and equity issuance, possibly because growth companies have greater incentives to avoid debt overhang problems. Research and development expenses scaled by sales ($R\&D/Sales$) can proxy for a variety of company characteristics, such as the uniqueness of the product (Titman, 1984), information asymmetry, or growth potential. We also include an $R\&D$ indicator variable (*R&D dummy*) that equals one if R&D expenses are

missing, and zero otherwise. We control for the corporate payout policy which may be related to capital structure decisions by including the dividend-to-assets ratio (*Dividend/Assets*). To control for the risk and financial constraints faced by companies, we include Altman's (1968) unleveraged *Z-score*, *Stock volatility*, and *Earnings volatility*. To control for stock liquidity, we include Amihud's (2002) illiquidity measure (*Stock illiquidity*), which is adjusted for skewness following Gopalan, Kadan, and Pevzner (2011). We expect firms to be more likely to issue equity when their stock performance has been good. To measure a company's past stock performance, we use cumulative stock returns (*Stock return*) obtained by compounding monthly stock returns over the previous quarter.

Faulkender and Petersen (2006) document that firms having access to public bond markets, as measured by the presence of a debt rating, take on more debt. To capture a company's access to bond markets, we include a debt rating indicator variable (*Debt rating*) that equals one if a firm has a debt rating assigned by Standard & Poor's, and zero otherwise. Chang, Dasgupta, and Hilary (2006) find that firms with greater analyst coverage are more likely to issue equity as opposed to debt. Thus, we include analyst coverage (*Analyst following*) which is defined as the maximum number of analysts who make annual earnings forecasts in any month over a three-month period. Finally, Chang, Chen, and Dasgupta (2012) find that more short-term institutional ownership increases the likelihood of equity issues relative to debt issues. To control for the investment horizons of institutional shareholders, we include as control variables short- and long-term institutional ownership (*STIO* and *LTIO*) defined based on the classification method of Yan and Zhang (2009).

E. Methodology

Endogeneity between options trading and corporate financing decisions is an important concern for our study. First, the relation that we observe may be spurious if our model omits any variables that affect both corporate financing decisions and exchanges' listing decisions. Second, it is plausible that causation runs from financing decisions to options trading. Firms may issue equities when market conditions are good, thereby attracting more attention and incentivizing exchanges to list options. To address these endogeneity issues, we adopt two main strategies.

First, we employed a propensity-score matching approach developed by Rosenbaum and Rubin (1983), which effectively reduces the bias resulted from omission of observable variables and from misspecification of the functional form linking the variables of interest to the outcome (Armstrong, Jagolinzer, and Larcker, 2010).⁶⁷ Mayhew and Mihov (2004) adopt a similar control sample approach to correct for the endogeneity of option listing when examining how volatility changes around option listing. This approach matches a firm that undergoes a treatment with a firm that is similar along all the relevant observable dimensions but does not receive the treatment. In our study, the treatment of interest is the probability of having options listing.

To construct our propensity-score matched sample, we first use a Probit model to estimate the probability of option listing based on a set of firm-level

⁶⁷ In addition to the propensity-score matching approach, I select the controlled firms using an approach similar to that of Baber and Lyon (1996, 1997). Specifically, I form one-to-one matched-pairs by matching each optioned firm to a non-optioned firm based on industry, market capitalization, liquidity, and trading volume (Mayhew and Mihov, 2004; Danielsen, Van Ness, and Warr, 2007). The results, reported in Appendix D, suggesting that our results are robust to this alternative matching approach.

characteristics that have been documented as important determinants of option listing by previous studies. Specifically, we estimate

$$\text{Prob.}[OptList_{i,t-1} = 1] = \Phi(\alpha + \gamma X_{i,t-2} + \delta Industry_{i,t-1} + \theta Quarter_t) \quad (1)$$

where the dependent variable, *OptList*, takes a value of one if firm *i* has options being traded on exchange in quarter *t*-1, and zero otherwise. Φ denotes the cumulative density function of the standard normal distribution. *X* denotes a set of one quarter-lagged firm-level characteristics. Mayhew and Mihov (2004) find that Nasdaq-listed stocks and stocks with high market capitalization, trading volume, and volatility are more likely to be selected for option listing. We thus include as controls the Nasdaq dummy (*Nasdaq*), the natural log of market capitalization ($Ln(Market\ cap)$), the mean value of daily volume divided by shares outstanding over the quarter (*Stock turnover*), and *Stock volatility*. Danielsen, Van Ness and Warr (2007) find that option exchanges tend to select stocks with high liquidity, so we include *Stock illiquidity* as an additional control. Given that investor interest is an important factor affecting listing decisions (Jennings and Starks, 1986), we control for *STIO*, *LTIO*, and *Analyst following* to account for investor interest. Finally, the S&P1500 indicator (*S&P1500*) is added to capture firm visibility. Appendix A reports the results of our analysis of the determinants of option listing. Also included are the two-digit SIC industry fixed effects (*Industry*) and quarter fixed effects (*Quarter*). The standard errors of the estimated coefficients allow for clustering of observations by firm. We report the coefficients reflecting the marginal effects that capture the impact of a one unit change in explanatory variables on the dependent variable. Our results are consistent with previous studies. Importantly, the Pseudo- R^2 of our propensity-score model is 0.59, indicating

that our specification has reasonable explanatory power. In an untabulated test, we re-estimate equation (1) in our matched sample, the Pseudo- R^2 declines significantly to 0.01.⁶⁸

Next, we use the predicted probabilities (propensity scores) to perform a one-to-one nearest neighboring match without replacement. We match an optioned-firm (a treatment observation) with another non-optioned observation (a control observation) from the same quarter. The maximum difference in the predicted probabilities between the matched pairs is restricted to 1 percent. These restrictions yield a sample of 64,924 firm-quarter observations (32,462 matched pairs). We test the mean differences of variables between the treatment and control groups and report the levels of significance in Panel B of Appendix A. In particular, 4 of 9 control variables are insignificantly different at the 5% level. In the cases in which the means are statistically different, the economic differences between the treatment and control sample are very small, less than 10% of the standard deviation.

Our second approach is to focus on a subsample of firms with option listing for the first time during our sample period. We construct a matched sample of firms without option listing over the same period based on all relevant firm characteristics prior to the option listing. Based on this sample, we use a difference-in-difference approach to compare the change in firms' financing decisions before and after the options introduction and compare this change with that for a control firm over the same period.

⁶⁸ As there is no significant difference in the control variables between optioned and non-optioned firms, the control variables in the matched sample cannot effectively explain the option listing variable. The significant reduction in R^2 indicates the accuracy of the matching.

F. Summary Statistics

Table I reports the descriptive statistics separately for the overall sample and for the propensity-score matched samples. We winsorize all variables at the top and bottom 0.5% of their distributions. Panel A shows that 43.7% of our firms have options traded on exchanges. The mean value of quarterly options trading volume is \$9.1 million. Panel B presents the summary statistics on the debt–equity choice. On average, 5% (13%) of firms in our sample issue equity (debt) in a given quarter. Conditional on issuance, the average (median) size of equity and debt issues is 34% (14%) and 15% (8%) of total assets, respectively. The mean and median values of *Leverage* are 0.203 and 0.157, respectively, with a standard deviation of 0.205.

[Insert Table I here]

IV. Main Results

In this section, we first examine how options trading affects firms' choices regarding debt versus equity, and the size of equity issuances. We then explore the effects of options trading on leverage ratios. Finally, we conduct tests to mitigate endogeneity concerns.

A. Options Trading and the Debt-equity Choice

We use Probit regressions similar to those used by Hovakimian, Opler, and Titman (2001) to examine how a firm's debt-equity choice in a given quarter is affected by options trading. Specifically, we estimate the model

$$\text{Prob.}[E\text{Issue}_{i,t} = 1] = \Phi(\alpha + \beta \text{OptList}_{i,t-1} + \gamma X_{i,t-1} + \delta \text{Industry}_{i,t} + \theta \text{Quarter}_t) \quad (2)$$

where the dependent variable, *EIssue*, takes a value of one if the net equity issue constitutes more than 3% of total assets, and zero if net debt issue exceeds

3% of total assets for firm i at quarter t . Only issue quarters in which the firms issue net debt or equity exceeding 3% of book value of total assets are considered; quarters in which both are issued or neither are above 3% cutoff are not considered. Φ denotes the cumulative density function of the standard normal distribution. The coefficient on *OptList*, the options trading indicator, is expected to be positive. Finally, X denotes a set of pre-determined control variables. Apart from the control variables that are discussed in Section III.D, we also control for the size of external financing (the sum of net debt and equity issued divided by total assets) and the deviation of the one-quarter lagged debt ratio from the estimated target debt ratio. We include the latter variable because the trade-off theory suggests that firms that are above (below) a target ratio should issue equity (debt). We report the target leverage ratio estimation in Appendix B, where we regress the leverage ratio on the control variables and industry and quarter dummies.⁶⁹ Except for target leverage ratio, all variables are lagged by one period. Also included are the industry fixed effects (*Industry*) and quarter fixed effects (*Quarter*). The standard errors of the estimated coefficients allow for clustering of observations by firm. We report the coefficients reflecting the marginal effects that capture the impact of a one unit change in explanatory variables on the dependent variable.

[Insert Table II here]

We estimate equation (2) based on all firm-quarters in which firms issue either debt or equity and present the results in column (1) of Table II. The estimated coefficient on *OptList* is positive and statistically significant (z -

⁶⁹ We choose not to include firm fixed effects in the estimation of the target leverage ratio because Chang and Dasgupta (2011) illustrate that estimating target leverage ratio with firm fixed effects greatly exaggerate the evidence for target behavior in the debt-equity choice regression due to the look-ahead bias.

statistics = 7.5), suggesting that options trading is positively associated with a higher likelihood of issuing equity as opposed to debt. Economically, having option listed increases the probability of equity issuance by roughly 0.06, corresponding to a 25% increase relative to the conditional likelihood of equity issues in our sample (0.24).⁷⁰ Column (2) report the results estimated using the propensity-score matched sample. *OptList* attracts a positive and significant coefficient (z -statistics = 3.6), confirming the results of our baseline regression.

B. Options Trading and the Size of Equity Issues

Next, we examine the effect of options trading on the size of equity issuances. Specifically, we estimate the model

$$ESize_{i,t} = \alpha + \beta OptList_{i,t-1} + \gamma X_{i,t-1} + \delta Industry_{i,t} + \theta Quarter_t + \varepsilon_{i,t} \quad (3)$$

where $ESize_{i,t}$ denotes the size of net equity issue scaled by total assets, and $X_{i,t-1}$ is the set of supplier characteristics described in Section III.D. Also included are the industry fixed effects (*Industry*) and quarter fixed effects (*Quarter*). Only equity issues exceeding 3% of total assets are included in the regressions.

[Insert Table III here]

We first estimate equation (3) using Ordinary Least Squares (OLS) regressions. Columns (1) and (3) present the result for the whole sample and for the propensity-score matched sample, respectively. The estimated coefficients on *OptList* are negative and statistically significant in both samples (z -statistics are equal to -2.0), suggesting that non-optioned firms make relatively larger equity issues given their inability to issue equity more frequently.⁷¹

⁷⁰ Among all firm-quarters in which firms issue either debt or equity, 24% of firms issue equity.

⁷¹ Similarly, Chang, Dasgupta, and Hilary (2006) find that firms with lower analyst coverage make larger equity issues.

Economically, having option listed reduces the issuance size by almost 10% from its mean value (0.338). Since equity issuance is an endogenous choice by the firm, we estimate a Heckman (1979) selection model to mitigate the self-selection bias. Following Leary and Roberts (2010), we include in the first stage variables that are likely to affect the firm's requirement for external funds, as well as the choice of equity vis-à-vis debt financing. We estimate this specification based on full sample and propensity-score matched sample, and report the second stage results in columns (2) and (4). *OptList* attracts negative and significant coefficients in both regressions. Appendix C presents the first stage regression results.

C. Options Trading and Leverage

We expect that the impact of options trading on the firm's financing choices will be accumulated and reflected in its leverage. To test this conjecture, we regress the leverage ratio on *OptList* and other firm characteristics. Specifically, we estimate the following model

$$Leverage_{i,t} = \alpha + \beta OptList_{i,t-1} + \gamma X_{i,t-1} + \delta Firm + \theta Quarter_t + \varepsilon_{i,t} \quad (4)$$

where $Leverage_{i,t}$ denotes the ratio of total debt over total assets, and $X_{i,t-1}$ is the set of supplier characteristics described in Section III.D.⁷² Also included are the firm fixed effects (*Firm*) and quarter fixed effects (*Quarter*).⁷³ The results, tabulated in Tale IV, reveal that optioned firms maintain lower leverage ratios. Economically, having option listed reduces the leverage by almost 9% from its mean value (0.203).

⁷² Note that we do not include as *Net operating loss* and *Earnings dilution* control variables as they are factors mainly affecting financing choices.

⁷³ We include firm fixed effects because Lemmon, Roberts, and Zender (2008) show that the majority of variation in capital structure is time-invariant.

[Insert Table IV here]

Overall, we find that firms with options trading issue equity more frequently, but in smaller amounts. We also provide evidence that optioned firms maintain lower leverage ratios. Our results still hold after partially controlling for the potential selection bias using the propensity-score matching approach.

D. Difference-in-Difference Regressions

To further address the endogeneity concern, we perform a difference-in-difference analysis using a sample of firms with options listed for the first time during the sample period and their matched firms without listed options for the same period. For a firm to be classified into our treatment group, we require it to exist in our sample at least two quarters before and two quarters after the option introduction (quarters -2 to +2). Our candidate control group consists of non-optioned firms that are not selected for option listing any time prior to the option introduction and within the subsequent 2 quarters. Similarly, we need them to exist in our sample at least two quarters before and two quarters after the option introduction (quarters -2 to +2). We then follow the procedure discussed in Section III.E and generate matched pairs based on a set of observable firm characteristics prior to the option introduction. Our final sample consists of 16,240 firm-quarter observations (8,120 matched pairs) during a five-year window around the option listing quarter. We conduct a difference-in-difference analysis to compare the change in firms' financing decisions before and after the option introduction relative to non-optioned firms in the period following an options listing. Specifically, we estimate the following three models

$$\begin{aligned} \text{Prob}[E\text{Issue}_{i,t}=1] = & \Phi(\alpha + \beta\text{Treatment}\times\text{Post} + \eta\text{Treatment} + \mu\text{Post} \\ & + \gamma X_{i,t-1} + \delta\text{Industry}_{i,t} + \theta\text{Quarter}_t) \end{aligned} \quad (5)$$

$$\begin{aligned} E\text{Size}_{i,t} = & \alpha + \beta\text{Treatment}\times\text{Post} + \eta\text{Treatment} + \mu\text{Post} + \gamma X_{i,t-1} \\ & + \delta\text{Industry}_{i,t} + \theta\text{Quarter}_t + \varepsilon_{i,t} \end{aligned} \quad (6)$$

And

$$\begin{aligned} \text{Leverage}_{i,t} = & \alpha + \beta\text{Treatment}\times\text{Post} + \eta\text{Treatment} + \mu\text{Post} + \gamma X_{i,t-1} \\ & + \delta\text{Firm}_i + \theta\text{Quarter}_t + \varepsilon_{i,t} \end{aligned} \quad (7)$$

where the *Treatment* is a dummy variable that equals one if a firm belongs to the treatment group, and zero otherwise. *Post* is a dummy variable that equals one if treatment firms and the corresponding control firms are in the post-listing period, and zero otherwise. Our variable of interest is *Treatment* $\times$ *Post*, which captures the difference in the probability of equity issuance before and after an options listing for the treatment group relative to that for the control group. The results, presented in column (1) of Table V, indicate that the probability of issuing equity is significantly higher for firms with listed options relative to firms without listed options after the option has been introduced.

[Insert Table V here]

We estimate equation (6) and report the results in column (2) of Table V. The coefficient of *Treatment* $\times$ *Post* is insignificant. The insignificant coefficient might be attributed to the fact that our regression only includes equity issues exceeding 3% of total assets. As optioned firms tend to make smaller issues, our regression fails to account for those small issues made by optioned firms following an option listing. We present the results for leverage regression in Column (3). The coefficient of *Treatment* $\times$ *Post* is negative and statistically

significant, suggesting a significant reduction in the leverage for optioned firm relative to non-optioned firm following an option listing.

V. Further Analysis

A. Cross-sectional Heterogeneity in Results

In this section, we perform further tests to identify channels through which options trading affect corporate financing decisions. All the control variables in Table II-V are included in the regressions but their coefficients are not reported for the sake of brevity.

A.1 Options Trading Volume

Easley, O'Hara, and Srinivas (1998) argue that options trading may only assist in improving the informational efficiency of optioned stocks if the liquidity available in the options market is sufficiently high. Therefore, we test whether the liquidity of the options market, measured by options trading volume (*OptVol*), has any impact on firm financing decisions among firms with exchange-listed options. We augment our baseline models by including the interaction term between *OptVol* and *OptList* as an additional control variable and re-estimate equations (2)-(4). The results are reported in Panel A of Table V. The coefficient of interaction term is positive and statistically significant in column (1), indicating that optioned firms in active markets are more likely to issue equity. In column (2), the coefficient of the interaction term is positive but insignificant. As options firms make smaller issues, the large equity issues included in our regression are more likely to be made by non-optioned which are insensitive to options trading volume. In leverage ratio regression, the

coefficient of the interaction term is negative and significant, suggesting that optioned firms in active markets tend to maintain lower leverage ratios.

[Insert Table VI here]

A.2 Information Asymmetry

As options trading improves the informational efficiency of stock prices and reduces information asymmetry, the effect of options trading on financing decisions should be more pronounced in firms face greater information asymmetry. We use the number of analyst following and earning quality (Dechow and Dichev, 2002) to measure the degree of information asymmetry and interact them with *OptList*. The results are reported in Panel B of Table V. In general, our results suggest that the effect of options trading is more pronounced when firms are subject to greater information asymmetry. The coefficient of the interaction between *Analyst following* and *OptList* is marginally significant in *Leverage* regression, with a *t*-statistics of 1.6. The interaction between *Earnings quality* and *OptList* attracts an insignificant in *ESize* regression.

A.3 Short-sale Constraints

Given options trading can facilitate the informed traders' participation by mitigating short-sale constraints, we expect our results to be more evident when firms are subject to high short-sale constraints. Following Asquith, Pathak, and Ritter (2005), we define short-sale constrained stocks as stocks located in the top 30th percentile of short interest ratios that are also located in the bottom 30th percentile of institutional ownership and construct a short-sale constrained

indicator (*Short*).⁷⁴ We interact it with *OptList* and report the results in Panel C of Table VI. Again, the interaction term attracts an insignificant in *ESize* regression. Our results in columns (1) and (3) suggest that the effect of options trading is more evident for short-sale constrained firms.

B. Institutional Ownership, Analyst Coverage and Options Trading

To provide direct evidence that options trading attracts market participants that are able to enhance the information environment of the firm, we examine how institutional ownership and analyst coverage change around option listing. We conduct a difference-in-difference regression analysis based on the sample constructed in Section IV.D and report the results in Table VII. We re-estimate equation (7) by using *IO* as the dependent variable. Following Yan and Zhang (2009), we include a number of controls that are shown by previous studies to affect institutions' preferences: *Ln(Market cap)*, *Ln(Firm age)*, the dividend-to-price ratio (*Dividend yield*), S&P 500 index membership (*S&P500*), and the *Stock volatility* are included to account for prudence (e.g., Del Guercio, 1996); the log of stock price and *Stock turnover* are incorporated to control for liquidity and transaction costs. As measures that predict future stock returns, also included are the book-to-market ratio (*B/M*) and two past stock returns, which are compounded monthly stock returns calculated over the current quarter (*Stock Return_{t-1,t}*) and over the three quarters preceding the current quarter (*Stock_{t-4,t-1}*). In addition, *EBITDA/Assets* and *Analyst following* are employed to control for profitability and sell-side analyst coverage. The results are reported in Table VII. Column (1) indicates that institutional ownership

⁷⁴ We obtain data for adjusted end-of-month short-interest from Compustat. Short-interest ratio is defined as short interest divided by number of shares outstanding.

increases significantly for firms with listed options relative to firms without listed options after the option has been introduced. In columns (2) and (3), we focus on institutional ownership with different horizons and estimate equation (7) using *LTIO* and *STIO* as dependent variables, respectively. We find that only short-term institutional ownership increase significantly following an option listing. Economically, the short-term institutional ownership of firms with listed options increases by 13% from its mean value following an options listing, as compared to firms without listed options. This is consistent with the notion that short-term institutions improve the transparency of the information environment through informed trading and monitoring via "exit" (Chang, Chen, and Dasgupta, 2012). O'Brien and Bhushan (1990) and Brennan and Subrahmanyam (1995) find that firms with more institutional shareholders attract more analyst following. Moreover, analysts are more likely to follow firms that are more transparent and for which the information gathering cost are lower (Chang, Dasgupta, and Hilary, 2006). We thus expect that optioned firms attract more analysts following after option listing. As number of analyst following is non-negative and discrete, we re-estimate equation (6) by running negative binomial regressions with *Analyst following* as the dependent variable and present the results in column (4) of Table VII. The coefficient estimate on *Treatment*×*Post* is positive and statistically significant, indicating that the number of analysts following firms with listed options increases by 13% relative to non-optioned firms following an option listing. Our results suggest that both the quantity and quality of information increase after option listing. Our findings are also consistent with Cao (1990), who suggests that optioned firms should attract more informed investors and analysts.

[Insert Table VII here]

C. Options Trading and SEO

To provide further evidence that options trading enhance informational efficiency and reduce information asymmetry, we look at seasoned equity offerings, a highly visible and important corporate financing decision. To the extent that options trading encourages information incorporation into stock price, we expect optioned firms to experience less negative abnormal returns at SEOs announcements.

We obtain the initial sample of SEO that occurred between 1996 and 2012 from Thomson Financial's Securities Data Corporation (SDC) new issues database. We limit our sample to complete SEOs that 1) include at least some primary shares, 2) are issued by firms listed on the NYSE, Amex, or Nasdaq, 3) have securities with CSRP share codes 10 or 11, and 4) have an offer price of at least \$3 and less than \$400 (DeAngelo, DeAngelo, and Stulz, 2010; Chan and Chan, 2014). After matching with our main sample, we identify 3,256 SEOs from 1996 to 2012.

To examine the valuation effect of SEO announcement, we employ a standard event study methodology. Specifically, we estimate the one factor market model to calculate the daily abnormal returns. We use the equal-weighted CRSP index as market portfolio and set the estimation window as days (-301, -46) prior to the announcement date, where day 0 is the announcement day.⁷⁵ The daily abnormal returns are accumulated to obtain the cumulative abnormal return. We report the results in Table VIII. The

⁷⁵ Similar results are obtained if we use the value-weighted CRSP index as market portfolio.

dependent variable is an issuer's 3-day cumulative abnormal returns ($CAR(-1,1)$) in column (1). The coefficient of *OptList* is positive and significant, suggesting that optioned firms experience higher abnormal returns at the SEOs announcements. Economically, the average announcement effect for an issuer with option listed is higher by 1.3% than for a non-optioned issuer. In columns (2) and (3), we use $CAR(-2,-2)$ and $CAR(-5,5)$ as dependent variables, respectively. *OptList* attracts a positive and significant coefficient in both regressions.

[Insert Table VIII here]

VI. Conclusion

The U.S. equity options market has experienced tremendous growth over the past few decades. While previous studies mainly examine the impact that options trading has on the underlying stocks, little is known about the role of options trading in firm decision making. Our paper fills this gap by investigating how options trading affects firm financing decisions.

Using a large sample of firms covered by Compustat, CRSP, and OptionMetrics, we find strong evidence that firms with exchange-listed options are more likely to issue equity as opposed to debt. To the extent that firms with options trading are more flexible in issuing equity and able to issue equity more frequently, they make smaller issues to avoid the potential cost of issuing too much. We show that optioned firms have lower leverage ratios, suggesting that the impact of options trading on the firm's financing choices. These results are robust to endogeneity issues. We find that our results are more pronounced in firms with higher options trading volume, in firms facing greater information asymmetry, and in firms subject to higher short-sale constraints. We also

provide evidence that firms attract more short-term institutional shareholders and analysts following an options listing. Finally, we show that firms with exchange-listed options experience higher abnormal returns at SEO announcements.

Collectively, our findings are consistent with the informational role of options trading documented in prior literature. We go one step further by showing that options trading affects firm financing decisions by improving firms' information environment. Our findings suggest a feedback effect of the options market on firm decision making. This calls for further research on the feedback effects of financial markets on real economic activities.

Appendix A Estimation of propensity-score

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. Panel A presents the results of the propensity-score regression. The dependent variable is *OptList*, a dummy variable that equals one if a firm has options being traded on exchanges, and zero otherwise. Panel B reports the mean values of the treatment and control firms' characteristics and their corresponding *t*-statistics. *Nasdaq* is a dummy variable that equals one if a firm's stock is traded on Nasdaq, and zero otherwise. *Market cap* equals the number of shares outstanding multiplied by the closing stock price at the end of the quarter. *Stock turnover* is the mean value of daily shares traded (volume) divided by shares outstanding over the quarter. *Stock volatility* is standard deviation of daily stock returns over the quarter. *Stock illiquidity* is the mean square root of the absolute value of daily stock return over daily trading volume (in millions of dollars) over the quarter. *STIO* (*LTIO*) is the number of shares held by short-term (long-term) institution investors divided by the total number of shares outstanding. *Analyst following* is the maximum number of analysts making annual earnings forecast any month over a 3-month period. *S&P1500* is a dummy variable that equals one if the firm is included in the S&P 1500, and zero otherwise. All explanatory variables are lagged one period relative to the dependent variable. Constant terms, quarter fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The *z*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Panel A Determinants of option listing			
Dependent variable: <i>OptList</i>	Probit		
<i>Nasdaq</i>	0.026*** (3.8)		
<i>Ln(Market cap)</i>	0.069*** (14.2)		
<i>Stock turnover</i>	0.014*** (4.2)		
<i>Stock volatility</i>	2.426*** (16.8)		
<i>Stock illiquidity</i>	-0.509*** (-7.9)		
<i>STIO</i>	0.198*** (9.2)		
<i>LTIO</i>	0.121*** (3.2)		
<i>Analyst following</i>	0.021*** (10.4)		
<i>S&P1500</i>	0.116*** (11.6)		
Industry and quarter fixed effects	Y		
N/R ²	271,600/0.59		
Panel B Post-match differences			
	Optioned <i>N</i> = 32,464	Non-Optioned <i>N</i> = 32,464	
	(1)	(2)	(3)
Variables	Mean	Mean	Difference in Means
<i>Nasdaq</i>	0.514	0.510	0.004
<i>Ln(Market cap)</i>	5.681	5.776	-0.095***
<i>Stock turnover</i>	0.039	0.039	0.000
<i>Stock volatility</i>	0.839	0.853	-0.014*
<i>Stock illiquidity</i>	0.169	0.185	-0.016***
<i>STIO</i>	0.180	0.192	-0.012***
<i>LTIO</i>	0.081	0.085	-0.004***
<i>Analyst following</i>	3.816	3.805	0.011
<i>S&P1500</i>	0.196	0.231	-0.035***

Appendix B Estimation of target leverage ratios

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. The dependent variable is *Leverage* at quarter t . *Assets* is the book value of total assets. *Firm age* is the number of years elapsed since a firm enters the CRSP database. *PPE/Assets* is net Property, Plant, and Equipment (PPE) scaled by *Assets*. *EBITDA/Assets* is earnings before interest, taxes, depreciation and amortization (EBITDA) scaled by *Assets*. *Marginal tax rate* is the simulated marginal tax rate after interest expenses obtained from John Graham's Web site. *M/B* is the market-to-book ratio defined as $(Assets + Market\ value\ of\ equity - Book\ value\ of\ equity)/Assets$. *R&D/Sales* is R&D expenses scaled by total sales. *Dividend/Assets* is dividends scaled by *Assets*. *Z-score* is $(3.3 \times pretax\ income + sales + 1.4 \times retained\ earnings + 1.2 \times (current\ assets - current\ liabilities))/Assets$. *Stock return* is buy-and-hold stock returns computed over the quarter. *Earning volatility* is the historical standard deviation (using available data during the previous 12 quarters) of the ratio of *EBITDA/Assets*. *Stock volatility* is standard deviation of daily stock returns over the quarter. *Stock illiquidity* is the mean square root of the absolute value of daily stock return over daily trading volume (in millions of dollars) over the quarter. *Debt rating* is a dummy variable equal to one if the firm has a debt rating assigned by Standard & Poor's and zero otherwise. *Analyst following* is the maximum number of analysts making annual earnings forecast any month over a 3-month period. *STIO* (*LTIO*) is the number of shares held by short-term (long-term) institution investors divided by the total number of shares outstanding. Constant terms, quarter fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The t -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: <i>Leverage</i>	OLS
<i>OptList</i>	-0.027*** (-8.9)
<i>Ln(Assets)</i>	0.028*** (19.0)
<i>Ln(Firm age)</i>	-0.016*** (-7.0)
<i>PPE/Assets</i>	0.199*** (19.8)
<i>EBITDA/Assets</i>	0.010 (0.8)
<i>Marginal tax rate</i>	-0.137*** (-12.5)
<i>M/B</i>	-0.003*** (-7.1)
<i>R&D/Sales</i>	-0.000 (-0.9)
<i>R&D dummy</i>	0.044*** (13.2)
<i>Dividend/Assets</i>	-2.034*** (-9.9)
<i>Z-score</i>	-0.003*** (-9.9)
<i>Stock return</i>	-0.015*** (-12.5)
<i>Earning volatility</i>	-0.093*** (-7.7)
<i>Stock volatility</i>	0.544*** (12.7)
<i>Stock illiquidity</i>	0.016*** (12.9)
<i>Debt rating</i>	0.126*** (25.1)
<i>Analyst following</i>	-0.004*** (-12.9)
<i>STIO</i>	0.001 (0.1)
<i>LTIO</i>	-0.007 (-0.4)
Industry and quarter fixed effects	Y
N/ R ²	275,435/0.33

Appendix C First stage regression in the Heckman procedure

Industry equity issue is the proportion of firms issuing equity in the two-digit SIC. *Assets* is the book value of total assets. *Firm age* is the number of years elapsed since a firm enters the CRSP database. *PPE/Assets* is net Property, Plant, and Equipment (PPE) scaled by *Assets*. *EBITDA/Assets* is earnings before interest, taxes, depreciation and amortization (EBITDA) scaled by *Assets*. *Marginal tax rate* is the simulated marginal tax rate after interest expenses obtained from John Graham's Web site. *M/B* is the market-to-book ratio defined as $(\text{Assets} + \text{Market value of equity} - \text{Book value of equity})/\text{Assets}$. *R&D/Sales* is R&D expenses scaled by total sales. *Dividend/Assets* is dividends scaled by *Assets*. *Z-score* is $(3.3 \times \text{pretax income} + \text{sales} + 1.4 \times \text{retained earnings} + 1.2 \times (\text{current assets} - \text{current liabilities}))/\text{Assets}$. *Debt rating* is a dummy variable equal to one if the firm has a debt rating assigned by Standard & Poor's, and zero otherwise. *Analyst following* is the maximum number of analysts making annual earnings forecast any month over a 3-month period. *Cash balance* is the sum of cash and marketable securities divided by *Assets*. *Net working capital* is $(\text{Non-cash current assets} - (\text{total current liabilities} - \text{short term debt}))/\text{Assets}$. *Anticipated future investment* is actual investment to total assets ratio over the next quarter. *Anticipated future cash flow* is actual cash flow to total assets ratio over the next quarter. *Projected current investment* is average investment growth rate over the previous three quarters multiplied by the previous quarter's investment. *Projected current cash flow* is average cash flow growth rate over the previous three quarters multiplied by the previous quarter's cash flow. Constant terms, quarter fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The z-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable: <i>Elssue</i>	Full sample	Propensity-score matched sample
	(1)	(2)
<i>Industry equity issue</i>	5.603*** (25.7)	5.517*** (13.2)
<i>Ln(Assets)</i>	-0.141*** (-19.1)	-0.194*** (-12.9)
<i>Ln(Firm age)</i>	-0.193*** (-16.2)	-0.157*** (-7.2)
<i>PPE/Assets</i>	0.109** (2.3)	0.236*** (2.6)
<i>Marginal tax rate</i>	-0.975*** (-15.6)	-0.749*** (-6.7)
<i>M/B</i>	0.049*** (12.2)	0.039*** (6.4)
<i>R&D/Sales</i>	0.009*** (5.6)	0.010*** (3.9)
<i>R&D dummy</i>	-0.092*** (-4.9)	-0.065** (-2.0)
<i>Dividend/Assets</i>	-7.371*** (-4.2)	-4.485 (-1.5)
<i>Z-score</i>	-0.009*** (-3.2)	-0.015*** (-3.4)
<i>Debt rating</i>	0.092*** (3.9)	0.104*** (2.8)
<i>Analyst following</i>	0.002 (0.8)	-0.000 (-0.1)
<i>Cash balance</i>	-0.398*** (-9.7)	-0.466*** (-6.6)
<i>Net working capital</i>	-0.327*** (-5.9)	-0.322*** (-3.3)
<i>Anticipated future investment</i>	0.663*** (13.7)	0.497*** (5.4)
<i>Anticipated future cash flow</i>	-0.022 (-0.6)	-0.064 (-0.9)
<i>Projected current investment</i>	0.042*** (6.2)	0.038*** (2.8)
<i>Projected current cash flow</i>	0.000 (0.0)	0.004 (0.3)
Industry and quarter fixed effects	Y	Y
N	256,015	60,554

Appendix D Options trading and the financing decision - Alternative matching approach

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. In column (1), the dependent variable is *EIssue*, which equals one if net equity issued exceeds 3% of total assets, and zero if debt is issued at quarter *t*. Companies are defined as issuing equity (debt) when the net equity (debt) issued divided by total assets exceeds 3 percent. Cases where companies issue both debt and equity in a given quarter are omitted. The dependent variable in columns (2) & (3), *Esize*, is the size of net equity issue scaled by total assets at the beginning of the fiscal quarter. The dependent variable in column (4) is *Leverage* at quarter *t*. Other variable definitions are in the legend of Table II. *OptList* is a dummy variable that equals one if a firm has options being traded on exchanges, and zero otherwise. In columns (1), (2) and (4), we estimate OLS regressions. Column (3) reports the results from the second stage regression in the Heckman procedure. Only equity issues exceeding 3% of total assets are included. Constant terms, quarter fixed effects, and two-digit SIC industry (firm) fixed effects are included in regressions (1) to (3) (regression (4)) but their coefficients are not reported. The *t*(*z*)-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	<i>Eissue</i> Porbit (1)	<i>Esize</i> OLS (2)	<i>Esize</i> Heckman (3)	<i>Leverage</i> OLS (4)
<i>OptList</i>	0.032** (2.3)	-0.048*** (-2.9)	-0.049*** (-2.8)	-0.005* (-1.8)
<i>External financing</i>	0.090*** (3.3)			
<i>Deviation from target</i>	-0.078** (-2.4)	-0.092** (-2.3)	-0.120*** (-2.7)	
<i>Ln(Assets)</i>	-0.057*** (-7.1)	-0.060*** (-5.0)	-0.020 (-1.0)	0.042*** (11.5)
<i>Ln(Firm age)</i>	-0.032*** (-2.9)	-0.066*** (-4.4)	-0.028 (-1.4)	0.026*** (3.2)
<i>PPE/Assets</i>	-0.070 (-1.6)	0.003 (0.1)	-0.106* (-1.7)	0.138*** (7.4)
<i>EBITDA/Assets</i>	0.125 (1.4)	-0.915*** (-6.7)	-0.992*** (-6.9)	-0.113*** (-4.4)
<i>Earnings dilution</i>	0.010 (0.3)	0.013 (0.5)	0.032 (1.1)	
<i>Marginal tax rate</i>	-0.208*** (-3.1)	0.106 (1.3)	0.268** (2.6)	-0.065*** (-5.1)
<i>Net operating loss</i>	0.006 (1.5)	-0.004 (-0.8)	-0.011** (-2.1)	
<i>M/B</i>	0.016*** (5.2)	0.004 (1.2)	0.002 (0.4)	-0.002*** (-3.7)
<i>R&D/Sales</i>	0.001 (0.7)	0.000 (0.2)	-0.002 (-0.8)	-0.000 (-0.4)
<i>R&D dummy</i>	-0.054*** (-3.1)	0.008 (0.3)	0.026 (1.0)	-0.003 (-1.1)
<i>Dividend/Assets</i>	-2.428* (-1.7)	2.809* (1.8)	5.675*** (2.7)	-0.406*** (-2.6)
<i>Z-score</i>	-0.007*** (-3.4)	0.001 (0.4)	0.001 (0.3)	-0.005*** (-5.9)
<i>Stock return</i>	0.169*** (8.2)	0.154*** (5.3)	0.148*** (5.0)	-0.004*** (-2.6)
<i>Earning volatility</i>	0.122 (1.6)	0.138 (1.3)	0.135 (1.3)	-0.057** (-2.3)
<i>Stock volatility</i>	0.458 (1.3)	0.882 (1.5)	0.901 (1.5)	0.399*** (6.1)
<i>Stock illiquidity</i>	-0.150*** (-3.6)	-0.231*** (-4.4)	-0.229*** (-3.9)	0.047*** (4.9)

<i>Debt rating</i>	0.005 (0.3)	0.017 (0.9)	-0.009 (-0.4)	0.063*** (8.9)
<i>Analyst following</i>	0.000 (0.2)	0.001 (0.3)	0.002 (0.7)	-0.002*** (-3.2)
<i>STIO</i>	0.037 (0.8)	0.260*** (3.1)	0.275*** (3.1)	-0.001 (-0.1)
<i>LTIO</i>	-0.396*** (-4.0)	-0.126 (-1.2)	-0.107 (-1.0)	-0.027* (-2.0)
Industry and quarter fixed effects	Y	Y	Y	N
Firm and quarter fixed effects	N	N	N	Y
N/ R ²	30,562/0.30	9,251/0.29	226,727	238,602/0.80

Appendix E Financing decisions around option listing- Alternative matching approach

The sample consists of firms with options listed for the first time during the sample period and the matched non-optioned firms during a five-quarter window [-2 , 2] around the option introduction. *Treatment* is a dummy variable that equals one if a firm belongs to the treatment group, and zero otherwise. *Post* is a dummy variable that equals one if treatment firms and the corresponding control firms are in the post-listing period, and zero otherwise. The dependent variables in columns (1)-(3) are *EIssue*, *ESize*, and *Leverage*, respectively. Other variable definitions are in the legend of Table II. Constant terms, quarter fixed effects, and industry (firm) fixed effects are included in columns (1)-(2) (column (3)) but their coefficients are not reported. The $z(t)$ -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	<i>Eissue</i> (1)	<i>Esize</i> (2)	<i>Leverage</i> (3)
<i>Treatment*Post</i>	0.072** (2.0)	-0.029 (-0.6)	-0.009*** (-3.1)
<i>Treatment</i>	0.066** (2.2)	0.144*** (3.7)	-0.007 (-1.2)
<i>Post</i>	-0.096*** (-3.7)	0.010 (0.3)	0.001 (0.7)
<i>External financing</i>	0.064** (2.0)		
<i>Deviation from target</i>	-0.168*** (-2.6)	-0.143* (-1.9)	
<i>Ln(Assets)</i>	-0.096*** (-6.9)	-0.103*** (-4.9)	0.040*** (5.9)
<i>Ln(Firm age)</i>	-0.041** (-2.3)	-0.079*** (-3.6)	0.039** (2.2)
<i>PPE/Assets</i>	-0.165*** (-2.7)	0.127* (1.7)	0.140*** (3.6)
<i>EBITDA/Assets</i>	0.038 (0.2)	-0.646** (-2.3)	-0.040 (-0.9)
<i>Earnings dilution</i>	0.020 (0.3)	-0.060 (-1.2)	
<i>Marginal tax rate</i>	-0.239** (-2.0)	0.070 (0.5)	-0.077*** (-2.9)
<i>Net operating loss</i>	0.020* (1.7)	0.008 (0.5)	
<i>M/B</i>	0.026*** (4.7)	0.013*** (2.8)	-0.001 (-1.5)
<i>R&D/Sales</i>	0.008*** (3.2)	0.002 (0.6)	-0.001 (-1.4)
<i>R&D dummy</i>	-0.032 (-1.1)	-0.051 (-1.4)	0.002 (0.6)
<i>Dividend/Assets</i>	-2.303 (-0.8)	0.544 (0.2)	-0.198 (-1.5)
<i>Z-score</i>	-0.002 (-0.3)	0.006 (0.7)	-0.003 (-1.4)
<i>Stock return</i>	0.270*** (8.6)	0.181*** (4.7)	-0.002 (-0.7)
<i>Earning volatility</i>	-0.007 (-0.1)	-0.062 (-0.5)	-0.066 (-1.3)
<i>Stock volatility</i>	-0.368 (-0.5)	0.704 (0.8)	0.076 (1.1)
<i>Stock illiquidity</i>	-0.144** (-2.3)	-0.144* (-1.8)	0.030*** (3.5)
<i>Debt rating</i>	0.022 (0.6)	0.078** (2.2)	0.090*** (4.7)
<i>Analyst following</i>	0.002 (0.6)	0.007 (1.6)	-0.004** (-2.4)
<i>STIO</i>	0.000 (0.0)	0.282*** (2.8)	-0.019 (-1.1)

<i>LTIO</i>	-0.338** (-2.2)	-0.090 (-0.4)	0.012 (0.4)
Industry and quarter fixed effects	Y	Y	N
Firm and quarter fixed effects	N	N	Y
N/ R ²	5,230/0.33	2,475/0.28	31,387/0.89

Appendix F Institutional ownership, analyst following, and options listing

Market cap equals the number of shares outstanding multiplied by the closing stock price at the end of the fiscal year. *Dividend yield* is dividend per share/stock price. *B/M* is book value of equity/*Market cap*. *Stock turnover* is the mean value of monthly shares traded (volume) divided by shares outstanding over the quarter. *Stock return_{t-1,t}* (*Stock return_{t-4,t-1}*) is compounded monthly stock returns calculated over the current quarter (the three quarters preceding the current quarter). *S&P500* is a dummy variable that equals one if the firm is included in the S&P 500. *Industry median number of analysts* are computed by three-digit SIC code and by year. *Herfindahl* index is computed based on the three-digit SIC code. *Big player dummy* equals one if a firm's sale is above the 75th percentile of the distribution of the three-digit SIC industry. *Past equity issues* is the sum of equity issues in the past four quarters divided by total assets. *Expected sales growth* is sales next year deflated by current sales. Other variable definitions are in the legend of Table II. Constant terms, quarter fixed effects, and firm (industry) fixed effects are included in columns (1)-(3) (column (3)) but their coefficients are not reported. The *t*(*z*)-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent variable</i>	<i>IO</i> OLS (1)	<i>STIO</i> OLS (2)	<i>LTIO</i> OLS (3)	<i>Analyst following</i> Negative Binomial (4)
<i>Treatment*Post</i>	0.022*** (5.8)	0.011*** (3.8)	0.001 (0.7)	0.075*** (3.2)
<i>Treatment</i>	0.012* (1.6)	0.010** (2.0)	0.001 (0.4)	0.072* (1.8)
<i>Post</i>	0.002 (0.6)	0.002 (1.0)	0.000 (0.3)	0.084*** (4.5)
<i>Ln(Market cap)</i>	0.023** (2.4)	0.008 (1.3)	0.004 (1.3)	
<i>Ln(Firm age)</i>	0.050* (1.9)	0.013 (0.7)	0.006 (0.7)	-0.177*** (-7.1)
<i>Dividend yield</i>	0.154 (0.4)	-0.118 (-0.5)	0.014 (0.1)	
<i>B/M</i>	-0.000 (-0.2)	-0.000 (-0.1)	-0.000 (-0.5)	
<i>Ln(Stock price)</i>	0.062*** (6.4)	0.041*** (6.0)	0.009*** (2.7)	0.145*** (4.9)
<i>Stock turnover</i>	0.006** (2.2)	0.007*** (4.3)	0.001 (0.7)	0.076*** (4.5)
<i>Stock volatility</i>	-0.464*** (-3.9)	-0.338*** (-4.1)	-0.031 (-0.6)	-4.204*** (-3.2)
<i>Stock return_{t-1,t}</i>	-0.013*** (-4.2)	-0.001 (-0.3)	-0.005*** (-4.5)	
<i>Stock return_{t-4,t}</i>	-0.002 (-1.1)	0.005*** (3.2)	-0.004*** (-3.3)	
<i>ROA</i>	0.034 (1.5)	0.049*** (2.7)	-0.016** (-2.0)	-0.834*** (-2.9)
<i>Analyst following</i>	0.005*** (3.3)	0.002** (2.6)	0.001 (1.4)	
<i>Leverage</i>	0.023 (0.8)	0.017 (1.0)	0.008 (0.7)	-0.256** (-2.3)
<i>S&P500</i>	-0.035 (-0.7)	-0.070** (-2.4)	0.019 (1.4)	0.505*** (7.1)
<i>M/B</i>				-0.008 (-1.4)
<i>Industry median number of analysts</i>				0.051*** (5.2)
<i>Ln(Sales)</i>				0.138*** (7.3)
<i>Herfindahl index</i>				-0.288*** (-3.3)
<i>Big player dummy</i>				0.134*** (3.1)
<i>Debt rating</i>				0.212*** (4.3)
<i>Past equity issue</i>				0.019*** (2.6)
<i>Expected sale growth</i>				0.028

	(1.3)			
Industry and quarter fixed effects	N	N	N	Y
Firm and quarter fixed effects	Y	Y	Y	N
N/ R ²	27,623/0.90	27,623/0.83	27,623/0.77	20,964

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Table I Summary statistics

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. *OptList* is a dummy variable that equals one if a firm has options being traded on exchanges, and zero otherwise. *OptVol* is the quarterly option volume (in millions of dollars). *Assets* is the book value of total assets. $\Delta E/Assets$ is (sale of common stock — purchase of common stock)/Assets. $\Delta D/Assets$ is (long-term debt issuance — long-term debt reduction + changes in current debt)/Assets. We classify firms as issuing debt or equity when the corresponding issue size exceeds 3%. *Firm age* is the number of years elapsed since a firm enters the CRSP database. *PPE/Assets* is net Property, Plant, and Equipment (PPE) scaled by Assets. *EBITDA/Assets* is earnings before interest, taxes, depreciation and amortization (EBITDA) scaled by Assets. *Marginal tax rate* is the simulated marginal tax rate after interest expenses obtained from John Graham's Web site. *M/B* is (Assets + Market value of equity - Book value of equity)/Assets. *R&D/Sales* is R&D expenses scaled by total sales. *Dividend/Assets* is dividends scaled by Assets. *Z-score* is $(3.3 \times \text{pretax income} + \text{sales} + 1.4 \times \text{retained earnings} + 1.2 \times (\text{current assets} - \text{current liabilities}))/Assets$. *Stock return* is buy-and-hold stock returns computed over the quarter. *Earning volatility* is the historical standard deviation (using available data during the previous 12 quarters) of the ratio of *EBITDA/Assets*. *Stock volatility* is standard deviation of daily stock returns over the quarter. *Stock illiquidity* is the mean square root of the absolute value of daily stock return over daily trading volume (in millions of dollars) over the quarter. *Net operating loss* is net loss carryforwards/Assets. *Earnings dilution* is a dummy variable that equals one if one minus the assumed tax rate times yield on Moody's Baa rated debt is less than a firm's after tax earnings-price ratio, and zero otherwise. *Debt rating* is a dummy variable equal to one if the firm has a debt rating assigned by Standard & Poor's and zero otherwise. *Analyst following* is the maximum number of analysts making annual earnings forecast any month over a 3-month period. *STIO* (*LTIO*) is the number of shares held by short-term (long-term) institution investors divided by the total number of shares outstanding. Dollar values are converted into 2005 constant dollars using the GDP deflator.

	Full Sample <i>N</i> = 275,435			Propensity-Score Matched Sample <i>N</i> = 64,928		
	(1) Mean	(2) Median	(3) S.D	(4) Mean	(5) Median	(6) S.D
Panel A: Option trading						
<i>OptList</i>	0.437	0.000	0.496	0.500	0.500	0.500
<i>OptVol</i> (\$millions)	9.095	0.000	41.34	1.319	0.000	9.879
Panel B: Issuance activities and leverage						
% of firms issuing equity	0.048	0.000	0.191	0.051	0.000	0.221
% of firms issuing debt	0.134	0.000	0.346	0.120	0.000	0.325
$\Delta E/Assets$	0.338	0.135	0.615	0.362	0.151	0.648
$\Delta D/Assets$	0.147	0.076	0.286	0.149	0.077	0.288
<i>Leverage</i>	0.203	0.157	0.205	0.190	0.125	0.209
Panel C: Firm characteristics						
<i>Assets</i> (\$millions)	1867.2	181.0	6409.9	959.9	232.8	3575.8
<i>Firm age</i>	17.23	12.00	13.48	15.70	11.00	12.19
<i>PPE/Assets</i>	0.259	0.181	0.232	0.250	0.173	0.229
<i>EBITDA/Assets</i>	-0.007	0.014	0.092	-0.006	0.014	0.083
<i>Marginal tax rate</i>	0.267	0.333	0.111	0.269	0.337	0.110
<i>M/B</i>	2.265	1.539	2.789	2.466	1.630	3.253
<i>R&D/Sales</i>	0.460	0.000	2.905	0.630	0.000	3.419
<i>Dividend/Assets</i>	0.002	0.000	0.005	0.001	0.000	0.005
<i>Z-score</i>	-0.339	0.640	4.837	-0.248	0.613	4.092
<i>Stock return</i>	0.026	0.000	0.329	0.023	-0.002	0.335
<i>Earning volatility</i>	0.038	0.018	0.076	0.038	0.017	0.077
<i>Stock volatility</i>	0.042	0.034	0.028	0.039	0.033	0.023
<i>Stock illiquidity</i>	0.612	0.177	1.169	0.190	0.135	0.215
<i>Net operating loss</i>	0.390	0.000	1.682	0.362	0.000	1.425
<i>Earnings dilution</i>	0.043	0.000	0.202	0.035	0.000	0.183
<i>Debt rating</i>	0.244	0.000	0.430	0.221	0.000	0.415
<i>Analyst following</i>	4.998	3.000	6.266	3.948	3.000	3.342
<i>STIO</i>	0.164	0.131	0.153	0.188	0.163	0.143
<i>LTIO</i>	0.080	0.051	0.087	0.085	0.061	0.082

Table II Options trading and the debt-equity choice

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. The dependent variable, *EIssue*, equals one if net equity issued exceeds 3% of total assets, and zero if debt is issued at quarter *t*. Companies are defined as issuing equity (debt) when the net equity (debt) issued divided by total assets exceeds 3 percent. Cases where companies issue both debt and equity in a given quarter are omitted. *OptList* is a dummy variable that equals one if a firm has options being traded on exchanges, and zero otherwise. *External financing* is (Net debt issued + net equity issued)/total assets. *Deviation from target* is the deviation of the one-quarter lagged debt ratio from the estimated target debt ratio. *Assets* is the book value of total assets. *Firm age* is the number of years elapsed since a firm enters the CRSP database. *PPE/Assets* is net Property, Plant, and Equipment (*PPE*) scaled by *Assets*. *EBITDA/Assets* is earnings before interest, taxes, depreciation and amortization (*EBITDA*) scaled by *Assets*. *Marginal tax rate* is the simulated marginal tax rate after interest expenses obtained from John Graham's Web site. *M/B* is the market-to-book ratio defined as (*Assets* + Market value of equity - Book value of equity)/*Assets*. *R&D/Sales* is R&D expenses scaled by total sales. *Dividend/Assets* is dividends scaled by *Assets*. *Z-score* is $(3.3 \times \text{pretax income} + \text{sales} + 1.4 \times \text{retained earnings} + 1.2 \times (\text{current assets} - \text{current liabilities}))/\text{Assets}$. *Stock return* is buy-and-hold stock returns computed over the quarter. *Earning volatility* is the historical standard deviation (using available data during the previous 12 quarters) of the ratio of *EBITDA/Assets*. *Stock volatility* is standard deviation of daily stock returns over the quarter. *Stock illiquidity* is the mean square root of the absolute value of daily stock return over daily trading volume (in millions of dollars) over the quarter. *Net operating loss* is net loss carryforward/*Assets*. *Earnings dilution* is a dummy variable that equals one if one minus the assumed tax rate times yield on Moody's Baa rated debt was less than a firm's after tax earnings-price ratio, and zero otherwise. *Debt rating* is a dummy variable equal to one if the firm has a debt rating assigned by Standard & Poor's, and zero otherwise. *Analyst following* is the maximum number of analysts making annual earnings forecast any month over a 3-month period. *STIO* (*LTIO*) is the number of shares held by short-term (long-term) institution investors divided by the total number of shares outstanding. Constant terms, quarter fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The *z*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	Full sample Probit	Propensity-score matched sample Probit
<i>EIssue</i>	(1)	(2)
<i>OptList</i>	0.061*** (7.5)	0.042*** (3.6)
<i>External financing</i>	0.060*** (6.6)	0.086*** (2.9)
<i>Deviation from target</i>	-0.146*** (-9.5)	-0.172*** (-4.9)
<i>Ln(Assets)</i>	-0.056*** (-16.5)	-0.076*** (-8.0)
<i>Ln(Firm age)</i>	-0.043*** (-9.6)	-0.050*** (-4.8)
<i>PPE/Assets</i>	-0.115*** (-7.3)	-0.148*** (-3.9)
<i>EBITDA/Assets</i>	-0.005 (-0.2)	-0.023 (-0.3)
<i>Earnings dilution</i>	-0.015 (-1.1)	-0.010 (-0.3)
<i>Marginal tax rate</i>	-0.258*** (-10.4)	-0.244*** (-4.1)
<i>Net operating loss</i>	0.005*** (2.9)	0.018*** (4.0)
<i>M/B</i>	0.017*** (7.9)	0.020*** (3.9)
<i>R&D/Sales</i>	0.004***	0.006***

	(5.3)	(2.8)
<i>R&D dummy</i>	-0.063***	-0.079***
	(-8.9)	(-5.1)
<i>Dividend/Assets</i>	-1.623**	-0.271
	(-2.4)	(-0.2)
<i>Z-score</i>	0.000	0.002
	(0.5)	(1.0)
<i>Stock return</i>	0.106***	0.162***
	(14.4)	(8.9)
<i>Earning volatility</i>	0.040	0.026
	(1.3)	(0.3)
<i>Stock volatility</i>	0.910***	0.970***
	(7.5)	(2.9)
<i>Stock illiquidity</i>	-0.048***	-0.182***
	(-13.7)	(-3.7)
<i>Debt rating</i>	-0.002	0.016
	(-0.2)	(0.8)
<i>Analyst following</i>	0.001	0.002
	(0.8)	(1.0)
<i>STIO</i>	0.165***	0.036
	(7.3)	(0.8)
<i>LTIO</i>	-0.269***	-0.193**
	(-6.1)	(-2.2)
Industry and quarter fixed effects	Y	Y
N/ R ²	39,583/0.28	8,782/0.32

Table III Options trading and the size of equity issue

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. The dependent variable, *ESize*, is the size of net equity issue scaled by total assets at the beginning of the fiscal quarter. *OptList* is a dummy variable that equals one if a firm has options being traded on exchanges, and zero otherwise. Other variable definitions are in the legend of Table II. In columns (1) and (3), we estimate OLS regressions. Only equity issues exceeding 3% of total assets are included. Columns (2) and (4) report the results from the second stage regression in the Heckman procedure. Constant terms, quarter fixed effects, and two-digit SIC industry fixed effects are included in all regressions but their coefficients are not reported. The $t(z)$ -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	Full sample OLS	Full sample Heckman	Propensity-score matched sample OLS	Propensity-score matched sample Heckman
<i>Elssue</i>	(1)	(2)	(3)	(4)
<i>OptList</i>	-0.034** (-2.0)	-0.040** (-2.4)	-0.042** (-2.0)	-0.040* (-1.9)
<i>Deviation from target</i>	0.021 (0.5)	-0.001 (-0.0)	-0.112* (-1.8)	-0.128** (-2.0)
<i>Ln(Assets)</i>	-0.028*** (-3.4)	0.011 (1.1)	-0.045*** (-2.9)	-0.003 (-0.2)
<i>Ln(Firm age)</i>	-0.064*** (-6.5)	-0.018 (-1.5)	-0.058*** (-3.5)	-0.017 (-0.9)
<i>PPE/Assets</i>	-0.043 (-1.5)	-0.113*** (-3.6)	0.016 (0.3)	-0.062 (-0.9)
<i>EBITDA/Assets</i>	-0.570*** (-6.4)	-0.603*** (-6.0)	-1.030*** (-5.7)	-1.091*** (-4.3)
<i>Earnings dilution</i>	0.034* (1.7)	0.033* (1.8)	0.085* (1.9)	0.052 (1.2)
<i>Marginal tax rate</i>	0.074 (1.2)	0.317*** (4.9)	0.274** (2.6)	0.418*** (3.7)
<i>Net operating loss</i>	-0.001 (-0.1)	-0.004 (-0.8)	0.001 (0.1)	0.004 (0.3)
<i>M/B</i>	0.018*** (3.4)	0.011** (2.0)	0.014** (2.3)	0.010* (1.7)
<i>R&D/Sales</i>	0.002 (1.2)	0.000 (0.1)	0.001 (0.5)	-0.001 (-0.4)
<i>R&D dummy</i>	-0.006 (-0.5)	0.017 (1.2)	-0.016 (-0.6)	-0.009 (-0.4)
<i>Dividend/Assets</i>	0.949 (0.8)	2.798* (1.8)	-0.031 (-0.0)	1.533 (0.8)
<i>Z-score</i>	-0.006* (-2.0)	-0.007* (-1.8)	0.002 (0.7)	0.007 (1.6)
<i>Stock return</i>	0.116*** (6.5)	0.108*** (6.2)	0.178*** (4.8)	0.161*** (4.7)
<i>Earning volatility</i>	0.049 (0.7)	0.055 (0.7)	0.228 (1.5)	0.261* (1.6)
<i>Stock volatility</i>	-0.222 (-0.9)	-0.238 (-0.9)	1.391* (1.9)	1.715** (2.3)
<i>Stock illiquidity</i>	-0.002 (-0.4)	-0.001 (-0.2)	-0.189** (-2.3)	-0.178** (-2.1)
<i>Debt rating</i>	-0.006 (-0.4)	-0.034* (-1.8)	-0.004 (-0.2)	-0.031 (-1.2)
<i>Analyst following</i>	0.000 (0.2)	-0.000 (-0.3)	0.002 (0.5)	0.002 (0.6)
<i>STIO</i>	0.332*** (7.5)	0.342*** (7.6)	0.414*** (4.7)	0.448*** (5.0)
<i>LTIO</i>	0.132 (1.0)	0.168 (1.3)	-0.060 (-0.3)	-0.018 (-0.1)
Industry and quarter fixed effects	Y	Y	Y	Y
N/ R ²	13,165/0.20	256,015	3,339/0.23	60,554

Table IV Options trading and leverage

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. The dependent variable is *Leverage* at quarter t . *OptList* is a dummy variable that equals one if a firm has options being traded on exchanges, and zero otherwise. The variable definitions are in the legend of Table II. Constant terms, quarter fixed effects, and firm fixed effects are included in all regressions but their coefficients are not reported. The t -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	Full sample OLS	Propensity-score matched sample OLS
<i>Leverage</i>	(1)	(2)
<i>OptList</i>	-0.018*** (-7.4)	-0.008*** (-2.6)
<i>Ln(Assets)</i>	0.048*** (20.1)	0.058*** (12.1)
<i>Ln(Firm age)</i>	0.028*** (5.6)	0.035*** (3.7)
<i>PPE/Assets</i>	0.182*** (14.5)	0.175*** (8.7)
<i>EBITDA/Assets</i>	-0.086*** (-8.5)	-0.086*** (-3.7)
<i>Marginal tax rate</i>	-0.079*** (-10.3)	-0.057*** (-4.3)
<i>M/B</i>	-0.002*** (-5.1)	-0.000 (-0.1)
<i>R&D/Sales</i>	0.000 (0.4)	-0.000 (-0.3)
<i>R&D dummy</i>	0.003 (1.2)	-0.001 (-0.4)
<i>Dividend/Assets</i>	-0.560*** (-4.3)	-1.079*** (-3.9)
<i>Z-score</i>	-0.004*** (-9.9)	-0.005*** (-4.8)
<i>Stock return</i>	-0.008*** (-8.1)	-0.008*** (-4.1)
<i>Earning volatility</i>	-0.052*** (-3.8)	-0.044* (-1.9)
<i>Stock volatility</i>	0.334*** (11.1)	0.332*** (5.1)
<i>Stock illiquidity</i>	0.011*** (12.7)	0.067*** (7.5)
<i>Debt rating</i>	0.074*** (13.0)	0.077*** (8.9)
<i>Analyst following</i>	-0.003*** (-9.1)	-0.001* (-2.0)
<i>STIO</i>	-0.037*** (-5.5)	-0.023** (-2.3)
<i>LTIO</i>	-0.063*** (-5.4)	-0.060*** (-3.2)
Firm and quarter fixed effects	Y	Y
N/ R ²	275,435/0.74	64,928/0.81

Table V Financing decisions around option listing

The sample consists of firms with options listed for the first time during the sample period and the matched non-optioned firms during a five-quarter window [-2 , 2] around the option introduction. *Treatment* is a dummy variable that equals one if a firm belongs to the treatment group, and zero otherwise. *Post* is a dummy variable that equals one if treatment firms and the corresponding control firms are in the post-listing period, and zero otherwise. The dependent variables in columns (1)-(3) are *Elssue*, *ESize*, and *Leverage*, respectively. Other variable definitions are in the legend of Table II. Constant terms, quarter fixed effects, and industry (firm) fixed effects are included in columns (1)-(2) (column (3)) but their coefficients are not reported. The $z(t)$ -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	<i>Elssue</i> (1)	<i>Esize</i> (2)	<i>Leverage</i> (3)
<i>Treatment*Post</i>	0.093** (2.1)	0.100 (1.1)	-0.010*** (-3.1)
<i>Treatment</i>	0.059* (1.7)	-0.011 (-0.1)	-0.002 (-0.3)
<i>Post</i>	-0.086*** (-2.6)	-0.079 (-1.2)	0.000 (0.1)
<i>External financing</i>	0.111** (2.2)		
<i>Deviation from target</i>	-0.149* (-1.9)	-0.189 (-0.9)	
<i>Ln(Assets)</i>	-0.112*** (-5.9)	-0.101*** (-2.6)	0.055*** (6.5)
<i>Ln(Firm age)</i>	-0.071*** (-3.6)	-0.096*** (-2.6)	0.043* (1.7)
<i>PPE/Assets</i>	-0.180** (-2.4)	0.115 (0.9)	0.172*** (4.7)
<i>EBITDA/Assets</i>	-0.336* (-1.7)	-1.722** (-2.4)	-0.092** (-2.0)
<i>Earnings dilution</i>	0.078 (1.0)	0.105 (0.9)	
<i>Marginal tax rate</i>	-0.055 (-0.4)	0.509* (1.9)	-0.051* (-1.9)
<i>Net operating loss</i>	0.020** (2.0)	0.028 (0.8)	
<i>M/B</i>	0.021** (2.2)	0.032*** (2.8)	-0.000 (-0.2)
<i>R&D/Sales</i>	0.003 (1.1)	0.000 (0.0)	-0.001 (-1.4)
<i>R&D dummy</i>	-0.026 (-0.9)	-0.023 (-0.4)	-0.001 (-0.3)
<i>Dividend/Assets</i>	-4.671* (-1.7)	-1.620 (-0.4)	-0.652 (-1.6)
<i>Z-score</i>	0.003 (0.9)	0.004 (0.7)	-0.002 (-1.1)
<i>Stock return</i>	0.239*** (6.3)	0.169** (2.0)	-0.002 (-0.9)
<i>Earning volatility</i>	-0.224 (-1.6)	-0.149 (-0.5)	0.021 (0.6)
<i>Stock volatility</i>	-0.912 (-1.2)	0.542 (0.5)	0.065 (0.9)
<i>Stock illiquidity</i>	-0.157** (-2.5)	-0.216* (-1.9)	0.025** (2.2)
<i>Debt rating</i>	0.011 (0.3)	0.072 (1.0)	0.062*** (3.5)
<i>Analyst following</i>	0.003	0.002	-0.001

	(0.6)	(0.2)	(-0.9)
<i>STIO</i>	-0.096	0.452**	-0.037**
	(-1.0)	(2.4)	(-2.2)
<i>LTIO</i>	-0.484**	-0.398	0.001
	(-2.3)	(-1.3)	(0.0)
Industry and quarter fixed effects	Y	Y	N
Firm and quarter fixed effects	N	N	Y
N/ R ²	2,743/0.35	1,249/0.29	16,240/0.89

Table VI Cross-sectional differences in the effects of options trading on financing decisions

Data are collected from Compustat Quarterly, CRSP, and OptionMetrics databases for the years 1996 to 2013. *OptList* is a dummy variable that equals one if a firm has options being traded on exchanges, and zero otherwise. *Earnings quality* is defined according to Dechow and Dichev (2002). *Short* is a dummy variable that equals to one if a stock is in the top 30th percentile of quarterly short interest ratios that is also ranked in the bottom 30th percentile of stocks by institutional ownership, and zero otherwise. The dependent variables in columns (1)-(3) are *EIssue*, *ESize*, and *Leverage*, respectively. Other variable definitions are in the legend of Table II. Constant terms, quarter fixed effects, and industry (firm) fixed effects are included in columns (1)-(2) (column (3)) but their coefficients are not reported. The $z(t)$ -statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	<i>EIssue</i> (1)	<i>ESize</i> (2)	<i>Leverage</i> (3)
Panel A Option volume and the impact of <i>OptList</i> on financing decisions			
<i>OptList</i>	0.047*** (5.7)	-0.037*** (-2.7)	-0.014*** (-5.6)
<i>OptList</i> × <i>OptVol</i>	0.020*** (5.0)	0.003 (0.3)	-0.008*** (-6.8)
N	39,583	13,165	275,435
Panel B Information asymmetry and the impact of <i>OptList</i> on financing decisions			
<i>OptList</i>	0.086*** (8.3)	0.011 (0.5)	-0.020*** (-6.6)
<i>OptList</i> × <i>Analyst following</i>	-0.007*** (-4.5)	-0.015*** (-4.9)	0.001 (1.6)
<i>Analyst following</i>	0.007*** (4.4)	0.013*** (4.0)	-0.003*** (-7.1)
N	39,583	13,165	275,435
<i>OptList</i>	0.036*** (2.6)	0.036 (1.0)	-0.017*** (-3.7)
<i>OptList</i> × <i>Earnings quality</i>	0.342** (2.6)	-0.155 (-0.4)	-0.111* (-1.8)
<i>Earnings quality</i>	0.080 (0.9)	0.166 (0.8)	0.122** (2.5)
N	18,787	4,829	147,132
Panel C Short-sale constraint and the impact of <i>OptList</i> on financing decisions			
<i>OptList</i>	0.025*** (2.8)	0.004 (0.2)	-0.012*** (-4.2)
<i>OptList</i> × <i>Short</i>	0.080*** (3.0)	-0.016 (-0.3)	-0.012* (-1.8)
<i>Short</i>	0.019 (1.0)	0.012 (0.3)	0.013** (2.3)
N	23,104	6,660	175,266

Table VII Institutional ownership, analyst following, and options listing

Market cap equals the number of shares outstanding multiplied by the closing stock price at the end of the fiscal year. *Dividend yield* is dividend per share/stock price. *B/M* is book value of equity/*Market cap*. *Stock turnover* is the mean value of monthly shares traded (volume) divided by shares outstanding over the quarter. *Stock return_{t-1,t}* (*Stock return_{t-4,t-1}*) is compounded monthly stock returns calculated over the current quarter (the three quarters preceding the current quarter). *S&P500* is a dummy variable that equals one if the firm is included in the S&P 500. *Industry median number of analysts* are computed by three-digit SIC code and by year. *Herfindahl* index is computed based on the three-digit SIC code. *Big player dummy* equals one if a firm's sale is above the 75th percentile of the distribution of the three-digit SIC industry. *Past equity issues* is the sum of equity issues in the past four quarters divided by total assets. *Expected sales growth* is sales next year deflated by current sales. Other variable definitions are in the legend of Table II. Constant terms, quarter fixed effects, and firm (industry) fixed effects are included in columns (1)-(3) (column (3)) but their coefficients are not reported. The *t(z)*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

<i>Dependent variable</i>	<i>IO</i> OLS (1)	<i>STIO</i> OLS (2)	<i>LTIO</i> OLS (3)	<i>Analyst following</i> Negative Binomial (4)
<i>Treatment*Post</i>	0.028*** (6.4)	0.022*** (6.5)	0.001 (0.6)	0.125*** (6.7)
<i>Treatment</i>	-0.003 (-0.3)	0.000 (0.1)	0.005 (1.4)	-0.047 (-1.4)
<i>Post</i>	0.001 (0.5)	-0.004 (-1.6)	0.001 (0.9)	0.056*** (4.7)
<i>Ln(Market cap)</i>	0.019* (1.7)	0.007 (1.0)	0.000 (0.1)	
<i>Ln(Firm age)</i>	0.076** (2.6)	-0.000 (-0.0)	0.034** (2.4)	-0.191*** (-7.7)
<i>Dividend yield</i>	0.388 (0.8)	-0.006 (-0.0)	-0.158 (-1.1)	
<i>B/M</i>	0.000 (1.0)	0.000 (0.5)	0.000* (1.7)	
<i>Ln(Stock price)</i>	0.062*** (5.3)	0.031*** (4.2)	0.012*** (2.8)	0.138*** (4.1)
<i>Stock turnover</i>	0.001 (0.1)	0.004 (1.1)	-0.001 (-0.7)	0.053** (2.4)
<i>Stock volatility</i>	-0.291* (-1.7)	-0.294** (-2.5)	-0.032 (-0.7)	-6.943*** (-5.7)
<i>Stock return_{t-1,t}</i>	-0.016*** (-4.0)	-0.001 (-0.4)	-0.005*** (-3.5)	
<i>Stock return_{t-4,t}</i>	-0.002 (-0.5)	0.008*** (4.0)	-0.003** (-2.1)	
<i>ROA</i>	0.023 (0.9)	0.031* (1.7)	-0.013 (-1.2)	-0.296 (-0.9)
<i>Analyst following</i>	0.004*** (2.7)	0.002* (1.8)	0.001* (1.9)	
<i>Leverage</i>	-0.037 (-1.3)	-0.011 (-0.5)	0.000 (0.0)	0.097 (0.8)
<i>S&P500</i>	0.035 (1.0)	0.000 (0.0)	0.022 (1.2)	0.494*** (2.9)
<i>M/B</i>				-0.005 (-0.7)
<i>Industry median number of analysts</i>				0.046*** (3.8)
<i>Ln(Sales)</i>				0.039** (2.0)
<i>Herfindahl index</i>				-0.210*** (-2.4)
<i>Big player dummy</i>				0.018 (0.5)
<i>Debt rating</i>				0.087 (1.5)

<i>Past equity issue</i>				0.010 (1.0)
<i>Expected sale growth</i>				0.011 (0.6)
Industry and quarter fixed effects	N	N	N	Y
Firm and quarter fixed effects	Y	Y	Y	N
N/ R ²	15,557/0.88	15,557/0.79	15,557/0.76	11,588

Table VIII Option trading and SEO announcement returns

Data are collected from Compustat Quarterly, CRSP, OptionMetrics and Thomson Financial's SDC New Issues databases for the years 1996 to 2012. $CAR(-1,1)$ is an issuer's 3-day cumulative abnormal returns. $CAR(-2,2)$ ($CAR(-5,5)$) is an issuer's 5(11)-day cumulative abnormal returns. *Proceeds* equals the number of shares issued in the offering times the offer price as reported in the SDC database. Other variable definitions are in the legend of Table II. Constant terms, industry and quarter fixed effects are included in all regressions but their coefficients are not reported. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic-consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variable	$CAR(-1,1)$	$CAR(-2,2)$	$CAR(-5,5)$
	(1)	(2)	(3)
<i>OptList</i>	0.013*** (2.9)	0.019*** (3.7)	0.022*** (3.1)
<i>Ln(Market cap)</i>	0.002 (1.0)	0.000 (0.1)	-0.001 (-0.3)
<i>Leverage</i>	-0.016* (-1.8)	-0.018* (-1.7)	-0.034** (-2.4)
<i>M/B</i>	-0.000 (-0.7)	-0.001 (-0.9)	-0.003*** (-3.3)
<i>Stock return</i>	0.007 (1.2)	0.005 (0.8)	0.001 (0.1)
<i>Stock volatility</i>	-0.628*** (-4.4)	-0.726*** (-4.9)	-0.877*** (-4.0)
<i>Proceeds/Market cap</i>	0.016 (1.1)	0.016 (1.1)	-0.011 (-0.6)
<i>Nasdaq</i>	0.008* (1.7)	0.005 (0.9)	-0.000 (-0.0)
Industry and quarter fixed effects	Y	Y	Y
N/ R^2	3,256/0.9	3,256/0.07	3,256/0.07