The Threat of Shareholder Intervention and Firm Innovation*

Jin Qi

ABSTRACT

This research demonstrates that the threat of shareholder intervention negatively affects firm manager innovation incentive. The underlying mechanism is that innovation may cause stock price to reflect less accurate information about a firm's fundamental value, which makes firm managers vulnerable to shareholder intervention. Firm managers under the threat of shareholder intervention will be biased against innovation projects to minimize job termination risk. Consistent with this mechanism, I find that (1) increasing the threat of shareholder intervention has a significant and economically important negative impact on firm innovation; (2) the threat of shareholder intervention exerts less negative effects on firms that are more likely to have efficient stock prices—firms with more monitoring institutional investors and/or more financial analysts. To establish causality, I exploit a novel identification strategy that relies on a quasi-natural experiment of activist investor closures to generate exogenous variation in the threat of shareholder intervention. The results from the difference-in-differences estimation show that firm-level innovation significantly improves following exogenous activist investor closures. This identification strategy suggests a negative causal effect of shareholder intervention threat on firm innovation.

Keywords: Innovation, Shareholder Intervention Threat, Stock Price Efficiency, Monitoring Investors, Financial Analysts

JEL Classifications: G34, G14, O31, G23, G32

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1. Introduction

In the past two decades, an important feature of corporate governance reform is the growing shift from a director-centric to a more shareholder-centric governance system. Securities and Exchange Commission (SEC) rule changes have greatly empowered shareholders to exert influence or control over board elections, management compensation, and major business strategies. Firm management is now facing an increasing intervention threat from shareholders, especially activist shareholders. *The Economist* (February 7, 2015) estimates that, "since the end of 2009, 15% of the members of the S&P 500 index of America's biggest firms have faced an activist campaign...[and] about 50% of S&P 500 firms have had an activist on their share register." How does this important change in the corporate governance landscape affect corporate long-term investment, and in particular, firm innovation? My research examines this question by constructing a theoretical framework that explains managers' incentives under shareholder intervention threat and by empirically documenting the economic impact of intervention threat on firm innovation.

Burkart, Gromb, and Panunzi (1997) theorize that shareholder control constitutes an expropriation threat that *ex ante* reduces managerial incentives and non-contractible, firm-specific investment. Shareholder control that enables shareholders to reverse managers' investment decisions, reduces the private benefits that managers can obtain from taking effort and initiating profitable projects. My research extends Burkart, Gromb, and Panunzi by examining a new mechanism that is based on contingent control of shareholders. In today's publicly-traded firms, the exercise of shareholder control is often contingent on the information reflected in stock prices. Relying on stock prices as a public signal of a firm's performance is rooted in the theory that stock prices aggregate information from various market participants and, thus, provide valuable guidance (Hayek, 1945; Grossman, 1976; Roll, 1984; Holmstrom and Tirole, 1993). If shareholder intervention is based on the information contained in stock prices, the information efficiency of stock prices is key to determining shareholder intervention and managerial incentives.

Prior literature shows that pursuing innovation increases information asymmetry between corporate insiders and outside investors, because firm managers are often reluctant to disclose innovation-related information to the market, and uniqueness of the innovation project makes it difficult for outside investors to precisely determine the value of the project (Bhattacharya and Ritter, 1983; Maksimovic and Pichler, 2001; Aboody and Lev, 2000). Recent research provides evidence that for firms with greater information asymmetry, stock prices are less efficient in incorporating value-relevant information. For example, Kelly and Ljungqvist (2012) empirically demonstrate that stock prices fall substantially as a firm's information asymmetry increases. Thus, pursuing innovation is associated with less accurate information reflected in stock prices. When shareholder intervention decisions are based on the information contained in stock prices, the reduction in price informativeness will increase the likelihood of shareholder intervention. Since firm managers are inclined to minimize job termination risk, managers under shareholder intervention threat will be biased against innovation projects. Therefore, I propose that the threat of shareholder intervention negatively affects firm manager innovation incentives.

To empirically evaluate the economic impact of shareholder intervention threat on firm innovation, I construct a sample of 2097 U.S. publicly-traded firms from 2001 to 2008. The threat of shareholder intervention is measured by the percentage of firm outstanding shares held by activist institutional investors. This study examines how the threat of shareholder intervention *ex ante* affects managers' innovation incentives. Thus, the intervention threat measure is based on the presence of activist institutional investors who have a history of activist interventions against any U.S. incorporated firms, rather than based on SEC 13D filings, which indicates actual intervention of the focal firm. In addition, prior studies on shareholder activism have focused on the activist investors with 5% ownership. According to a recent report by J.P. Morgan, even small stakes (less than 1%) can be sufficient for activist shareholders to be effective.[1] My primary measure of shareholder intervention threat is based on the ownership of all activist institutional investors. I construct additional intervention threat measures with thresholds of 1% and 5% ownership to assess the effects of more influential activist investors. The results from

[1] See the J.P. Morgan report "The Activist Revolution: Understanding and Navigating a New World of Heightened Investor Scrutiny" (January 2015). The report shows that about 26.8% of activist campaigns targeting $10 billion-plus market capitalization companies and 59.2% of campaigns targeting $25 billion-plus companies were initiated by activists who held less than 1% of firm outstanding shares at announcement.

OLS and negative binomial estimations show that the threat of shareholder intervention has a significant and economically important negative effect on firm innovation.

In the above-mentioned mechanism, the threat of shareholder intervention reduces managers' innovation incentives mainly because innovation is often associated with less accurate information as reflected in stock prices. If this mechanism is valid, then for firms that are more likely to have efficient stock prices, such as those held by more monitoring institutional investors and/or followed by more financial analysts, shareholder intervention threat will exert less effect on firm innovation. Improved stock price efficiency means that the value of the innovation project is more likely to be reflected in stock prices. Thus, firm managers who undertake innovation projects are less likely to be mistakenly penalized. Consistent with the proposed mechanism, I find that for firms with higher holdings by monitoring institutional investors, the effect of shareholder intervention threat on innovation becomes weaker. Also, for firms that are followed by more financial analysts, intervention threat exerts less negative effect on firm innovation.

A potential concern is that the negative association between shareholder intervention threat and firm innovation is driven by activist investors' selection of less innovative firms. To address this reverse causality, I rely on a quasi-natural experiment of activist investor closures to generate exogenous variation in the threat of shareholder intervention. During the 2007-2009 financial crisis, market-wide liquidity shocks caused dramatic declines in the performances of activist hedge funds. Greenwood and Schor (2009) show that pressuring firms into a takeover is the most profitable activist strategy. However, the collapse of the global mergers and acquisitions (M&A) markets makes this major activist strategy unprofitable. With increasing redemption requests and declining returns from activist strategies, many activist investors decided to wind down their businesses and redeem their investors. I identify 20 activist investors who closed their operations in the U.S. during 2007-2010, accounting for 12.7% of the activist investors in 2006. Activist investor closures are plausibly exogenous, as the closure decisions are unlikely to have been motivated by information on the innovation performances of portfolio firms. Difference-in-Differences (DiD) estimation results provided here indicate that firm innovation significantly improves relative to control firms following exogenous activist investor closures. This finding provides clear evidence for the causal effect of shareholder intervention threat on firm innovation.

This research contributes to the literature on how corporate governance affects firm innovation. The existing literature shows that governing an innovative firm is fundamentally different from governing a conventional firm. The optimal corporate governance to motivate innovation should involve high tolerance for failure (Manso, 2011; Tian and Wang, 2014), a compensation scheme that rewards long-term success (Ederer and Manso, 2013), and protection of managers against career risks (Aghion, Van Reenen, and Zingales, 2013). My research shows that increasing shareholder power and intervention threat reduces manager incentives to innovate. More restrictions on shareholder intervention may be beneficial for governing innovative firms. In addition, recent studies by Edmans (2009), and Edmans and Manso (2011) theorize that institutional investors can exercise governance through trading, which causes stock price to be more efficient. My study suggests that this governance role of institutional investors is essential for innovative firms.

The remainder of this paper is organized as follows. Section 2 is a review of the literature on corporate governance and innovation. Section 3 contains the theoretical framework and hypotheses. Section 4 describes the data and variable measurements. Section 5 contains the primary empirical results. In Section 6, I discuss the quasi-natural experiment of activist investor closures, and estimate the effects of activist investor closures on firm innovation. Section 7 concludes the paper.

2. Related Literature

This research fits into the theoretical and empirical literature on corporate governance and innovation. An early paper by Holmstrom (1989) states that innovation projects may have extraordinary returns, but they are also highly risky, unpredictable, and idiosyncratic. The success of innovation projects requires long-term commitment and substantial human effort. Recent research has highlighted that governing innovative firms should be fundamentally different from governing conventional firms, due to these unique characteristics. For example, Manso (2011) theorizes that the optimal innovation-motivating incentive scheme should involve substantial tolerance for failure and rewards for long-run success. Tian and Wang (2014) show that initial public offering (IPO) firms backed by more failure-tolerant venture capital investors are more likely to pursue innovation. Aghion, Van Reenen, and Zingales (2013) demonstrate that institutional investors help increase firm innovation incentives by “insulating” firm managers against the reputational consequences of innovation failure, rather than “disciplining” lazy managers. Ederer and Manso (2013) use a controlled laboratory experiment to show that the standard pay-for-performance compensation, which has been effective in inducing managerial effort in conventional firms, is detrimental to innovative firms. In addition, they find that threats of job termination undermines innovation incentives, while “golden parachutes” mitigate these negative effects.

The traditional view regarding dual-class share structure is that excess insider voting rights entrench managers and decrease firm value (Gompers, Ishii, and Metrick, 2010). Chemmanur and Jiao (2012) contend that dual-class share structure may benefit IPO firms because the entrenchment effect enables talented managers to undertake the innovation projects that are intrinsically more valuable, but have high near-term uncertainty. Similarly, in the prior literature anti-takeover provisions are viewed as destroying shareholder value by entrenching firm managers. However, Chemmanur and Tian (2013) provide evidence that anti-takeover provisions help improve corporate innovation by insulating firm managers from short-term pressures in the equity market. In addition, Sapra, Subramanian, and Subramanian (2014) suggest that there is a non-monotonic U-shaped relationship between external takeover pressure and firm innovation. In particular, firms are more innovative when anti-takeover laws are severe enough to deter takeovers or when an unhindered market is developed for corporate control.

This research is also related to the literature on the effects of financial markets and stock prices on corporate innovation. Stein (1989) develops a model of short-termism driven by the stock market. In his model, firm managers mislead the stock market by forsaking good investments to boost current earnings. In equilibrium, the stock market correctly adjusts for earnings inflation. He and Tian (2013) demonstrate that financial analysts of the market exert pressure on firm managers to meet short-term earnings targets, which impedes a firm's commitment to long-term innovation investment. Fang, Tian, and Tice (2013) provide evidence that stock liquidity impedes firm innovation by exposing firms to the risk of hostile takeovers and by reducing institutional investors' incentives to gather information.

3. Theoretical Framework

Burkart, Gromb, and Panunzi (1997) identify a trade-off between shareholder control and managerial initiative. Even when shareholder control is *ex post* efficient, it constitutes an expropriation threat that *ex ante* reduces managerial incentives and non-contractible, firm-specific investment. They propose a mechanism in which shareholder control reduces the private benefits that managers can obtain from taking effort and initiating profitable projects. Their research suggests using a dispersed ownership structure to prevent outside investors from exercising excessive control. I extend Burkart, Gromb, and Panunzi by examining a new mechanism that emphasizes contingent control of shareholders.

Aghion and Bolton (1992) show that optimal control allocations may involve contingent control, in which controls are allocated between investors and managers (entrepreneurs) depending on the realization of the first-period signal. The prior literature shows that the stock market is a monitor of managerial performance (Holmstrom and Tirole, 1993), and many corporate governance actions are driven by the information summarized in the stock prices. For example, Smith (1996) shows that shareholder activism is often triggered by poor stock price performance, and Coughlan and Schmidt (1985) demonstrate that the replacement of top management is associated with changes in stock price performance. Shareholders in today's publicly-traded firms often base their intervention decisions on the information reflected in the stock prices, especially when shareholders do not have incentives to obtain private information due to high monitoring costs.

3.1 Innovation, Information Asymmetry, and Stock Price Efficiency

Firm projects are categorized into "innovation" projects and "industry standard" projects. Following March (1991) and Manso (2011), an innovation project refers to the exploration of new actions that are superior to previously known actions, and an industry standard project refers to the exploitation and refinement of existing well-established actions. The discrete choice between an innovation project and an industry standard project can be viewed as a choice on the firm's strategic direction. Schumpeter (1942) and Aghion and Howitt (1992) demonstrate that innovation drives economic growth through creative destruction. A new innovation destroys the rents of established companies that enjoy monopoly power derived from their previous technological capability. These studies imply that in the long run, firms that pursue innovation as their strategic direction have higher cash flows than firms that focus on exploiting an existing technology advantage.

An established view in the innovation literature is that pursuing innovation increases information asymmetry between the corporate insiders and the outside investors. When a firm undertakes an innovation project, the manager of the firm may be reluctant to disclose the innovation project to prevent competitors from imitating it. For example, Bhattacharya and Ritter (1983) propose a model in which innovative firms face a trade-off when deciding whether to disclose private information about innovation projects. Disclosing innovation information to outside investors may help raise external financing at better financial terms. However, the downside risk is that competitors may obtain useful innovation information from the disclosure, which may reduce the firm's initial advantage in the innovation rivalry. In a related study, Maksimovic and Pichler (2001) show that the firms that are pioneering new technologies may finance their investment in such technologies with private offerings instead of public offerings, in order to prevent revealing the innovation information to potential industry entrants. These studies imply that firms disclose less information when undertaking an innovation project than when undertaking an industry standard project.

Informed market participants, such as institutional investors and financial analysts, can obtain private information through monitoring and analyzing firms. Innovation is a complicated process that requires substantial amounts of knowledge and monitoring effort to fully assess the potential of a project. An innovation project is unique to the firm that developed the innovation. The relative uniqueness of the innovation makes it difficult for outsiders to precisely determine the value of the project. Thus, informed market participants may have less precise information if a firm undertakes an innovation project than if the firm selects an industry standard project. Aboody and Lev (2000) provide evidence that R&D is a major contributor to information asymmetry, and that insiders exploit this asymmetry to gain substantially from insider trading.

Recent research provides evidence that information asymmetry leads to inefficient stock prices. Kelly and Ljungqvist (2012) empirically demonstrate that increases in information asymmetry causes a substantial fall in stock prices. Based on rational expectations models, they show that greater information asymmetry exposes uninformed investors to more liquidity risk and, thus, reduces uninformed investors' demand for the assets. Fishman and Hagerty (1992) provide an alternative theory that the efficiency of stock prices is partly determined by the distribution of information between the insiders and the market professionals. They state that "unequal access (to information) leads to less aggressive trading by the market professionals and more aggressive trading by the insider, but the net effect is an order flow that is less sensitive to traders' information and thus less informative (p.112)." Overall, these studies show that greater information asymmetry is associated with less efficient stock prices.

In sum, when compared with "industry standard" projects, pursuing "innovation" projects is associated with less efficient stock prices. The association of innovation and stock price efficiency has important implications for firm managers when they are under significant threat of shareholder intervention.

3.2 Shareholder Intervention Threat and Firm Innovation

When firms are under the threat of shareholder intervention, firm managers will consider the likelihood of shareholder intervention associated with an investment project. The intervention likelihood is determined by the precision of the information reflected in the stock prices. As discussed above, pursuing innovation may lead to less efficient stock prices. Thus, the likelihood of intervention associated with some innovation projects would be greater than that of industry standard projects.

When under significant intervention threat, firm managers face a trade-off when deciding to undertake an innovation project. An innovation project may provide higher expected future cash flows than an industry standard project. However, an innovation project may be associated with higher likelihood of shareholder intervention. Thus, firm managers may forgo good innovation projects to avoid the risk of shareholder intervention and the termination of their jobs. As the threat of shareholder intervention increases, firm managers will have stronger incentives that bias towards conservative, industry standard projects. Thus, I hypothesize that

Hypothesis 1: *The threat of shareholder intervention negatively affects firm manager innovation incentives.*

In the above analysis, the threat of shareholder intervention reduces managers' innovation incentives mainly because innovation is often associated with less accurate information reflected in stock prices. I further examine the roles of monitoring institutional investors and financial analysts in improving stock price efficiency. Stock price efficiency is defined as the extent to which stock prices are informative about a firm's fundamental value. With more efficient stock prices, the value of innovation is more likely to be reflected in stock prices. Thus, a good manager with valuable innovation projects is less likely to be mistakenly penalized by activist investors.

Institutional investors are important information providers on the financial market. Boehmer and Kelley (2009) demonstrate that stocks with greater institutional ownership are priced more efficiently, and both institutional holdings and institutional trading activities contribute to the information efficiency of stock prices. Piotroski and Roulstone (2004) provide evidence that institutional investors help accelerate the incorporation of firm-specific earnings news into stock prices. According to Chen, Harford, and Li (2007), among all institutional investors, independent institutions with long-term investments specialize in monitoring firm management. These "monitoring institutional investors" are more likely to obtain information about the value of the innovation projects, and convey that information to the stock market. When monitoring institutional investors help improve stock price efficiency, innovation projects are less likely to be intervened, as intervention is now based on more accurate information. As a result, firm managers will have more incentives to innovate.

Besides improving stock price efficiency, monitoring institutional investors have more roles to play. When monitoring institutional investors are actively involved in intervention activities, they can rely on their own private information rather than the information contained in the stock prices to make intervention decisions. This helps relieve firm managers from the intervention pressure caused by imprecise information in stock prices. When monitoring investors do not pursue shareholder activism, their information can be pivotal to the outcome of other investors' intervention activities. An activist shareholder often needs to unite with other shareholders to win an activism campaign. If the monitoring investors have information that a manager's innovation project can greatly improve shareholder value in the long run, monitoring investors will not support the activism campaign or may even defeat activist shareholder attempts. This role is particularly important for firms in which special interest groups take activism to promote their own interest at the expense of other shareholders. Overall, monitoring institutional investors can help promote manager incentives to pursue valuable innovation projects when the managers are under shareholder intervention threat. Thus, I hypothesize that

Hypothesis 2*: Among firms with higher holdings by monitoring institutional investors, shareholder intervention threat exerts less negative effects on firm innovation.*

Financial analysts are important information intermediaries between corporate managers and financial market investors. These analysts devote their resources to gather information about a firm's earnings prospects. Frankel and Li (2004) show that an increase in financial analysts that follow a firm is associated with reduced information asymmetry between insiders and outsiders. Similarly, Piotroski and Roulstone (2004) find that analyst forecasting activity accelerates the incorporation of the industry and firm-specific information into stock prices. Financial analysts improve stock price efficiency through their firm-specific earnings forecasts and stock recommendations, and through identifying earnings news that are common to a specific industry. When a firm is followed by more financial analysts, firm managers would expect that the value of their innovation projects is more likely to be incorporated into stock prices, and they are less likely to face intervention. Thus, firm managers will be less inclined to be biased against an innovation project when they are under intervention threat. Following this logic, I hypothesize that

Hypothesis 3*: When firms are followed by more financial analysts, shareholder inter-*

vention threat exerts less negative effects on firm innovation.

4. Data and Variable Measurement

I construct a firm-level panel dataset with data on innovation, shareholder intervention threat, shareholder monitoring, and financial analysts using a variety of sources. The starting point is the Compustat database, which contains basic financial and accounting data for all U.S. publicly listed firms since 1950. Innovation is measured using patent statistics. Patent data are manually collected from the Thomson Innovation database. The measure of shareholder intervention threat is constructed by combining the activist investor information from FactSet's corporate activism database with the ownership data from Thomson Reuters Institutional (13F) Holdings Database. Financial analyst information is obtained from the Institutional Brokers' Estimate System (I/B/E/S) Database. The final sample consists of an unbalanced panel of 2097 publicly-traded firms. These firms have at least one patent application during the sample period. The explanatory variables are constructed using data from 2001-2008. The dependent variables of innovation are constructed using patent data from 2001-2013.

Firm Innovation

Patents and patent statistics have been widely used as indicators of innovation (Griliches, 1990). The first measure of innovation in this study is the total number of patent applications filed by a firm in a given year (*Total Patents*). Patent application year, rather than patent grant year, is used to capture the time of innovation (Griliches, Pakes, and Hall, 1988). Patents vary in their value and impact. Prior literature suggests that patents of greater economic value were cited more frequently in subsequent patents (Trajtenberg, 1990; Harhoff, *et al.*, 1999). A second innovation measure is the count of highly-cited patents (*Highly-Cited Patents*). Firms with more highly-cited patents tend to have more original, influential inventions, and have larger share of the leading-edge technologies in their industry. To identify highly-cited patents, I calculate the median of the forward citations of all the patents in an industry (4-digit SIC industry) that are filed in a given year, and then localize the patents whose forward citations are higher than the median number of citations in its respective industry. For each firm, I count the number of highly-cited patents.

Patent and citation data are manually collected from the Thomson Innovation database. Thomson Innovation, launched by Thomson Reuters in 2007, is a comprehensive and integrated patent search and analysis platform. The database provides access to patent information from all major patenting authorities worldwide and the Derwent World Patents Index. Its collection of U.S. granted patents covers the years from 1836 to present, and the patents granted by the U.S. Patent and Trademark Office (USPTO). Based on Thomson Innovation, I obtain the patent portfolio for 2097 U.S. publicly-traded firms, with patent data up to 2013. The information includes patent assignee name, application date, publication date, count of forward citations, the publication number of the citing patents, patent class, name of inventor, etc.

A truncation problem exists in the database: many patents that have been filed, but have not yet been granted by USPTO, are not included in the database. As noted in the literature on innovation (e.g., Hall, Jaffe, and Trajtenberg, 2005), there is a significant lag (an average of two years) between patent applications and patent grants. As we approach the last year of the patent database, we observe only a fraction of all patents that have been filed. So, following Hall, Jaffe, and Trajtenberg (2001, 2005), the truncation bias is corrected by constructing "weight factors" based on the application-grant empirical distribution.

Shareholder Intervention Threat

In publicly-traded firms, shareholder intervention activities are often performed by activist institutional investors. The broad category of activist investors include pure-play activists and multi-strategy funds.[2] The pure-play activists specialize exclusively in activism, and pressure for firm change through concentrated stake in a company. The multi-strategy investors are typically diversified and use several strategies within the same pool of assets. These investors have broadened their traditional passive investment model to include more activist-oriented approach.

[2] See the J.P. Morgan report "The Activist Revolution: Understanding and Navigating a New World of Heightened Investor Scrutiny" (January 2015).

I measure the threat of shareholder intervention by the percentage of firm outstanding shares held by the activist institutional investors. First, I classify firm institutional investors into activist and non-activist groups. If an investor has activism campaigns (against any U.S. incorporated firms) in the current year or in the previous one year, the investor is categorized as an activist investor. Second, I identify activist investors based on FactSet's corporate activism database, SharkWatch. The database provides activist investor profiles with detailed information on their previous campaigns, tactics, and outcome. It tracks various types of activist investors, including investment advisors, mutual funds, pension funds, hedge funds, labor unions, and other institutions and stakeholders. I obtain the names of the activist investors from the SharkWatch database, and search these names in the Thomson Reuters Institutional Holdings (13F) Database. This procedure identifies 259 activist institutional investors who have at least one shareholder activism campaign during 2001-2008. Finally, for each publicly-traded firm, I aggregate the 13F holdings of all its activist investors, which gives us the basic measure of the threat of shareholder intervention.[3] For robustness check, I construct additional measures of shareholder intervention threat by requiring an activist investor to have at least 1% ownership, or alternatively 5% ownership in a firm, rather than including all activist investors of a firm.

Shareholder Monitoring

Chen, Harford, and Li (2007) show that among all institutional investors, the independent investors with long-term investments specialize in monitoring the firm. The extent of shareholder monitoring is measured by the percentage of firm outstanding shares held by these "monitoring investors". Following Chen, Harford, and Li, the "independent" investor group includes investment companies, independent investment advisors, and public pension funds. "Long-term investment" is defined as a firm holding shares for greater than one year. Bushee (1998) analyzes the investment patterns of institutions, and classifies institutional investors into three categories: dedicated, quasi-indexer, and transient. Dedicated institutions and quasi-indexers are most likely to perform the monitoring role.

[3] A limitation of this measure is that if an activist investor is not a 13F institutional investor, its influence in the firm is not captured by the measure.

As in Chen, Harford, and Li, the "monitoring investors" are constructed by intersecting the group of independent institutions holding long-term investments with Bushee's (1998) categories of dedicated investors and quasi-indexer investors. I focus on the monitoring activities of non-activist shareholders and their information effect. I select the monitoring investors that did not have activism campaigns (against any U.S. incorporated firms) in the past five years. Their ownership data are obtained from the Thomson Reuters Institutional Holdings (13F) Database. The final measure of shareholder monitoring is constructed by aggregating the 13F holdings of a firm's non-activist monitoring investors.

Analyst Following

The intensity of information collection by a firm's financial analysts is proxied by the number of financial analysts following the firm. Financial analyst data are retrieved from the Thomson Reuters I/B/E/S Detail History file. For each firm in each calendar year, I calculate the maximum number of financial analysts that make one-year-ahead forecasts. Firms that are not covered by the I/B/E/S database are assumed to have no analyst coverage.

Control Variables

As in the innovation literature, I control for firm-specific and industry characteristics that may affect firm innovation. I control for firm size, which is proxied by a firm's book value of total assets (*Assets*). Firms with greater growth opportunities are more likely to innovate. Firm growth opportunities are measured by Tobin's Q. Since firm innovation tends to affect stock market value, Tobin's Q will be endogenous in the regression. To address this concern, I include the industry median Tobin's Q ("industry Q") to control for the investment opportunities at the industry (4-digit SIC code) level. Since innovation is directly related to firm investment level, firm capital expenditure (scaled by total assets) is included as a control. I also control for firm profitability (measured by return-on-assets ratio (ROA)), asset tangibility (measured by net properties, plants, and equipment (PPE), scaled by total assets), financial leverage (measured by the ratio of debt to total firm value), and financial constraints (proxied by Kaplan and Zingales (1997) five variable KZ index).

Firm innovation activities may vary with firm age. Balasubramanian and Lee (2008)

Table 1
Summary Statistics

Variables	5%	25%	Median	75%	95%	Mean	SD	N
Total Patents	0	0	3.002	13.078	149.735	39.230	178.496	13414
Highly-Cited Patents	0	0	1.031	6.085	65.935	17.098	77.459	13414
Activist Investor Ownership	0	0.001	0.008	0.040	0.149	0.033	0.056	13414
Monitoring Investor Ownership	0.003	0.087	0.231	0.350	0.513	0.234	0.165	13362
Analysts	0	2	6	13	29.25	9.121	9.591	13014
Assets (in Millions)	12.9	82.3	421.0	2503.0	30356.3	6429.0	21696.7	13414
Tobin's Q	0.692	1.191	1.789	2.959	7.858	2.928	6.045	13414
Industry Q	0.956	1.354	1.798	2.533	3.881	2.105	2.568	13414
ROA	-0.528	-0.029	0.095	0.169	0.304	0.020	0.298	13414
CapExp / Assets	0.004	0.016	0.031	0.055	0.141	0.045	0.049	13414
PPE / Assets	0.018	0.069	0.153	0.291	0.644	0.214	0.198	13414
Leverage	0	0.003	0.189	0.421	0.837	0.273	0.342	13414
KZIndex	-47.220	-8.169	-2.250	0.339	3.337	-11.187	38.607	13414
Firm Age	4	9	14	27	54	19.988	15.410	13414
Herfindahl Index	0.058	0.096	0.172	0.279	0.606	0.225	0.185	13414

show that firm age is negatively related to innovation quality. They argue that organizational inertia and reduced learning rates associated with older firms are the main reasons for the decline in innovation quality. Firm age is approximated by the number of years a firm is listed in the Compustat database. Aghion, *et al.* (2005) propose that product market competition discourages laggard firms from innovating but encourages neck-and-neck firms to innovate. They find an inverted-U relationship between a firm's product market competition and innovation. Product market competition (measured by the Herfindahl sale index) is included as a control. Industry fixed effects are controlled by including industry dummies. The definition of industry is based on the SIC 3-digit code. The variables *Assets, ROA, CapExp/Assets, PPE/Assets, Leverage,* and *KZIndex* have many outliers. To minimize the effect of outliers, these variables are winsorized at the 1^{st} and 99^{th} percentiles. Detailed variable definitions are provided in Appendix Table A1.

Summary Statistics

In Table 1, I report the summary statistics of the variables used in this study. The innovation variables *Total Patents* and *Highly-Cited Patents* are highly skewed. For *Total Patents*, the mean is 39.2, but the median is 3. Similarly, the mean of *Highly-Cited Patents is* 17.1, but the median is 1. For an average firm in the sample, 3.3% of the outstanding shares of the firm are held by activist institutional investors, 23.4% of the firm shares are held by non-activist monitoring investors, and the firm is followed by about 9 financial analysts. The measure of firm size, *Assets,* is also skewed, with mean being 6429 million, and median being 421 million. Regarding other variables, an average firm has a return-on-assets ratio of 0.02, capital expenditure-to-assets ratio of 0.045, PPE-to-assets ratio of 0.214, leverage ratio of 0.273, KZ Index of -11.187, and is 20 years old. At industry (4-digit SIC) level, an average firm's industry Q is 2.105, and Herfindahl sale Index is 0.225.

5. Empirical Results

5.1 The Effects of Shareholder Intervention Threat on Firm Innovation

To examine the effects of shareholder intervention threat on firm innovation, I estimate the empirical model in (1):

$$E(Innovation_{i,t+n}|X_{i,t},\, \nu_k,\, \mu_t,\, \eta_i) = \exp(\beta_0 + \beta_1 \times Intervention\,Threat_{i,t} + \gamma X_{i,t} + \nu_k + \mu_t + \eta_i) \tag{1}$$

Here, $Innovation_{i,t+n}$ is firm i's innovation performance at year $t+n$. Innovation projects on average take two years to yield successful, patentable technologies. I examine firm innovation outcome from year $t+1$ to year $t+4$, with a focus on the innovation outcome at year $t+2$. $Intervention\,Threat_{i,t}$ represents the level of shareholder intervention threat of firm i at year t, and is measured by the percentage of firm outstanding shares held by the group of activist institutional investors. $X_{i,t}$ are control variables, ν_k is an industry fixed effect, μ_t is a year fixed effect, and η_i is a firm fixed effect. Equation (1) adopts the log-link formulation because of the non-negative and highly skewed nature of the count-based data.

OLS and negative binomial estimators are applied to estimate (1). I perform an overdispersion test on the patent data (Cameron and Trivedi, 2005, 2009), and the test results indicate the presence of considerable overdispersion in our data. A negative binomial estimator, which explicitly models overdispersion, is appropriate in this situation. As in Blundell, Griffith, and Van Reenen (1999), and Aghion, Van Reenen, and Zingales

(2013), I control for firm fixed effects η_i using the "presample mean scaling" method. Specifically, I use a firm's average number of patents (and highly-cited patents) over the presample period as a proxy for unobserved heterogeneity. This method controls for permanent differences in a firm's propensity to innovate. Year fixed effects and industry fixed effects are controlled by including year dummies and industry dummies (constructed based on 3-digit SIC code). Standard errors are clustered by firm to avoid inflated t-statistics.

Table 2: The Effects of Shareholder Intervention Threat on Firm Innovation

This table shows the pooled OLS and negative binomial estimates of the effects of shareholder intervention threat on firm innovation. The main explanatory variable *Intervention Threat* is measured by the percentage of firm outstanding shares held by activist institutional investors. Firm fixed effects are controlled using the "presample mean scaling" method, following the procedure in Blundell, Griffith, and Van Reenen (1999). Robust standard errors clustered by firm are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Model	OLS	OLS	Negative Binomial	Negative Binomial
Dependent Variable	ln ($Total\ Patents_{t+2}$)	ln ($Highly\text{-}Cited\ Patents_{t+2}$)	$Total\ Patents_{t+2}$	$Highly\text{-}Cited\ Patents_{t+2}$
	(1)	(2)	(3)	(4)
Intervention Threat	**-0.962*****	**-0.823*****	**-1.239*****	**-0.921****
	(0.311)	(0.276)	(0.423)	(0.467)
ln *(Assets)*	0.289***	0.220***	0.500***	0.457***
	(0.018)	(0.016)	(0.025)	(0.026)
Industry Q	0.005	0.005	0.008	0.012
	(0.004)	(0.004)	(0.008)	(0.008)
ROA	-0.075	-0.053	-0.299***	-0.225**
	(0.063)	(0.054)	(0.097)	(0.109)
CapExp / Assets	2.177***	1.838***	3.403***	3.611***
	(0.381)	(0.332)	(0.581)	(0.644)
PPE / Assets	-0.431***	-0.315**	-0.890***	-0.870***
	(0.153)	(0.131)	(0.224)	(0.246)
Leverage	-0.250***	-0.210***	-0.270***	-0.289***
	(0.048)	(0.042)	(0.070)	(0.079)
KZIndex	-0.000	-0.000	0.001	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
ln *(Firm Age)*	-0.133***	-0.104***	-0.226***	-0.236***
	(0.032)	(0.029)	(0.043)	(0.047)
Herfindahl Index	-0.569	-0.490	-0.601	-0.551
	(0.387)	(0.344)	(0.550)	(0.594)
Herfindahl Index ^{2}	0.181	0.214	-0.195	-0.238
	(0.438)	(0.385)	(0.622)	(0.659)
Constant	-0.277*	-0.346***	-1.998***	-2.308***
	(0.142)	(0.126)	(0.555)	(0.562)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	13414	13414	13414	13414

In Table 2, I report the estimated effects of shareholder intervention threat on firm innovation at year $t+2$. Columns (1) and (2) include the OLS estimates, where the dependent variable ln(*Total Patents*$_{t+2}$) is the natural logarithm of one plus the total number of patents applied by firm i at year $t+2$, and *ln*(*Highly-Cited Patents*$_{t+2}$) is the natural logarithm of one plus the number of patents applied by firm i at year $t+2$ that received a higher amount of citations (than the industry median) in subsequent years. The coefficients on shareholder intervention threat are negative and statistically significant. It shows that a ten percentage point increase in activist investor ownership (e.g., from the median of 0.008 to 0.108) is associated with a 9.6% decrease in the total number of patents and an 8.2% decrease in the number of highly-cited (highly influential) patents. In Columns (3) and (4), I report the results of the negative binomial estimations, with *Total Patents*$_{t+2}$ and *Highly-Cited Patents*$_{t+2}$ being the dependent variables. The coefficients on shareholder intervention threat remain significant with a larger marginal effect. These results show that the threat of shareholder intervention negatively affects firm innovation incentives. In Appendix Table A2, I present the estimated effects of shareholder intervention threat (at time t) on firm innovation performance from $t+1$ to $t+4$. The estimation results are qualitatively similar over the four years, although the effects decline slightly at years $t+3$ and $t+4$.

The results are robust to using alternative ways of measuring shareholder intervention threat. The primary measure of intervention threat (Table 2) is constructed by aggregating the 13F holdings of all activist institutional investors in a firm. Alternatively, we can select activist institutional investors who own more than 1% of firm outstanding shares, or own more than 5% of firm outstanding shares. As shown in Appendix Table A3, the results are similar using a different share ownership threshold. For example, the marginal effect of shareholder intervention threat is -0.993 based on activist institutional investors who have at least 1% ownership, and is -0.987 based on activist investors who have at least 5% ownership. When including all activist institutional investors of a firm, the marginal effect is -0.962 (Table 2). I also examine whether the effect of shareholder intervention threat on innovation is monotonic. In an untabulated analysis, I include a quadratic term for $InterventionThreat_{i,t}$ in equation (1), and rerun the regressions. The coefficient of the quadratic term of $Intervention\,Threat_{i,t}$ is not statistically significant.

5.2 Shareholder Monitoring and Analyst Following

This research highlights the information roles of institutional investors and financial analysts. I propose that when "monitoring" institutional investors and financial analysts help incorporate innovation-related information into stock price, improving price efficiency, the negative effects of shareholder intervention threat on firm innovation will be reduced. The information roles of monitoring institutional investors and financial analysts are particularly important for the firms that are less transparent and suffer more from the information asymmetry problem.

I estimate empirical models in (2) and (3) using OLS and negative binomial methods:

$$E(Innovation_{i,t+n}|X_{i,t},\, \nu_k,\, \mu_t,\, \eta_i) = \exp(\beta_0+\beta_1\times Intervention\,Threat_{i,t}+\beta_2\times Shareholder\,Monitoring_{i,t} + \beta_3 \times Intervention\,Threat_{i,t} \times Shareholder\,Monitoring_{i,t} + \gamma X_{i,t} + \nu_k + \mu_t + \eta_i) \quad (2)$$

$$E(Innovation_{i,t+n}|X_{i,t},\, \nu_k,\, \mu_t,\, \eta_i) = \exp(\beta_0+\beta_1\times Intervention\,Threat_{i,t}+\beta_2\times Analyst\,Following_{i,t} + \beta_3 \times Intervention\,Threat_{i,t} \times Analyst\,Following_{i,t} + \gamma X_{i,t} + \nu_k + \mu_t + \eta_i) \quad (3)$$

Here, $Shareholder\,Monitoring_{i,t}$ indicates the level of shareholder monitoring, which is measured by the percentage of firm outstanding shares held by the group of non-activist, monitoring institutional investors. $Analyst\,Following_{i,t}$ represents the intensity of information collection by financial analysts, and is proxied by the number of financial analysts following the firm.[4] The information effects of monitoring institutional investors and financial analysts are tested in a subsample of firms that are more likely to suffer from information asymmetry problem. I sort firms into quintiles based on market capitalization, and retain firms in the lower quintiles. Firms with large market capitalization have

[4] $Shareholder\,Monitoring_{i,t}$ and $Analyst\,Following_{i,t}$ are highly correlated, with Pearson's correlation coefficient equal to 0.526. This means that firms that have more monitoring institutional investors tend to have more analysts that follow the firms and make forecasts.

greater visibility and less information asymmetry. The roles of monitoring institutional investors and financial analysts in bridging information asymmetry will be greater for small capitalization firms than for large firms.

Table 3 reports the estimated interaction effects of shareholder monitoring and analyst following respectively. Coefficients in columns (1), (3), (5), and (7) show a positive and significant interaction effect of shareholder monitoring, implying that the monitoring activities of non-activist shareholders mitigate the negative effects of shareholder intervention threat on firm innovation. Using the estimation result in column (1) as an example, the estimated interaction effect of shareholder monitoring is 4.544. Consider a firm in which 8.7% of firm outstanding shares are held by monitoring institutional investors (at the 25th percentile of the shareholder monitoring distribution). Increasing the firm's intervention threat (proxied by activist investor ownership) from the median value of 0.008 to the 90 percentile value of 0.102, leads to a decrease in firm innovation by 12.4% ($= [-1.711 + 4.544 \times 0.087] \times [0.102 - 0.008]$). In contrast, for a firm that has 35% of outstanding shares held by monitoring institutional investors (at the 75th percentile of the shareholder monitoring distribution), increasing intervention threat from the median value of 0.008 to the 90 percentile value of 0.102, leads to a decrease in firm innovation by 1.1% ($= [-1.711 + 4.544 \times 0.35] \times [0.102 - 0.008]$). Overall, at the higher levels of shareholder monitoring, the threat of shareholder intervention exerts less negative effect on firm innovation.

The estimated interaction effects of analyst following are reported in columns (2), (4), (6), and (8) of Table 3. The coefficients on the interaction term $Intervention\,Threat \times ln(Analysts)$ are positive and statistically significant in all four columns. This means that firms followed by more analysts are less likely to forego innovation in response to increasing threat of shareholder intervention. Taking the results in column (2) as an illustration of this effect, the estimate of the interaction effect of analyst following is 0.783. Consider a firm that is followed by only 2 financial analysts (at the 25th percentile of the analyst following distribution). An increase of intervention threat level from the median value of 0.008 to the 90 percentile value of 0.102, is associated with a drop in firm innovation by 10.6% ($= [-1.987 + 0.783 \times 1.099] \times [0.102 - 0.008]$). However, when

Table 3: The Interaction Effects of Non-Activist Shareholder Monitoring and Analyst Following

This table examines whether the effects of shareholder intervention threat on firm innovation vary with the levels of shareholder monitoring and analyst following. Columns (1), (3), (5), and (7) report the estimated interaction effect of shareholder monitoring. Columns (2), (4), (6), and (8) report the interaction effect of analyst following. Firm fixed effects are controlled using "presample mean scaling" method, following the procedure in Blundell, Griffith, and Van Reenen (1999). Robust standard errors clustered by firm are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Model	OLS		OLS		Negative Binomial		Negative Binomial	
Dependent Variable	ln ($Total\ Patents_{t+2}$)		ln ($Highly\text{-}Cited\ Patents_{t+2}$)		$Total\ Patents_{t+2}$		$Highly\text{-}Cited\ Patents_{t+2}$	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intervention Threat	-1.711***	-1.987***	-1.329***	-1.570***	-2.467***	-2.657***	-2.130***	-2.521***
	(0.392)	(0.438)	(0.345)	(0.381)	(0.671)	(0.692)	(0.706)	(0.720)
Shareholder Monitoring	-0.210		-0.221*		-0.118		-0.045	
	(0.130)		(0.115)		(0.178)		(0.191)	
Intervention Threat × *Shareholder Monitoring*	**4.544*** **		**3.279*** **		**5.680** **		**5.050** **	
	(1.425)		(1.265)		(2.391)		(2.346)	
ln *(Analysts)*		0.055**		0.021		0.114***		0.099***
		(0.026)		(0.022)		(0.034)		(0.036)
Intervention Threat × ln *(Analysts)*		**0.783*** **		**0.592*** **		**0.864** **		**0.901** **
		(0.235)		(0.205)		(0.381)		(0.373)
ln *(Assets)*	0.242***	0.207***	0.181***	0.160***	0.439***	0.379***	0.395***	0.339***
	(0.018)	(0.021)	(0.016)	(0.018)	(0.027)	(0.029)	(0.028)	(0.030)
Industry Q	0.001	0.001	0.002	0.002	0.003	0.003	0.011	0.009
	(0.004)	(0.004)	(0.003)	(0.003)	(0.019)	(0.019)	(0.020)	(0.019)
ROA	-0.029	-0.042	-0.010	-0.018	-0.209**	-0.242**	-0.133	-0.153
	(0.057)	(0.061)	(0.047)	(0.051)	(0.098)	(0.098)	(0.107)	(0.109)
CapExp / Assets	1.615***	1.461***	1.373***	1.308***	2.425***	2.065***	2.556***	2.212***
	(0.352)	(0.370)	(0.302)	(0.320)	(0.593)	(0.614)	(0.688)	(0.707)
PPE / Assets	-0.284**	-0.171	-0.195	-0.125	-0.542**	-0.289	-0.464*	-0.228
	(0.143)	(0.150)	(0.120)	(0.125)	(0.234)	(0.243)	(0.267)	(0.274)
Leverage	-0.191***	-0.197***	-0.151***	-0.156***	-0.204***	-0.199***	-0.222***	-0.211**
	(0.046)	(0.048)	(0.039)	(0.042)	(0.070)	(0.071)	(0.082)	(0.083)
KZIndex	-0.000	-0.000	-0.000	-0.000	0.000	0.000	-0.000	-0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)
ln *(Firm Age)*	-0.112***	-0.094***	-0.085***	-0.077**	-0.185***	-0.154***	-0.205***	-0.177***
	(0.034)	(0.036)	(0.029)	(0.031)	(0.048)	(0.049)	(0.052)	(0.053)
Herfindahl Index	-0.728**	-0.674*	-0.669**	-0.647*	-0.705	-0.632	-0.624	-0.530
	(0.371)	(0.380)	(0.324)	(0.333)	(0.595)	(0.605)	(0.650)	(0.662)
Herfindahl Index ^{2}	0.348	0.290	0.372	0.341	-0.083	-0.118	-0.250	-0.309
	(0.426)	(0.434)	(0.360)	(0.369)	(0.719)	(0.738)	(0.777)	(0.801)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	10682	10375	10682	10375	10682	10375	10682	10375

the number of analysts following the firm increases to 13 (at the 75th percentile of the analyst following distribution), increasing intervention threat does not significant affect firm innovation. These results basically support the hypothesis that financial analysts help mitigate the negative effects of shareholder intervention threat on firm innovation.

6. Quasi-Natural Experiment of Activist Investor Closures

In the empirical analysis of Section 5.1, the negative coefficients in the regressions of firm innovation on shareholder intervention threat support the hypothesis that the intervention threats negatively affect firm manager innovation incentives. A major concern is that less innovative firms may attract more activist institutional investors and, thus, a higher level of intervention threat. To address this reverse causality concern, I adopt an identification strategy that relies on a quasi-natural experiment of activist investor closures to generate exogenous variation in levels of shareholder intervention threat. For this natural experiment to be valid, two conditions must be satisfied. First, activist investor closures must correlate with a decrease in shareholder intervention threat (relevance condition). Second, activist investor closures must only affect firm innovation through their effect on shareholder intervention threat (exogeneity condition). Section 6.1 discusses the main reasons for activist investor closures, and explains why the closure events are plausibly exogenous. Section 6.2 examines the magnitude of the intervention threat change caused by activist investor closures.

6.1 The Closures of Activist Institutional Investors

Activist institutional investors often undertake intervention activities, and their shareholdings constitute a real threat to firm managers. During the 2007-2009 financial crisis, a large portion of activist institutional investors closed their businesses.[5] For example, Tim Barakett, the founder of Atticus Capital and "one of the fathers of modern hedge fund activism", closed down two flagship activist funds in 2009[6], and returned approximately

[5] Activist investor closure in this paper means that an activist investor winds down its business and investment affairs. In industry parlance, "closure" also refers to funds closing to new investors. The latter type of closure is not the subject of this research.

[6] Tim Barakett liquidated Atticus Global and Atticus Trading Funds in 2009. Atticus European Fund continued, which is managed by David Slager. Atticus (the management company) did not have SEC filings after 2009.

$3 billion to investors (*Financial Times*, August 12, 2009). Among activist institutional investors, the closure events concentrated on activist hedge funds. In the financial crisis period, the whole hedge fund industry experienced a liquidity crisis. Investor confidence in the world's financial market and in hedge funds fell dramatically, especially after the collapse of Lehman Brothers Holdings, Inc. in 2008. Many hedge funds received substantial redemption requests from the fund investors, even when fund performance remained relatively strong. According to *New York Law Journal* (March 2, 2009), in 2008 hedge fund redemption reached nearly $400 billion, and the assets under management by the hedge fund industry declined from $2.2 trillion in mid-2008 to $ 1.3 trillion by the end of 2008.

In the financial crisis period, hedge fund closures were largely driven by market-wide liquidity shocks. Brunnermeier and Pedersen (2009) show that in times of crisis, sharp reductions in asset liquidity (the ease of trading assets) and funding liquidity (the availability of funding) are mutually reinforcing, leading to a liquidity spiral. Boyson, Stahel, and Stulz (2010) demonstrate that these liquidity spirals cause contagion in hedge fund worst returns. As market-wide liquidity shocks led to deteriorating hedge fund performances and increasing redemption requests, a large number of hedge funds chose to close their funds. Ben-David, Franzoni, and Moussawi (2012) provide evidence that hedge funds exited the U.S. stock market en masse in 2008 in response to shocks to funding liquidity.

The characteristics and strategies of activist hedge funds make the performance of these funds more sensitive to liquidity shocks. Hedge funds that are actively involved in shareholder activism (including pure-play activists and multi-strategy funds) often need to have "patient money" to execute their strategies or to win an activism campaign. The fund managers need time to negotiate with corporate board and management, coordinate with other shareholders, and work on transactions such as mergers, acquisitions, and spin-offs. The adverse liquidity shocks and redemption requests may force activist hedge funds to liquidate their positions prematurely. As a result, the returns from the activist strategies cannot be fully realized.

Even when activist funds were not forced to liquidate their positions, the returns from their activist strategies also declined dramatically. Greenwood and Schor (2009) state that activist hedge fund returns "are largely explained by the ability of activists to force target firms into a takeover", and "activist investors' portfolios perform poorly during a period in which market wide takeover interest declined" (p.363). The authors argue that, from the perspective of activist hedge funds, takeovers are an optimal way to exit their sizeable position in the target. Before the 2007-2009 financial crisis, pressuring firms for takeover was the most profitable activist strategy, and was pursued by many activist hedge funds.[7] However, during the 2007-2009 financial crisis this takeover strategy became unattractive, as the global M&A markets fell sharply. According to Becht, Franks, Grant, and Wagner (2014), the number of takeovers conducted by activist hedge funds dropped by 57% between 2007 and 2008, and a further 40% between 2008 and 2009. Other activist strategies, such as improving corporate governance and business strategies, also experienced difficulties, and outcomes became unpredictable. Cheffins and Armour (2011) argue that under normal economic conditions, shareholders are often receptive to activist overtures when a company is performing poorly, while, during financial crisis, shareholders often opt for caution and are reluctant to disrupt the status quo. Patrick McGurn, special counsel to RiskMetrics Group, parent company of proxy advisor ISS Governance Services, commented that "[with uncertainty on the financial market,] concerns about the market and economy trumped concerns about individual management or boards" (*Financial Times*, July 6, 2008).[8]

In sum, in the financial crisis period, the returns of activist investors declined sharply because of the market-wide liquidity shocks and the collapse of the global M&A markets. Combined with increasing redemption requests, many activist hedge funds decided to close and redeem their investors. Activist investor closures are plausibly exogenous, as the closure decisions are unlikely to have been motivated by information on the innovation performance of portfolio firms. In fact, the activist investor closures are concentrated during the financial crisis period, with cases rarely occurring before and after. This

[7] Becht, Franks, Grant, and Wagner (2014) show that abnormal returns vary considerably across different types of activist strategies. The average returns is 11 percent for takeover strategy, 7 percent for other forms of restructuring, and zero to 3 percent for strategies related to governance and payout policy.

[8] See "Shareholder Democracy is on Hold", *Financial Times*, July 7, 2008.

implies that the adverse and precipitous economic and market conditions are the main reasons for activist investor closures. The analyses in Section 6.3 show that treatment firms and closely matched control firms have parallel innovation performances before the activist investor closures, and this provides supportive evidence that activist investor closures were not driven by the changes in the innovation performances of portfolio firms. Overall, activist investor closures are plausibly exogenous, as required for identification.

To identify all activist investors that closed between 2007 and 2010, I combine four sources of activist investor information: FactSet's corporate activism database, SEC filings, Hedge Fund Research (HFR) database, and Factiva news. First, I identify the names of activist investors and the history of their activism campaigns from FactSet's corporate activism database. Second, I search the SEC filings and obtain the last filing dates of individual investors. The investors whose last filing dates ended in or before 2011 are included as candidates for closing activist investors. I search for these investors and their key executives in Factiva news to verify closure events. This procedure helps remove the cases in which activist investors changed names and operated under new names, as well as the cases in which investor assets fell below the minimum filing requirement (e.g., $100 million for 13F filings). In addition, I verify investor closures through Hedge Fund Research (HFR) database if the activist investor is hedge fund. The final sample includes 20 activist institutional investors that closed their businesses in the U.S. between 2007 and 2010. Appendix Table A4 lists these activist investors. Compared with the years of 2005 and 2006, in which 157 institutional investors actively pursued shareholder activism, about 12.7% of these activist investors closed down.

6.2 Identifying Treatment and Control Firms

The purpose of the quasi-natural experiment design is to examine how firm innovation responds following the exogenous changes in the level of shareholder intervention threat. The group of treatment firms are the U.S. publicly-traded firms in which one or more of the firm's activist institutional investors closed their funds during 2007-2010. The identification of treatment firms is based on SEC 13F filings, and the data are retrieved from the Thomson Reuters Institutional Holdings (13F) Database. I track the shareholdings of the 20 activist investors two years before their closure. Publicly-traded firms, whose

Table 4: Differences in Firm Characteristics between Treatment Firms and Control Firms

The table reports the pairwise comparison between the treatment and control firms on important firm characteristics, and their corresponding t-statistics. The sample comprises 206 treatment firms that experienced exogenous change in shareholder intervention threat caused by the activist investor closures between 2007 and 2010, and the same number of control firms. Treatment and control firms are matched by calendar year, 3-digit SIC industry, total assets, Tobin's Q, and shareholder intervention threat. Growth rate of total patents and growth rate of highly-cited patents are calculated as the average growth rate over the four years before activist investor closures.

Firm Characteristics	Treatment	Control	Differences	T-statistics
Assets, in billions	5.204	7.021	-1.817	-0.98
Firm Tobin's Q	2.804	2.429	0.375	0.98
Activist Investor Ownership	0.111	0.105	0.006	0.73
Monitoring Investor Ownership	0.290	0.299	-0.009	-0.65
Analysts	11.311	12.273	-0.962	-1.18
ROA	0.004	0.011	-0.007	-0.20
CapExp / Assets	0.046	0.049	-0.003	-0.48
R&D / Assets	0.186	0.178	0.008	0.33
PPE / Assets	0.215	0.193	0.022	0.93
Leverage	0.316	0.262	0.054	1.20
KZIndex	-18.914	-16.920	-1.994	-0.25
Firm Age	17.049	20.058	-3.009	-2.11
Herfindahl Index	0.196	0.199	-0.003	-0.17
Cash / Assets	0.309	0.313	-0.004	-0.16
Net Short-term Debt	-0.267	-0.286	0.019	0.70
Growth Rate of Total Patents	0.033	0.031	0.002	0.03
Growth Rate of Highly-Cited Patents	0.051	0.033	0.018	0.22

shares (at least 1%) were held by these closing activist investors prior to closure, are defined as the treatment firms. I exclude the firms that do not have patent data. The final sample includes 206 treatment firms.

The control group consists of the U.S. publicly-traded firms that were not affected by activist investor closures. I match treatment firms and control firms by year, industry, firm size, investment opportunities, and intervention threat level. Specifically, the candidate control firms are required to be in the same total assets quintile, Tobin's Q quintile, and from the same year and 3-digit SIC industry as the treatment firms. I calculate the difference in activist investor holdings between each treatment firm and its candidate control firm one year prior to the closure event. For each treatment firm, I retain one candidate control firm that has the smallest difference in activist investor holdings. Both treatment and control firms are required to have Compustat data prior to and after activist investor closures. The final sample includes 206 treatment firms and 206 closely-matched control firms.

To assess how well the control firms match the treatment firms, I compare important firm characteristics in the pre-event year between the treatment group and control group. As displayed in Table 4, there are no statistically significant differences between the treatment and control groups for firm size, investment opportunities, shareholder intervention threat, and other important firm characteristics associated with innovation. The only exception is that the treatment firms are slightly younger than the control firms. Importantly, the growth rates in innovation variables are similar between the treatment and control firms. The growth rates in the number of total patents and in the number of highly-cited patents are computed over the four years prior to the closure events. The data in Table 4 confirm that the matching process has removed meaningful differences among the treatment and control firms in the observable firm characteristics.

Identification requires that the activist investor closures should generate exogenous variation in the levels of shareholder intervention threat (relevance condition). Following activist investor closures, the total number of activist investors within a firm declined. When activist investors as a group have less ownership, they will have less power to win an activism campaign. Thus, the intervention threat imposed on firm management will decline after activist investor closures. I estimate the magnitude of the intervention threat change following activist investor closures, and I examine the intervention threat level of a firm during the three years before and the three years after the closure event year. The results from difference-in-differences estimation show that the ownership of treatment firms by activist investors decreased by 1.49 percentage points relative to control firms (with a p-value of 0.019). Compared with the pre-closure intervention threat level of the treatment group, activist investor closures caused a reduction of 13.4% in intervention threat. Overall, activist investor closures led to an economically important decrease in the threat of shareholder intervention.

6.3 The Effect of Activist Investor Closures on Firm Innovation

The difference-in-differences estimator (DiD) is applied to estimate changes in firm innovation following exogenous changes in the threat of shareholder intervention. The estimator removes common time trends that affect both treatment and control firms, as well as biases that could be the result from permanent differences between the two groups of firms. The key identifying assumption of DiD is that, in the absence of the treatment,

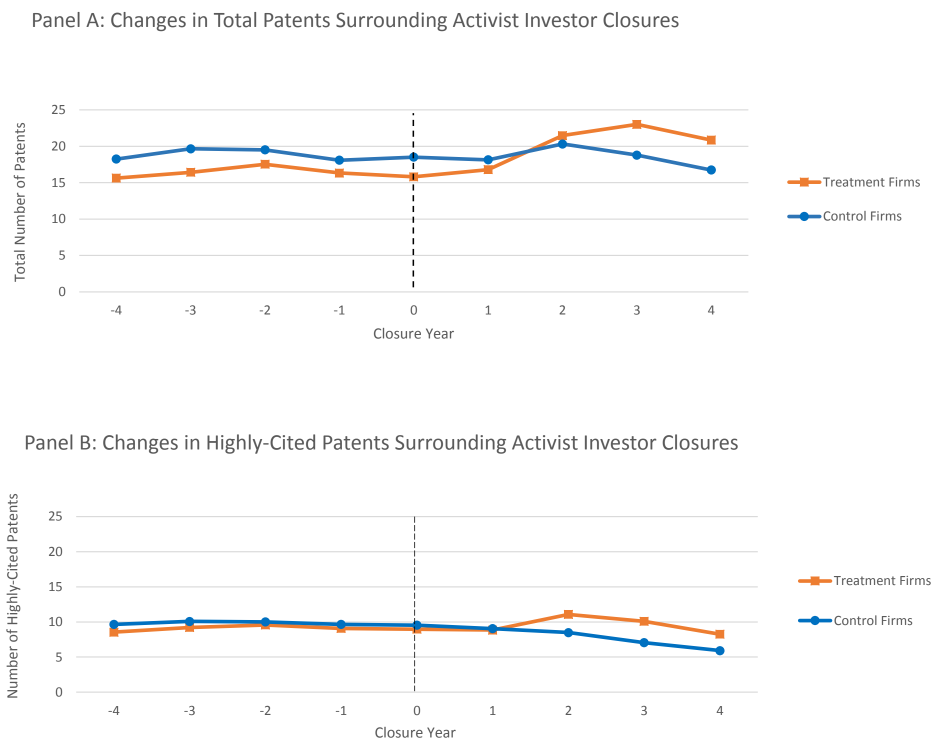

Figure 1: Innovation Paths of Treatment and Control Firms

Notes: This figure illustrates the innovation of treatment firms and control firms from four years before activist investor closures to four years after the closure events. Panel A presents the changes in the number of total patents surrounding activist investor closures, and Panel B shows the changes in the number of highly-cited patents. For each year, I calculate the mean of the innovation variables across treatment firms and across control firms, respectively. Treatment group consists of 206 U.S. publicly-traded firms that experienced exogenous change in the level of shareholder intervention threat due to activist investor closures between 2007 and 2010. The control group includes 206 U.S. publicly-traded firms matched by calendar year, 3-digit SIC industry, total assets, Tobin's Q, and shareholder intervention threat, which did not experience activist investor closures.

the average outcomes for the treatment and control groups would have followed parallel paths over time.

Figure 1 illustrates the innovation paths of the treatment firms and control firms over a nine-year period centered on the year of activist investor closures. Panel A shows the changes in the number of total patents, and Panel B presents the changes in the number of highly-cited patents. In both panels, innovation is averaged across the 206 treatment firms and across the 206 control firms for each year. Year zero is the time of activist investor closures. As shown in both panels, during the four years before the closure events, the treatment and control firms follow a similar path until the onset of activist investor closures. Following activist closures, the innovation of treatment firms increases significantly relative to the control firms. In addition, as shown in Table 4, the growth rate of innovation is statistically identical across the treatment and control groups. The magnitudes of the differences (0.002 for total patents and 0.018 for highly-cited patents) are economically small. In sum, the graph of innovation path and the pairwise comparison of innovation growth rate suggest that the treatment firms and the closely matched control firms satisfy the parallel trends assumption required for difference-in-differences estimation.

The effect of activist investor closures on firm innovation is estimated using (4):

$$\ln(Innovation_{i,t}) = \alpha + \beta_1 I_i\,(Activist\,Closures) + \beta_2 I_{i,t}\,(Post) + \beta_3 I_i\,(Activist\,Closures) \times I_{i,t}\,(Post) + \gamma X_{i,t-1} + \nu_k + \mu_t + error_{i,t} \quad (4)$$

Here, subscripts i,t uniquely identify individual observations for firm i in year t. $Innovation_{i,t}$ represents innovation of firm i in year t. $I_i\,(Activist\,Closures)$ is an indicator variable equal to one if one or more of firm i's activist institutional investors closed their operations in the U.S. during 2007-2010. These activist investors hold at least 1% of the firm's outstanding shares. $I_{i,t}\,(Post)$ is an indicator variable equal to one if the observation occurs after the year of activist investor closures. $X_{i,t-1}$ is a vector of control variables. ν_k and μ_t represent industry and year fixed effects. The coefficient of interest is β_3 (the coefficient on the interaction term $I_i\,(Activist\,Closures) \times I_{i,t}\,(Post)$, which is a DiD estimate of the average effect of activist investor closures on firm innovation. Standard errors are clustered at the event (activist investor closure) level to account for the presence of serial correlation (Bertrand, Duflo, and Mullainathan 2004).

The results from estimating (4) are reported in Table 5. I examine firm innovation four years before and four years after the event of activist investor closures. In Column (1), the dependent variable is $ln\,(TotalPatents_t)$. The coefficients associated with $I_i\,(Activist\,Closures) \times I_{i,t}\,(Post)$ is positive and significant at the 5% level. The result suggests that, for an average firm that experiences an exogenous decrease in intervention threat due to activist investor closures, the firm's patent applications increase by 22.8%

Table 5: The Effects of Activist Investor Closures on Innovation: Difference-in-Differences Estimation

This table reports the difference-in-differences estimation on the effects of activist investor closures on firm innovation. Treatment firms are the U.S. publicly-traded firms that experienced exogenous change in the level of shareholder intervention threat due to activist investor closures between 2007 and 2010. Control firms are U.S. publicly-traded firms that were not affected by activist investor closures. Treatment firms and control firms are matched by year, industry (3-digit SIC code), total assets, Tobin's Q, and shareholder intervention threat. $I\,(Activist\,Closures)$ is an indicator variable equal to one if one or more of the firm's activist institutional investors closed their operations in the U.S. during 2007-2010, and zero otherwise. *I (Post)* is an indicator variable equal to one if the observation occurs after the year of activist investor closures, and zero otherwise. *I (Activist Closure)* $\times$*I (Post)* is an interaction term equal to one if the firm experienced activist investor closures and the observation is after the closure event year, and zero otherwise. Control variables include ln *(Assets), Tobin's Q, ROA, CapExp / Assets, PPE / Assets, Leverage, KZIndex,* ln *(Firm Age), Herfindahl Index, Herfindahl Index squared.* Standard errors are clustered at the event (activist investor closure) level, and are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	ln (*Total Patents*$_t$)	ln (*Highly-Cited Patents*$_t$)
	(1)	(2)
I (Activist Closure)	-0.027	-0.018
	(0.202)	(0.172)
I (Post)	-0.095	-0.156
	(0.122)	(0.114)
I (Activist Closure) $\times$*I (Post)*	**0.228****	**0.254*****
	(0.081)	(0.068)
Constant	-0.371	-0.160
	(0.304)	(0.295)
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	2888	2888
Adjusted R^2	0.405	0.389

over the four years after the closure events. In Column (2), the dependent variable is *ln* (*Highly-Cited Patents*$_t$). The estimate of coefficient β_3 is positive and statistically significant at the 1% level. The finding suggests that following activist investor closures, firms produce 25.4% more influential patents relative to control firms. In both columns, the coefficients on $I_i\,(Activist\,Closures)$ are close to zero, implying that there is no significant difference in firm innovation prior to activist investor closures between treatment and control firms.[9] Overall, these results confirm that an exogenous decrease in shareholder intervention threat leads to improved innovation incentives among firm managers.

[9] According to Meyer (1995), a large coefficient on $I_i\,(Activist\,Closures)$ is an indication that standard errors are understated due to the presence of a group effect in the error term. In my current study, the coefficients on $I_i\,(Activist\,Closures)$ are close to zero, suggesting that there is no significant group effect.

I conduct a set of robustness tests using alternative matching method and alternative selections of matching variables. The robustness test results are reported in Appendix Table A5. First, I use propensity score matching to select control firms. The matching begins with a probit regression of an binary variable that equals one if a firm experienced activist investor closures in a particular year (belongs to the treatment group) on a set of firm characteristics. Specifically, I include activist investor ownership, firm size (logarithm of total assets), Tobin's Q, industry fixed effects, and year fixed effects. The pseudo-R^2 of the probit regression is 0.16 with a p-value well below 0.001, which implies that the specification captures a significant amount of variation in the binary variable. Then I perform a nearest-neighbor match with replacement using the predicted probabilities (propensity scores) from the probit regression. For each treatment firm, I select one control firm that is from the same year and 3-digit SIC industry, and that has the closest propensity score. The DiD estimation results based on propensity score matching are reported in Panel A of Appendix Table A5. The results are qualitatively and quantitatively similar to the baseline DiD estimation (Table 5).

The estimation results on the effects of activist investor closures (Table 5) are robust to alternative selections of matching variables. As discussed in Section 3.2, firm manager's response to intervention threat change is conditional on the extent of shareholder monitoring and analyst following. I include these variables as additional matching variables. Panel B of Appendix Table A5 reports the DiD results. The treatment effects are positive and statistically significant, consistent with the hypothesis that firm innovation significantly improves following activist investor closures. Moreover, a firm's response to intervention threat change may depend on the firm's pre-closure innovation level, which reflects a firm's innovation resources. I include a firm's total number of patent applications, averaged over the three years prior to closure, as an additional matching criterion to the primary matching variables (year, 3-digit SIC industry, total assets, Tobin's Q, and intervention threat level). The results are reported in Panel C of Appendix Table A5. The estimated treatment effects of activist investor closures remain positive and significant. In addition, I use Hoberg-Phillips industry classification (Hoberg and Phillips, 2010, 2015) to replace the 3-digit SIC industry in the primary matching variables. Hoberg-Phillips industry classification is based on the relatedness of firms in the product market space. Panel D of Appendix Table A5 presents the DiD estimation results. The estimated treatment effects are similar to the baseline DiD results (Table 5), although the significance level for the treatment effect on *Total Patents* (Column (1)) declines slightly.

Following Bertrand and Mullainathan (2003), I investigate in greater detail the dynamic effects of activist investor closures on firm innovation (see Table 6). The interaction term $I_i\,(Activist\,Closures) \times I_{i,t}\,(Post)$ in equation (4) is replaced with the interaction of $I_i\,(Activist\,Closures)$ with nine time indicators. *Before (-4), Before (-3)*, *Before (-2)*, and *Before (-1)* are the dummy variables that equal one if the firm-year observation is before activist investor closures (4 years before, 3 years before, 2 years before, and 1 year before, respectively), and zero otherwise. *Event Year (0)* is a dummy variable that equals one if the firm-year observation is on the year that activist investor closure events occur, and zero otherwise. *After (+1)*, *After (+2)*, *After (+3)* and *After (+4)* are dummy variables equal to one if the firm-year observation is after activist investor closures (1 year after, 2 years after, 3 years after, and 4 years after, respectively) and zero otherwise.

One reverse causality concern is that activist investor closures may be driven by the poor innovation performance of these investors' portfolio firms. If this was indeed the case, then we should observe a significant difference in the innovation trend of treatment and control firms in the years preceding activist investor closures. In fact, the estimated coefficients on the interaction terms $I_i\,(Activist\,Closures) \times$*Before (-3)*, $I_i\,(Activist\,Closures) \times$*Before (-2)*, and $I_i\,(Activist\,Closures) \times$*Before (-1)* are statistically indistinguishable from zero. It shows that the treatment effect cannot be found prior to the closures of activist investors. This implies that innovation performance is unlikely to be the reason that activist investors closed their funds. Significant changes in innovation are observed in the subsequent years following the closure events. The estimated coefficients on $I_i\,(Activist\,Closures) \times$ *After (+2)* are significant at 1% level, and the coefficients on $I_i\,(Activist\,Closures) \times$*After (+3)* and $I_i\,(Activist\,Closures) \times$*After (+4)* are significant at 5% level. Overall, these results provide evidence supporting the causal interpretation of the effects of activist investor closures on firm innovation.

Table 6: Dynamic Analysis of the Effects of Activist Investor Closures on Firm Innovation

This table reports the estimation results on the dynamic effects of activist investor closures on firm innovation. $I\,(Activist\,Closures)$ is an indicator variable equal to one if one or more of the firm's activist institutional investors closed their funds. *Before (-3)*, *Before (-2)*, and *Before (-1)* are the dummy variables indicating that the firm-year observation is 3 years, 2 years, or 1 year before activist investor closures. *Event Year (0)* is a dummy that equals one if the firm-year observation is on the year in which activist investor closures occur. *After (+1)*, *After (+2)*, *After (+3)* and *After (+4)* are dummy variables indicating that the firm-year observation is 1 year, 2 years, 3 years, or 4 years after activist investor closures. Control variables include ln *(Assets), Tobin's Q, ROA, CapExp / Assets, PPE / Assets, Leverage, KZIndex,* ln *(Firm Age), Herfindahl Index, Herfindahl Index squared.* Year and industry fixed effects are included. Standard errors are clustered at the event (activist investor closure) level, and are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Dependent Variable	ln ($Total\ Patents_t$)	ln ($Highly\text{-}Cited\ Patents_t$)
	(1)	(2)
I (Activist Closure)	-0.018	-0.032
	(0.190)	(0.169)
I (Activist Closure) × *Before (-3)*	0.014	-0.017
	(0.058)	(0.058)
I (Activist Closure) × *Before (-2)*	-0.035	0.032
	(0.069)	(0.061)
I (Activist Closure) × *Before (-1)*	-0.019	0.031
	(0.063)	(0.053)
I (Activist Closure) × *Event Year (0)*	-0.022	0.120
	(0.068)	(0.069)
I (Activist Closure) × *After (+1)*	0.016	0.168**
	(0.077)	(0.058)
I (Activist Closure) × *After (+2)*	0.185***	0.242***
	(0.051)	(0.054)
I (Activist Closure) × *After (+3)*	0.322**	0.392**
	(0.144)	(0.141)
I (Activist Closure) × *After (+4)*	0.498**	0.320**
	(0.204)	(0.112)
Constant	-0.273	-0.114
	(0.296)	(0.301)
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	3648	3648
Adjusted R^2	0.421	0.401

Most of the activist investor closures occurred during the financial crisis period. One potential concern is that the financial crisis differentially affected the treatment firms and control firms, which leads to differential innovation performance. I further investigate whether this was the case. Campello, Graham, and Harvey (2010) suggest that financially constrained firms are affected more by the financial crisis of 2008, and are more likely to bypass attractive investment opportunities. I test whether financial constraints change significantly for treatment firms relative to control firms surrounding activist investor closures. The presence of financial constraints is measured using the Kaplan-Zingales (1997) index (*KZIndex*). Prior to activist investor closures, *KZIndex* is not statistically different between treatment firms and control firms (Table 4). To test whether treatment and control firms have differential financial constraints following activist investor closures, I conduct a difference-in-differences test using financial constraints as the dependent variable. In Table 7 Column (1) I present the estimation results. The treatment effect is statistically indistinguishable from zero, which implies that financial constraints do not change differentially for treatment group relative to control group.

During the financial crisis, it is plausible that firms may rely more on internal financing. Duchin, Ozbas, and Sensoy (2010) find that internal financial resources mitigate the negative shocks to the supply of external finance during financial crisis, and corporate investment declines less for firms with more cash reserves. I test whether treatment and control firms differ in their cash reserve positions. Duchin, Ozbas, and Sensoy further show that during financial crisis, investment declines significantly for firms that lack short-term liquidity (measured by net short-term debt). I also test whether treatment and control firms have differential short-term liquidity around the time of activist investor closures. As shown in Table 4, *Cash/Assets* and *Net Short-term Debt* are not statistically different between treatment firms and control firms before activist investor closures. Again, I perform difference-in-differences tests using cash reserve and net short-term debt as dependent variables, and the results are reported in Columns (2) and (3) of Table 7. The treatment effects are not statistically significant, implying that treatment and control firms do not have differential cash reserves and short-term liquidity around activist investor closures. The three difference-in-differences estimations reported in Table 7 use a

Table 7: Difference-in-Differences Tests for Financial Constraints, Internal Financial Resources, and Short-term Liquidity

This table tests whether treatment and control firms differ in financial constraints, internal financial resources, and short-term liquidity around activist investor closures. Financial constraints is measured using Kaplan-Zingales (1997) index (*KZIndex*). Internal financial resources is proxied by *Cash/Assets*. Short-term Liquidity is measured using *Net Short-term Debt* (short-term debt minus cash). Difference-in-Differences estimator is applied. Standard errors are clustered at the event (activist investor closure) level, and are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

	Financial Constraints	Internal Financial Resources	Short-term Liquidity
Dependent Variable	*KZIndex*	*Cash/Assets*	*Net Short-term Debt*
	(1)	(2)	(3)
I (Activist Closure)	-9.162	0.027	-0.050
	(6.781)	(0.031)	(0.036)
I (Post)	3.544	0.011	-0.095**
	(9.932)	(0.015)	(0.033)
I (Activist Closure) $\times$*I (Post)*	7.837	-0.001	0.075
	(11.698)	(0.009)	(0.049)
Constant	-9.848**	0.280***	-0.243***
	(4.494)	(0.018)	(0.023)
Year Fixed Effects	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes
Observations	2302	2376	2376
Adjusted R^2	0.150	0.571	0.076

seven-year window, with three years before and three years after the activist investor closures. The results are robust to alternative shorter or longer windows. Detailed variable definitions for *KZIndex*, *Cash/Assets* and *Net Short-term Debt* are provided in Appendix Table A1. I conclude that treatment firms and control firms have similar financial constraints, internal financial resources, and short-term liquidity. Thus, it is not likely that the financial crisis has a differential impact on treatment firms relative to control firms. The significant effects of activist investor closures on innovation (as observed in Table 5) is not driven by the financial crisis.

7. Conclusion

The main finding of this research is that increasing the threat of shareholder intervention has a significant and economically important negative impact on firm innovation. It implies that shifting to a shareholder-centric governance system discourages manager incentives to innovate. Pursuing innovation is often associated with less accurate information reflected in stock prices, which increases the likelihood that a good manager with valuable innovation projects will be mistakenly penalized. Thus, firm managers under the threat of shareholder intervention, often refrain from pursuing innovation. Yet, for firms that are more likely to have efficient stock prices, intervention threat will have less effect on innovation. Consistent with this mechanism, I find that the negative effects of intervention threat on innovation are significantly reduced when a firm's shares are held by more monitoring institutional investors and/or the firm is followed by more financial analysts. My research suggests that corporate governance reform should consider the impacts of enhancing shareholder control on innovation of U.S. publicly-traded firms.

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Appendix Table A1. Variable Definition

Variables	Definition	Data Source
Total Patents$_{t+n}$	Firm i's total number of patent applications filed (and eventually granted) in year $t+n$.	Thomson Innovation Database
Highly-Cited Patents$_{t+n}$	Firm i's number of highly cited patents that are filed (and eventually granted) in year $t+n$. I first construct the median of the forward citations of all the patents in an industry, and then identify the patents whose forward citations are higher than the median number of citations in its respective industry in a given year.	Thomson Innovation Database
Shareholder Intervention Threat$_t$	The percentage of firm i's outstanding shares held by the group of activist institutional investors. An institutional investor is defined as activist investor if the investor has activism campaigns (against any U.S. incorporated firms) in the current year or in the previous one year.	FactSet's corporate activism database, SharkWatch; Thomson Reuters Institutional Holdings (13F) Database.
Shareholder Monitoring$_t$	The percentage of firm i's outstanding shares held by non-activist, monitoring institutional investors. The monitoring institutional investors are constructed by intersecting the group of independent institutions holding long-term investments with Bushee's (1998) categories of dedicated investors and quasi-indexer investors.	Thomson Reuters Institutional Holdings (13F) Database.
Analysts$_t$	The number of financial analysts that make one-year ahead forecasts for firm i at year t.	Thomson Reuters I/B/E/S Detail History file
Assets$_t$	Firm i's book value of total assets (item # 6)	Compustat
Market Value$_t$	Firm i's market value of equity (item #25 × item # 199)	Compustat
Tobin's Q$_t$	Firm i's Tobin's Q is computed as [market value of equity (item # 199×iterm # 25) + book value of assets (item # 6) − book value of equity (item #60) −balance sheet deferred taxes (item #74)] /book value of assets (item # 6)	Compustat
Industry Q$_t$	The median of the Tobin's Q of all firms in an industry (by 4-digit SIC code).	Compustat
ROA$_t$	Operating income before depreciation (item # 13) divided by lagged assets (item # 6)	Compustat
CapExp / Assets$_t$	Capital expenditure (item # 128) divided by lagged asset (item # 6)	Compustat
Leverage$_t$	Book value of debt (item #9 + item #34)/[Book value of debt (item #9 + item #34)+Stockholders' Equity (item #216)]	Compustat
KZIndex$_t$	Firm i's Kaplan and Zingales index measure is calculated as -1.002×Cash Flow + 0.283×Tobin's Q + 3.139×Leverage - 39.368×Cash Dividends - 1.315×Cash Holdings. Cash flow is calculated as [(item #18+item #14)/item #8], dividends is calculated as [(item #21+item #19)/item #8], and cash holdings is calculated as [item #1/item #8], where item #8 is lagged. Tobin's Q and Leverage are defined above.	Compustat
PPE/Assets$_t$	Property, Plant & Equipment (item # 8) divided by lagged asset (item # 6)	Compustat
Firm Age$_t$	Firm *i's* age in year t, approximated by the number of years listed on Compustat.	Compustat
Herfindahl Index$_t$	Herfindahl Hirschman Index, defined as the sum of squared market shares, constructed based on sales at 4-digit SIC industries.	Compustat
Cash/Assets	Cash (item #1) / total assets (item # 6)	Compustat
Net Short-term Debt	[Short-term Debt (item # 34)-Cash (item #1)] /total assets (item # 6)	Compustat

Appendix Table A2: The Effects of Shareholder Intervention Threat on Firm Innovation

This table shows the estimated effects of shareholder intervention threat on firm innovation at the years $t+1$, $t+2$, $t+3$, and $t+4$. Panel A reports the pooled OLS regression results. Panel B presents the negative binomial estimation results. The main explanatory variable *Intervention Threat* is measured by the percentage of firm outstanding shares held by activist institutional investors. Firm fixed effects are controlled using "presample mean scaling" method, following Blundell, Griffith, and Van Reenen (1999). Robust standard errors clustered by firm are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: OLS Estimation

Dependent Variable	ln (Total Patents$_{t+1}$)	ln (Total Patents$_{t+2}$)	ln (Total Patents$_{t+3}$)	ln (Total Patents$_{t+4}$)	ln (Highly-Cited Patents$_{t+1}$)	ln (Highly-Cited Patents$_{t+2}$)	ln (Highly-Cited Patents$_{t+3}$)	ln (Highly-Cited Patents$_{t+4}$)
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Intervention Threat	-0.940***	-0.962***	-0.844***	-0.699**	-0.780***	-0.823***	-0.757***	-0.682**
	(0.298)	(0.311)	(0.326)	(0.345)	(0.271)	(0.276)	(0.282)	(0.294)
ln *(Assets)*	0.281***	0.289***	0.295***	0.295***	0.217***	0.220***	0.220***	0.211***
	(0.018)	(0.018)	(0.020)	(0.021)	(0.015)	(0.016)	(0.017)	(0.017)
Tobin's Q	0.002	0.005	0.005	0.001	0.002	0.005	0.005	0.001
	(0.004)	(0.005)	(0.005)	(0.005)	(0.003)	(0.004)	(0.004)	(0.004)
ROA	-0.097	-0.075	-0.101	-0.121*	-0.058	-0.053	-0.072	-0.075
	(0.059)	(0.063)	(0.068)	(0.072)	(0.052)	(0.054)	(0.058)	(0.060)
CapExp / Assets	1.818***	2.177***	2.473***	2.588***	1.476***	1.838***	2.110***	1.860***
	(0.356)	(0.381)	(0.410)	(0.431)	(0.317)	(0.332)	(0.347)	(0.362)
PPE / Assets	-0.363**	-0.431***	-0.454***	-0.490***	-0.243*	-0.315**	-0.345**	-0.304**
	(0.147)	(0.153)	(0.161)	(0.170)	(0.128)	(0.131)	(0.136)	(0.139)
Leverage	-0.259***	-0.250***	-0.260***	-0.256***	-0.219***	-0.210***	-0.207***	-0.200***
	(0.044)	(0.048)	(0.052)	(0.056)	(0.038)	(0.042)	(0.045)	(0.048)
KZIndex	-0.000	-0.000	-0.000	0.000	-0.000	-0.000	-0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
ln *(Firm Age)*	-0.138***	-0.133***	-0.134***	-0.138***	-0.111***	-0.104***	-0.104***	-0.106***
	(0.031)	(0.032)	(0.035)	(0.037)	(0.028)	(0.029)	(0.030)	(0.032)
Herfindahl Index	-0.514	-0.569	-0.645	-0.720	-0.495	-0.490	-0.436	-0.477
	(0.363)	(0.387)	(0.421)	(0.459)	(0.326)	(0.344)	(0.366)	(0.391)
Herfindahl Index^2	0.163	0.181	0.237	0.360	0.227	0.214	0.179	0.289
	(0.410)	(0.438)	(0.480)	(0.528)	(0.364)	(0.385)	(0.413)	(0.447)
Constant	-0.340**	-0.277*	-0.346**	-0.311*	-0.344***	-0.346***	-0.387***	-0.420***
	(0.134)	(0.142)	(0.152)	(0.164)	(0.119)	(0.126)	(0.133)	(0.141)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14175	13414	12652	11908	14175	13414	12652	11908
Adjusted R^2	0.648	0.639	0.625	0.600	0.637	0.622	0.603	0.572

Appendix Table A2 (Continued)

Panel B: Negative Binomial Estimation

Dependent Variable	*Total* $Patents_{t+1}$ (1)	*Total* $Patents_{t+2}$ (2)	*Total* $Patents_{t+3}$ (3)	*Total* $Patents_{t+4}$ (4)	*Highly-Cited* $Patents_{t+1}$ (5)	*Highly-Cited* $Patents_{t+2}$ (6)	*Highly-Cited* $Patents_{t+3}$ (7)	*Highly-Cited* $Patents_{t+4}$ (8)
Intervention Threat	-1.128***	-1.239***	-1.160***	-1.137***	-0.735*	-0.921**	-0.958*	-0.929
	(0.403)	(0.423)	(0.430)	(0.438)	(0.427)	(0.467)	(0.503)	(0.576)
ln *(Assets)*	0.489***	0.500***	0.500***	0.490***	0.454***	0.457***	0.455***	0.434***
	(0.024)	(0.025)	(0.027)	(0.028)	(0.024)	(0.026)	(0.028)	(0.030)
Tobin's Q	0.004	0.008	0.011	0.001	0.004	0.012	0.013*	0.003
	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.008)	(0.007)	(0.007)
ROA	-0.298***	-0.299***	-0.317***	-0.378***	-0.227**	-0.225**	-0.255**	-0.290**
	(0.089)	(0.097)	(0.101)	(0.107)	(0.102)	(0.109)	(0.113)	(0.120)
CapExp / Assets	3.086***	3.403***	4.122***	3.925***	3.293***	3.611***	4.106***	3.734***
	(0.554)	(0.581)	(0.633)	(0.679)	(0.603)	(0.644)	(0.703)	(0.767)
PPE / Assets	-0.808***	-0.890***	-1.003***	-1.111***	-0.751***	-0.870***	-0.946***	-0.995***
	(0.210)	(0.224)	(0.239)	(0.259)	(0.227)	(0.246)	(0.263)	(0.287)
Leverage	-0.295***	-0.270***	-0.258***	-0.299***	-0.315***	-0.289***	-0.280***	-0.281***
	(0.061)	(0.070)	(0.072)	(0.074)	(0.070)	(0.079)	(0.081)	(0.089)
KZIndex	0.000	0.001	-0.000	0.001*	-0.000	0.000	-0.001	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln *(Firm Age)*	-0.241***	-0.226***	-0.229***	-0.230***	-0.254***	-0.236***	-0.237***	-0.244***
	(0.041)	(0.043)	(0.045)	(0.047)	(0.045)	(0.047)	(0.049)	(0.051)
Herfindahl Index	-0.431	-0.601	-0.789	-1.041*	-0.482	-0.551	-0.517	-0.811
	(0.518)	(0.550)	(0.586)	(0.627)	(0.566)	(0.594)	(0.627)	(0.685)
Herfindahl Index^2	-0.299	-0.195	0.087	0.443	-0.241	-0.238	-0.196	0.222
	(0.584)	(0.622)	(0.657)	(0.689)	(0.623)	(0.659)	(0.699)	(0.761)
Constant	-2.147***	-1.998***	-1.836***	-1.519***	-2.483***	-2.308***	-2.152***	-1.837***
	(0.556)	(0.555)	(0.556)	(0.557)	(0.556)	(0.562)	(0.551)	(0.572)
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	14175	13414	12652	11908	14175	13414	12652	11908

Appendix Table A3: Shareholder Intervention Threat and Innovation, Robustness Check

This table reports the robustness check on the effects of shareholder intervention threat on firm innovation using alternative measures of intervention threat. In Panel A, the main explanatory variable *Intervention Threat* is measured based on the ownership of the activist institutional investors who own more than 1% of firm outstanding shares. In Panel B, *Intervention Threat* is measured based on the ownership of the activist institutional investors who own more than 5% of firm outstanding shares. Firm fixed effects are controlled using the "presample mean scaling" method, following the procedure in Blundell, Griffith, and Van Reenen (1999). Robust standard errors clustered by firm are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Activist Institutional Investors with More than 1% Ownership

Model	OLS	OLS	Negative Binomial	Negative Binomial
Dependent Variable	ln (*Total Patents*$_{t+2}$)	ln (*Highly-Cited Patents*$_{t+2}$)	*Total Patents*$_{t+2}$	*Highly-Cited Patents*$_{t+2}$
	(1)	(2)	(3)	(4)
Intervention Threat	-0.993***	-0.829***	-1.245***	-0.939**
	(0.310)	(0.275)	(0.421)	(0.466)
ln *(Assets)*	0.288***	0.219***	0.499***	0.457***
	(0.018)	(0.016)	(0.025)	(0.026)
Industry Q	0.004	0.005	0.007	0.012
	(0.004)	(0.004)	(0.008)	(0.008)
ROA	-0.075	-0.053	-0.301***	-0.227**
	(0.063)	(0.054)	(0.097)	(0.109)
CapExp / Assets	2.171***	1.834***	3.394***	3.604***
	(0.381)	(0.332)	(0.581)	(0.644)
PPE / Assets	-0.429***	-0.313**	-0.885***	-0.868***
	(0.153)	(0.131)	(0.224)	(0.246)
Leverage	-0.249***	-0.210***	-0.270***	-0.289***
	(0.048)	(0.042)	(0.070)	(0.079)
KZIndex	-0.000	-0.000	0.001	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
ln *(Firm Age)*	-0.133***	-0.105***	-0.226***	-0.236***
	(0.032)	(0.029)	(0.043)	(0.047)
Herfindahl Index	-0.569	-0.490	-0.599	-0.548
	(0.387)	(0.344)	(0.550)	(0.595)
Herfindahl Index ^{2}	0.180	0.213	-0.199	-0.241
	(0.438)	(0.385)	(0.623)	(0.660)
Constant	-0.279*	-0.349***	-1.994***	-2.307***
	(0.142)	(0.127)	(0.555)	(0.562)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	13414	13414	13414	13414

Appendix Table A3 (Continued)

Panel B: Activist Institutional Investors with More than 5% Ownership

Model	OLS	OLS	Negative Binomial	Negative Binomial
Dependent Variable	ln (*Total Patents*$_{t+2}$)	ln (*Highly-Cited Patents*$_{t+2}$)	*Total Patents*$_{t+2}$	*Highly-Cited Patents*$_{t+2}$
	(1)	(2)	(3)	(4)
Intervention Threat	-0.987***	-0.851***	-1.329***	-1.142**
	(0.332)	(0.293)	(0.439)	(0.481)
ln *(Assets)*	0.286***	0.217***	0.497***	0.456***
	(0.018)	(0.016)	(0.025)	(0.026)
Industry Q	0.005	0.005	0.008	0.012
	(0.004)	(0.004)	(0.008)	(0.009)
ROA	-0.077	-0.054	-0.305***	-0.230**
	(0.063)	(0.054)	(0.097)	(0.109)
CapExp / Assets	2.168***	1.830***	3.398***	3.602***
	(0.381)	(0.333)	(0.584)	(0.646)
PPE / Assets	-0.424***	-0.309**	-0.878***	-0.863***
	(0.153)	(0.131)	(0.225)	(0.247)
Leverage	-0.250***	-0.211***	-0.271***	-0.289***
	(0.048)	(0.042)	(0.070)	(0.079)
KZIndex	-0.000	-0.000	0.001	0.000
	(0.000)	(0.000)	(0.001)	(0.001)
ln *(Firm Age)*	-0.134***	-0.105***	-0.227***	-0.237***
	(0.032)	(0.029)	(0.043)	(0.047)
Herfindahl Index	-0.567	-0.489	-0.596	-0.549
	(0.388)	(0.345)	(0.551)	(0.596)
Herfindahl Index ^{2}	0.181	0.214	-0.199	-0.240
	(0.439)	(0.386)	(0.624)	(0.662)
Constant	-0.294**	-0.360***	-1.994***	-2.307***
	(0.143)	(0.127)	(0.553)	(0.560)
Year Fixed Effects	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes	Yes
Observations	13414	13414	13414	13414

Appendix Table A4. List of Closed Activist Investors

The table lists the closures of activist institutional investors in 2007-2010. Column (1) provides the name of the closed activist institutional investors, and Column (2) states the year that they closed. Column (3) reports investor type, and Column (4) indicates the number of activism campaigns the investor undertook up to the closure year. The name of the activist institutional investors, their type, and their history of activism campaigns are based on FactSet's corporate activism database, SharkWatch.

Activist Institutional Investors (1)	Closure Year (2)	Investor Type (3)	No. of Activism Campaigns (4)
Sowood Capital Management, LP	2007	Hedge Fund	3
Cadence Investment Management, LLC	2007	Hedge Fund	1
Copper Arch Capital, LLC	2007	Hedge Fund	1
Keefe Managers, LLC	2007	Hedge Fund	1
K Capital Partners, LLC	2008	Hedge Fund	11
Flagg Street Capital, LLC	2008	Hedge Fund	2
Stevenson Capital Management, Inc.	2008	Investment Advisor	1
Trivium Capital Management, LLC	2008	Hedge Fund	1
Pirate Capital, LLC	2009	Hedge Fund	24
Mercury Real Estate Advisors, LLC	2009	Investment Advisor	20
Atticus Capital, LLC	2009	Hedge Fund	18
D.B. Zwirn & Co. LP	2009	Hedge Fund	6
RLR Capital Partners, LP	2009	Hedge Fund	3
Deephaven Capital Management, LLC	2009	Hedge Fund	2
Okumus Capital, LLC	2009	Hedge Fund	2
Vardon Capital Management, LLC	2009	Hedge Fund	2
Shamrock Partners Activist Value Fund LLC	2010	Hedge Fund	41
Duquesne Capital Management, LLC	2010	Hedge Fund	2
Eastbourne Capital Management, LLC	2010	Hedge Fund	2
Obrem Capital Management, LLC	2010	Hedge Fund	2

Appendix Table A5: The Effects of Activist Investor Closures on Innovation, Robustness Check

This table reports the robustness check on the estimated effects of activist investor closures on firm innovation (Table 5). Panel A presents the results using propensity score matching. Panels B, C, and D report the results using alternative matching variables. In Panel B, treatment firms and control firms are matched by year, industry (3-digit SIC), total assets, Tobin's Q, intervention threat level, shareholder monitoring, and financial analysts. In Panel C, treatment firms and control firms are matched by year, industry (3-digit SIC), total assets, Tobin's Q, intervention threat level, and pre-closure innovation level. In Panel D, treatment firms and control firms are matched by year, industry, total assets, Tobin's Q, and intervention threat level. Hoberg-Phillips industry classification is used to replace 3-digit SIC industry. Standard errors are clustered at the event (activist investor closure) level, and are displayed in parentheses. ***, **, and * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Difference-in-Differences Estimation, Propensity Score Matching

Dependent Variable	ln (*Total Patents*$_t$)	ln (*Highly-Cited Patents*$_t$)
	(1)	(2)
I (Activist Closure)	-0.218	-0.140
	(0.132)	(0.113)
I (Post)$_t$	0.064	-0.033
	(0.056)	(0.062)
I (Activist Closure) $\times$*I (Post)*$_t$	0.198**	0.278***
	(0.070)	(0.074)
Constant	-0.788*	-0.586*
	(0.375)	(0.317)
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	2827	2827
Adjusted R^2	0.470	0.440

Panel B: Difference-in-Differences Estimation, Using Shareholder Monitoring and Analyst Following as Additional Matching Variables

Dependent Variable	ln (*Total Patents*$_t$)	ln (*Highly-Cited Patents*$_t$)
	(1)	(2)
I (Activist Closure)	-0.195	-0.111
	(0.213)	(0.174)
I (Post)$_t$	-0.333***	-0.368***
	(0.079)	0.081)
I (Activist Closure) $\times$*I (Post)*$_t$	0.267**	0.425***
	(0.116)	(0.121)
Constant	-0.280	-1.191**
	(0.426)	(0.372)
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	2891	2891
Adjusted R^2	0.417	0.382

Appendix Table A5 (Continued)

Panel C: Difference-in-Differences Estimation, Using Pre-Closure Innovation Level as Additional Matching Variable

Dependent Variable	ln ($Total\ Patents_t$)	ln ($Highly\text{-}Cited\ Patents_t$)
	(1)	(2)
I (Activist Closure)	-0.039	0.055
	(0.080)	(0.074)
$I\ (Post)_t$	-0.164	-0.158
	(0.139)	(0.139)
$I\ (Activist\ Closure) \times I\ (Post)_t$	0.315**	0.290***
	(0.113)	(0.084)
Constant	-0.093	-0.768*
	(0.423)	(0.367)
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	2883	2883
Adjusted R^2	0.418	0.392

Panel D: Difference-in-Differences Estimation, Matching Based on Hoberg-Phillips Industry Classification

Dependent Variable	ln ($Total\ Patents_t$)	ln ($Highly\text{-}Cited\ Patents_t$)
	(1)	(2)
I (Activist Closure)	-0.128	-0.025
	(0.193)	(0.186)
$I\ (Post)_t$	-0.070	-0.119***
	(0.129)	(0.120)
$I\ (Activist\ Closure) \times I\ (Post)_t$	0.182*	0.254***
	(0.092)	(0.074)
Constant	-0.606**	-0.563**
	(0.245)	(0.213)
Control Variables	Yes	Yes
Year Fixed Effects	Yes	Yes
Industry Fixed Effects	Yes	Yes
Observations	2757	2757
Adjusted R^2	0.423	0.417