Corporate Governance and Innovation: Theory and Evidence[*]

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January 31, 2009

Abstract

We develop a theory of the effects of external corporate governance mechanisms — such as takeover pressure — and internal mechanisms — such as compensation contracts and monitoring intensity — on innovation. Our theory generates the following testable predictions: (i) innovation varies non-monotonically in a U-shaped manner with takeover pressure; (ii) innovation increases with monitoring intensity; and (iii) the sensitivity of innovation to changes in takeover pressure declines with monitoring intensity.

We show strong empirical support for these predictions using both *ex ante* and *ex post* measures of innovation. Our empirical analysis exploits the cross-sectional as well as time-series variations in takeover pressure created by the sequential passage of anti-takeover laws across different states.

Our study suggests that innovation is fostered by either an unhindered market for corporate control or strong anti-takeover laws that significantly deter takeovers. An unhindered market for corporate control fosters innovation through the incentives provided by takeover premia that increase with the degree of innovation. Severe anti-takeover laws may, however, also encourage innovation *ex ante* by reducing the likelihood of *ex post* private control benefit losses. The *interplay* between the relative magnitudes of these conflicting forces causes innovation to vary non-monotonically with takeover pressure.

JEL: G31, G34, K22

Keywords: Anti-takeover laws, Blockholders, Corporate Governance, Innovation, External Governance, Internal Governance, Monitoring, Takeovers.

1   Introduction

A growing body of empirical evidence shows that laws and institutions that influence corporate governance impact country-level economic growth (e.g., La Porta *et. al*, 1997, 2000). An independent strand of the literature demonstrates that innovation by firms is a key driver of economic growth (e.g., Aghion and Howitt, 2006). There is, however, relatively limited *micro* evidence of how laws and institutions affect innovation by firms *through* the channel of corporate governance. In this study, we theoretically and empirically show how external governance mechanisms — such as anti-takeover laws that affect the market for corporate control — and internal governance mechanisms — such as monitoring and compensation contracts — interact to affect innovation.

Our model generates the following testable implications. First, innovation varies non-monotonically in a U-shaped manner with the level of takeover pressure that a firm faces. Second, innovation is enhanced if managers are monitored more intensely. Third, increasing monitoring intensity lowers the sensitivity of innovation to takeover pressure leading to a "flatter" U-shaped relation between innovation and takeover pressure. We show strong empirical support for these predictions using *ex ante* and *ex post* measures of innovation. A novel contribution of our analysis is to show how the interplay between expected takeover premia and private benefits leads to a *non-monotonic* relation between innovation and takeover pressure. Innovation is therefore fostered *either* by practically non-existent anti-takeover laws that permit an unhindered market for corporate control, *or* by anti-takeover laws that are severe enough to effectively deter takeovers.

We build a model in which a *wealth–constrained* manager chooses the *degree of innovation* of a project. For example, suppose the manager of a pharmaceutical company could invest in either one of the following two projects: (1) inventing and launching a new drug for a hitherto incurable disease; or (2) manufacturing and launching a generic substitute for an existing drug. Launching a generic substitute involves uncertainties due to customer demand as well as competition from other manufacturers. In contrast, inventing a new drug entails additional uncertainties associated with the process of exploration and discovery, whether such a drug could be administered to humans, and whether it would receive FDA approval. Therefore, a significant portion of the risk associated with manufacturing and launching a generic substitute lies in the marketing stage, while a relatively greater proportion of the risk associated with inventing a new drug lies in the *exploration* stage, when the very existence of the drug is unknown.

We formalize the essence of the above example in a two-period model in which the manager of a firm chooses to invest in one of two projects: a "more innovative" project or a "less innovative" project. The projects' payoffs are uncertain and occur at the end of the second period. There is imperfect but symmetric information about the *true* expected payoffs (hereafter, the *qualities*) of the projects. The more innovative project differs from the less innovative one along three dimensions. First, the more innovative project has a higher mean quality. Second, the more innovative project has a higher payoff uncertainty than the less innovative one. Third, consistent with the fact that the more innovative project entails significantly greater uncertainty with respect to exploration, a larger proportion of the total uncertainty of the more innovative project stems from uncertainty about its quality.

The manager's project choice is observable. At the end of the first period, agents observe a public signal about the payoff of the chosen project. The signal partially resolves the uncertainty associated with the project's terminal payoff. Based on this signal, all agents update their prior assessments of the project's quality. The firm could potentially be taken over by a raider through a tender offer. We allow for potential synergies between the firm and the raider so that the raider can alter the project's terminal payoff. The synergies increase in the project's quality. There is imperfect, but symmetric information about the synergies generated by the raider.

The severity of external anti-takeover laws influences the takeover pressure the firm faces and, in turn, the firm's bargaining power when it negotiates with the raider. The firm's bargaining power is reflected in the minimum takeover premium the firm must be guaranteed by the raider. A takeover is, therefore, successful if and only if the takeover premium exceeds a threshold that increases with the severity of external anti-takeover laws. Hence, the likelihood of a takeover declines with the severity of external anti-takeover laws.

We capture two frictions in our environment. First, even though the manager's project choice is observable, it is non-verifiable and, therefore, *non-contractible*. Second, the manager derives pecuniary *private control benefits* that are also non-contractible. The manager's private benefits decline with the intensity with which shareholders monitor the manager. If the firm is taken over at the end of the first period, the manager cedes her control benefits to the raider. The project's payoff *net* of the manager's control benefits (hereafter the project's net payoff) as well as the payoff conditional on the firm being taken over are contractible. The shareholders can influence the manager's project choice through a compensation contract contingent on the project's contractible payoffs.

We derive the manager's optimal compensation contract and show that it can be implemented through an equity stake in the firm along with a payment that resembles a golden parachute in the event of a takeover. The golden parachute aligns the interests of the manager and shareholders by effectively compensating the manager for her loss of control benefits in the event of a takeover. The manager's optimal project choice maximizes the firm's *unconditional expected payoff* (expected payoff in the absence of a takeover) plus the *expected takeover premium* less the *expected loss of private benefits* in the event of a takeover.

In choosing the degree of innovation, the manager faces the following trade-off. The higher degree of uncertainty associated with the quality of the more innovative project increases the firm's likelihood of being taken over and, therefore, increases the manager's expected loss of control benefits. The higher likelihood of a takeover for the more innovative project, however, also results in a larger expected takeover premium. The manager trades off the positive effect of greater innovation on the expected takeover premium against its negative effect on the expected loss of control benefits. Since private benefits decline with monitoring intensity, this trade-off is influenced by the interaction between the intensity of monitoring of the manager and the takeover pressure the firm faces.

The predicted U-shaped relationship between the degree of innovation and takeover pressure arises as follows. When the takeover pressure is very low, the low likelihood of a takeover implies that the expected takeover premium and the expected loss of control benefits are both insignificant. Therefore, the manager chooses greater innovation because it has a higher unconditional expected payoff. When takeover pressure is very high, the expected takeover premium and the expected loss in control benefits are both high. The effect of the expected takeover premium, however, dominates. Because the expected takeover premium increases with the degree of innovation, it is again optimal to choose greater innovation. For moderate levels of takeover pressure, the effect of the higher loss of control benefits associated with greater innovation dominates. It is therefore optimal for the manager to choose lower innovation to reduce the likelihood of losing her control benefits.

The above intuition implies that the manager chooses lower innovation for moderate levels of takeover pressure because the effect of her expected loss of control benefits dominates. As monitoring intensity increases, the manager's private benefits decline so that the relative importance of private benefits in influencing the degree of innovation declines. Hence, the manager chooses greater innovation over a larger range of values of the takeover pressure. Furthermore, because the U-shaped

relation between innovation and takeover pressure is driven by the manager's potential loss of control benefits, an increase in the monitoring intensity also lowers the sensitivity of the degree of innovation to changes in takeover pressure. The U-shaped relation, therefore, becomes flatter as monitoring intensity increases.

We test the predictions of the model using *ex ante* and *ex post* measures of the degree of innovation. We use R&D intensity as our *ex ante* measure of the degree of innovation. We employ patents filed with the US Patent Office as well as citations to these patents as our *ex post* measures. We employ levels of ownership by institutional blockholders to proxy for internal monitoring intensity. We use the state-level index of the severity of anti-takeover statutes (hereafter referred to as "anti-takeover index") from Bebchuk and Cohen (2003) as our proxy for the external takeover pressure a firm faces. Our empirical analysis, which exploits the substantial cross-sectional and time-series variations in takeover pressure created by the sequential passage of anti-takeover laws in different states, proceeds in three steps.

First, we test our hypotheses using panel regressions with firm and year fixed effects. In these tests, we exploit the variation in the level of the anti-takeover index across time and across states, and variation in blockholder ownership across time and across firms. Because firms rarely change their state of incorporation or their industry in our sample, the firm fixed effects also control for time-invariant unobserved state- and industry-specific factors. We show that innovation varies in a U-shaped manner with the anti-takeover index. Second, we find a strong positive relation between innovation and our proxy for monitoring intensity. Finally, we show that the curvature of the U-shaped relationship between innovation and the anti-takeover index declines with monitoring intensity, that is, the U-shaped relationship becomes flatter.

Given the firm and year fixed effects, the identifying assumptions in the above tests are that *time-varying* unobserved firm, state, and industry-specific factors that influence the level of innovation are uncorrelated with the levels of the anti-takeover index and blockholder ownership. To weaken these identifying assumptions, we exploit the cross-sectional and time-series variation in the *changes* in the anti-takeover index and in blockholder ownership levels to undertake fixed effects "change-on-change" regressions (see Imbens and Wooldridge, 2007). We regress annual *changes* in our innovation proxies on *changes* in our explanatory variables after including state of incorporation, industry and year fixed effects. The identifying assumptions for these tests are that *time-varying* unobserved state

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and industry-specific factors that influence changes in innovation are uncorrelated with changes in the anti-takeover index and changes in blockholder ownership.

Finally, we address the possibility that unobserved state-wide changes *accompanying* the changes in anti-takeover laws drive the changes in innovation. We exploit the fact that our dataset contains data on innovation performed by *subsidiaries/ divisions* of firms. For these tests, we use the NBER patents database to identify the specific division/subsidiary of a firm that filed a patent.[1] State-wide changes accompanying the changes in anti-takeover laws would affect innovation done by subsidiaries/ divisions located in the state of incorporation; however, such changes are less likely to affect innovation by subsidiaries/ divisions located *outside* the state in which the firm is incorporated. Therefore, for firms incorporated in states that passed anti-takeover laws, we exclude all innovation done by subsidiaries and divisions located in the state of incorporation. Thus, by examining innovation done outside the state of incorporation for states that passed anti-takeover laws, we isolate the pure effect of the law-change. We find strong empirical support for all our predictions in these tests.

The economic magnitudes of our predicted effects are significant. When the value of the anti-takeover index before a law-change was zero (four), as it was is in the case of Delaware (Indiana), a one point increase in the value of the index decreases (increases) R&D intensity, patents and citations for firms incorporated in the state, respectively, by 19%, 17%, and 18% (25%, 11%, and 14%) more than for those firms incorporated in states that never experienced a law-change. Thus, when the takeover pressure was very low (Indiana), a decrease in takeover pressure increased the degree of innovation. When the takeover pressure was very high (Delaware), the decrease in takeover pressure decreased the degree of innovation. The empirical evidence therefore supports a statistically and economically significant U-shaped relationship between the degree of innovation and takeover pressure. Second, higher monitoring is associated with greater innovation – a one standard deviation increase in blockholder ownership is associated with 12% higher R&D/ sales, 26% more annual patents, and 27% more annual citations. Finally, higher monitoring leads to a flatter U-shaped relationship between takeover pressure and innovation. A one standard deviation increase in blockholder ownership flattens the curvature of annual R&D/ Sales, patents, and citations by 8%, 6%, and 6% respectively.

From a theoretical standpoint, we contribute to the literature that examines the effects of corporate

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[1] We first used the Directory of Corporate Affiliations to identify the divisions/subsidiaries of a firm. We then employed a name-matching algorithm to match the names of those divisions/subsidiaries to the "assignees" in the NBER patents database.

governance mechanisms on innovation. Stein (1988) develops a model with asymmetric information about the interim outcomes of projects between managers and investors. He shows that the threat of takeover induces myopic behavior on the part of managers. Burkart, Gromb, and Panunzi (1997) examine the costs and benefits of large shareholders and argue that *ex post* monitoring by large shareholders imposes costs *ex ante* by reducing beneficial managerial discretion. Manso (2007) develops a theory to show that the compensation contracts that provide incentives to a CEO to innovate exhibit the twin features of tolerance for failure in the short term, and reward for long-term performance. Aghion *et al* (2008) investigate the effects of institutional ownership on firm-level innovation. They predict and find that higher institutional ownership is positively associated with greater innovation. The existing studies thus examine how innovation is affected by *either* internal mechanisms such as managerial compensation contracts (Manso, 2007), and large shareholder monitoring (Burkart *et al*, 1997, Aghion *et al*, 2008), *or* by external mechanisms such as takeover pressure (Stein, 1988). Innovation is potentially driven by the interactions among the market for corporate control, compensation contracts, and monitoring. By integrating external and internal governance mechanisms in our framework, we demonstrate how the interactions between takeover premia and private control benefits lead to the novel prediction that innovation varies in a U-shaped manner with takeover pressure.

Our results are especially pertinent to the ongoing debate on the importance of the market for corporate control in fostering innovation. One strand of the literature (the "quiet life" view) argues that laws that hinder the market for corporate control encourage managerial slack and cause managers to refrain from investing in innovative activities (Jensen, 1988). In contrast, another strand of the literature (the "managerial myopia" view) argues that strong anti-takeover laws may foster innovation by facilitating long-term contracting (Shleifer and Summers, 1988) or by encouraging long-term investments in innovation by managers (Stein, 1988).

Our theory, which integrates long-term contracting and an external market for corporate control, shows that both perspectives are correct, albeit only "locally". When takeover pressure is above a threshold, a decrease in takeover pressure *decreases* innovation, which is consistent with the "quiet life" view. When takeover pressure is below the threshold, a decline in takeover pressure *increases* innovation, which is consistent with the "managerial myopia" view. An unhindered market for corporate control fosters innovation through the incentives provided by takeover premia. Severe anti-takeover laws may, however, also induce innovation by mitigating the adverse effects of private control benefit

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losses on managers' incentives to engage in innovative activities. The *interplay* between the magnitudes of these conflicting forces causes innovation to vary non-monotonically with takeover pressure.

From an empirical standpoint, our paper is related to studies that examine the real effects of corporate governance. Atanassov (2007) empirically examines the "quiet life" view versus "managerial myopia" view using the passage of business combination laws. While Atanassov (2007) tests for a monotonic relationship between takeover pressure and innovation, we show that the relationship between takeover pressure and innovation is, in fact, non-monotonic. Bertrand and Mullainathan (2003) examine the effect of passage of business combination statutes on plant-level productivity. Giroud and Mueller (2008) examine the differential effect of business combination laws on competitive and non-competitive industries. While these studies consider the effects of the passage of the business combination laws, we investigate the *sequential* effects of the passage of *every* anti-takeover law during our sample period.

Another strand of the empirical literature examines the effect of firm-level governance provisions on equity prices and equity returns. Gompers, Ishii and Metrick (2003) examine the effects of firm-level anti-takeover provisions on equity returns while Cremers and Nair (2005) study the effects of anti-takeover provisions and blockholder monitoring on equity prices.

The plan for the rest of the paper is as follows. In Section 2, we present the model. We derive the main testable implications of the theory in Section 3. We present our empirical analysis in Section 4. Section 5 concludes the paper. The proofs of all the propositions are provided in Appendix A. In Appendix B, we show that the main implications of the theory are robust to a more general model.

2   The Model

We consider a two-period model with dates $0, 1, 2$. At date 0, the manager of an all-equity firm chooses between two projects that differ in their *levels* of innovation. Henceforth, we denote the "more innovative" project by H and the "less innovative" project by L. The projects' payoffs occur at date 2. All agents are risk-neutral with a common discount rate that is normalized to zero. The manager is, however, wealth-constrained, which precludes the possibility of selling the firm to the manager at date 0.

2.1 Project Characteristics

The project $X \in \{H, L\}$ requires an initial investment C and generates a payoff of $P_X(2)$ at date 2.[2] The *true expected returns* of the projects (the expected returns from the perspective of a hypothetical omniscient agent) are unobservable to all agents, including the manager. As in Gibbons and Murphy (1992) and Holmstrom (1999), there is imperfect but symmetric information about the true expected returns of the projects. The projects differ from each other as follows. First, the more innovative project has a higher risk and a higher expected return than the less innovative one. Second, the more innovative project involves greater "exploration" relative to the less innovative one so that there is more uncertainty about its expected return.

To fix ideas, consider the following example. Suppose a pharmaceutical company could invest in either one of the following two projects: (1) inventing and launching a *new* drug (project H); or (2) manufacturing and launching a generic substitute for an existing drug (project L). Manufacturing and introducing a generic drug involves uncertainties arising from market demand, competition from other manufacturers, etc. In contrast, inventing a new drug entails *additional* uncertainties associated with the process of discovery and exploration, the uncertainty about whether such a drug could be administered to humans, and whether it would receive approval from the Food and Drug Administration.

The payoff of project $X \in \{H, L\}$ at date 2 is given by:

$$P_X(2) = 2\widetilde{\mu}_X + \sigma_X \widetilde{z}_1 + \sigma_X \widetilde{z}_2. \tag{1}$$

The parameter $\widetilde{\mu}_X$ in (1) determines the *true* expected return of the project, which we refer to as the project's *quality.* All agents have symmetric, normally distributed prior beliefs about the project's quality. Formally,

$$\widetilde{\mu}_X \sim N(m_X, s_X^2), \tag{2}$$

where m_X refers to the *mean quality* of the project. The parameter s_X^2 is the variance in agents' beliefs about the project's quality, which we refer to as the *quality uncertainty* of the project.

In (1), the variables $\widetilde{z}_1$ and $\widetilde{z}_2$ are independent standard normal random variables, which capture

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[2]The assumption that the projects require the same initial investment is not important for our analysis. We only require that the more innovative project have a higher net present value than the less innovative one.

the *intrinsic uncertainties* associated with the project. The random variables $\widetilde{z}_1$ and $\widetilde{z}_2$ represent "first period" uncertainty and "second period" uncertainty, respectively. The parameter σ_X, which is common knowledge, captures the level of intrinsic uncertainty of project X.

Because the more innovative project H has a higher risk and higher expected payoff than the less innovative project L,

$$m_H \;>\; m_L \;,$$

$$\sigma_H \;>\; \sigma_L.$$

$$(3)$$

Second, because the more innovative project is associated with a higher degree of quality uncertainty,

$$s_H > s_L. \tag{4}$$

Furthermore, we assume that

$$\frac{s_H}{\sigma_H} > \frac{s_L}{\sigma_L}, \tag{5}$$

which implies that, compared to the less innovative project L, a relatively greater proportion of the total uncertainty associated with the more innovative project H stems from uncertainty about its quality. For example, while a significant portion of the uncertainty associated with manufacturing and launching a generic substitute lies in the marketing stage, a relatively greater proportion of the uncertainty associated with inventing a new drug occurs in the *exploration* stage, when the very existence of the drug is in question. As we show shortly, conditions (3), (4) and (5) together imply that not only does the more innovative project have a higher expected return and a higher uncertainty than the less innovative project, but a larger proportion of the overall uncertainty of the more innovative project also stems from its quality uncertainty.

2.2   Intermediate Signals and Posterior Assessments of Project Quality

The manager's project choice at date 0 is observable. If the manager chooses project $X \in \{H, L\}$ at date 0, then all agents observe a signal $P_X(1)$ at date 1 that is given by

$$P_X(1) = \widetilde{\mu}_X + \sigma_X \widetilde{z}_1. \tag{6}$$

From (1), it follows that:

$$P_X(2) = P_X(1) + \widetilde{\mu}_X + \sigma_X \widetilde{z}_2, \tag{7}$$

so that the date 1 signal partially resolves the uncertainty about the date 2 payoffs.

Given the signal, all agents update their assessments about the quality of the project chosen by the manager. Using Bayes' rule (see DeGroot, 1970), the posterior distribution of the quality of project X is also normally distributed with mean $\widehat{m}_X$ and standard deviation $\widehat{s}_X$ given by:

$$\widehat{m}_X \equiv \frac{\sigma_X^2 m_X + s_X^2 P_X(1)}{s_X^2 + \sigma_X^2}, \tag{8}$$

$$\widehat{s}_X^2 \equiv \frac{s_X^2 \sigma_X^2}{s_X^2 + \sigma_X^2}. \tag{9}$$

We can rewrite the posterior mean given by (8) as

$$\widehat{m}_X = m_X + S_X \widehat{z} \tag{10}$$

where $\widehat{z}$ is a standard normal random variable and

$$S_X \equiv \frac{s_X^2}{\sqrt{s_X^2 + \sigma_X^2}} \tag{11}$$

It follows from (4), (5) and (11) that

$$S_H > S_L \tag{12}$$

Equation (12) implies that the uncertainty in the posterior assessments of project quality is higher for the more innovative project than for the less innovative one. Condition (3) captures the traditional risk-return tradeoff between the more innovative and less innovative project. Conditions (4) and (5), however, capture additional salient aspects of innovation that go beyond the usual tradeoff between risk and return. As emphasized by our motivating example at the beginning of this section, a *key feature* of our model is that more innovative projects are not only associated with greater quality uncertainty, but a relatively greater proportion of their total uncertainty stems from quality uncertainty. As we show below, this fact, in turn, implies that firms engaged in more innovative projects are more likely to be taken over as in Stein (1988).

2.3 Private Control Benefits and Monitoring Intensity

The manager derives *pecuniary* private control benefits $\alpha \in (0, \infty)$ provided she still controls the firm in the second period. These private control benefits are *non-verifiable* and, therefore, *non-contractible*. The private control benefits α decline with the monitoring intensity of the shareholders. For example, if the firm has a higher proportion of ownership by outside block-holders, then the manager will be better monitored so that the amount of private control benefits that she can extract is likely to be lower (Tirole, 2006).

2.4 Raider Synergies and Takeover Pressure

At date 1, the firm can be taken over by a raider through a tender offer. If the tender offer is successful, the raider controls the firm in the second period and alters the terminal payoff of the underlying project by creating *synergies* between the firm and the raider.

In particular, if the raider takes control of the firm at date 1, the project's terminal payoff at date 2 is

$$P_X^{raider}(2) = P_X(1) + \widetilde{\mu}_X^{raider} + \sigma_X \widetilde{z}_3, \tag{13}$$

where $\widetilde{z}_3$ is a standard normal random variable independent of $\widetilde{z}_1$, $\widetilde{\mu}_X$, and $\widetilde{\mu}_X^{raider}$. The synergies generated by the raider depend on the quality of the project. Specifically,

$$\widetilde{\mu}_X^{raider} = \widetilde{\mu}_X + \overbrace{\Theta\left(\widetilde{\mu}_X - m_X\right)}^{\text{synergy between firm and raider}} \tag{14}$$

In (14), the parameter $\Theta > 0$ determines the *synergies* generated by the raider. Equations (13) and (14) capture the intuitive notion that the higher the quality of the firm's project relative to the overall project pool, the larger the synergies created by the raider. In order to simplify the notation, we assume that Θ is a deterministic constant that is observable to all agents. All our results still hold if we generalize the model so that Θ is a random variable drawn from a distribution with a known positive mean and variance. If the raider takes over the firm, the incumbent manager loses her control benefits α to the raider.

The prevailing anti-takeover laws affect the firm's *bargaining power* in its negotiations with the raider. The more severe the anti-takeover laws are, the more difficult it is for the raider to take over the firm. We capture the severity of anti-takeover laws through the *minimum takeover premium* that

the raider has to pay in order to take over the firm. More precisely, in the absence of a takeover, the payoff to the firm (shareholders + manager) at date 2 *net* of the private benefits extracted by the manager is $P_X(\dot{2}) - \alpha$. Hence, the expected payoff to the firm at date 1 net of the manager's private benefits is $E_1\left[P_X(\dot{2}) - \alpha\right].$ Let $P_X^{takeover}$ be the total payoff that the raider offers the firm. The takeover is successful if and only if

$$P_X^{takeover} \geq E_1\left[P_X(\dot{2}) - \alpha\right] + \eta, \tag{15}$$

where $\eta > 0$. As anti-takeover laws become more severe, the parameter η *increases* so that takeover pressure *decreases*. The positive relationship between the minimum takeover premium and the severity of anti-takeover laws is consistent with the evidence in Comment and Schwert (1995) that the passage of anti-takeover laws resulted in significant increases in takeover premia.

In the following proposition, we show that, for the takeover to be successful, the expected synergies created by the raider must exceed a threshold that depends on the severity of anti-takeover laws. Further, we derive the payoff the firm receives from the raider.

Proposition 1 (Likelihood of Takeover and Takeover Payoff) *a) The raider succeeds in taking over the firm if and only if*

$$\Theta(\widehat{m}_X - m_X) \geq \eta. \tag{16}$$

where $\widehat{m}_X$ is the mean posterior project quality at date 1 (see 8).

b) The total payoff that the firm receives from the raider is

$$P_X^{takeover} = E_1[P_X^{raider}(2) - \alpha] = \widehat{m}_X + \Theta\left(\widehat{m}_X - m_X\right) - \alpha, \tag{17}$$

c) The likelihood of a takeover is higher for the more innovative project.

In words, condition (a) implies that the takeover is successful if and only if the expected synergies generated by the raider are sufficiently high to compensate for the takeover premium that it must pay the firm. It follows directly from (16) that the takeover is successful if and only if the project receives a sufficiently positive signal at date 1. As anti-takeover laws become severe, the parameter η increases. Thus, the level of the mean posterior quality of the project that could trigger a takeover increases, thereby reducing the likelihood of a takeover. The severity of anti-takeover laws, therefore, directly

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influences the *likelihood* of a successful takeover. We hereafter refer to the parameter η as the external *takeover pressure* faced by the firm.

2.5 Contracting between the Manager and Shareholders

At date 0, the manager and the shareholders enter into a long-term contract. The contract cannot prevent the pool of shareholders at date 1 from tendering their shares to a raider if it is in their interests to do so. However, the contract can specify a severance payment to the manager in the event of a takeover at date 1.

The manager's project choice X, her private control benefits α, and the date 1 signal $P_X(1)$ are all observable but *not verifiable* and, therefore, *non-contractible*. However, the date 2 net cash flows of the firm if it is not taken over (i.e., $P_X(2) - \alpha$) as well as the firm's date 1 net cash flows if it is taken over (i.e., $P_X^{takeover}$) are both contractible. At date 0, the shareholders can therefore write a compensation contract contingent on the contractible cash flows. Denote this compensation contract by $w(Q_X)$, where Q_X denotes the contractible portion of the firm's cash flows and is defined as

$$
\begin{aligned}
Q_X &\equiv P_X(2) - \alpha \text{ if the firm is not taken over at date 1,} \quad (18) \\
&\equiv P_X^{takeover} \text{ if the firm is taken over at date 1.}
\end{aligned}
$$

3 Equilibrium

In this section, we characterize the equilibrium of the model. We then derive the main results of the paper and generate the empirical implications.

3.1 Benchmark Environment

It is useful to analyze the benchmark environment in which there are no frictions, that is, the project choice X is contractible, and the manager derives no private control benefits. Therefore, in this environment, at date 0, the manager chooses the project that maximizes the total expected payoffs of the firm. The project choice therefore maximizes

$$
X^{benchmark} = \arg \max_{X \in \{H, L\}} \quad E[\underbrace{(1 - 1_X^T) \cdot P_X(2)}_{payoff \ if \ no \ takeover}] + \quad E[\underbrace{1_X^T \cdot P_X^{takeover}}_{payoff \ if \ takeover \ occurs}] \ , \quad (19)
$$

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where the indicator variable 1_X^T represents the event that the firm that has undertaken project X is taken over at date 1. In the benchmark environment, the shareholders maximize their expected payoffs by extracting all the surplus from the raider at date 1 and the raider earns zero profits. Therefore, $P_X^{takeover} = E_1[P_X^{raider}(2)]$ where $E_1[\cdot]$ denotes the expectation operator with respect to date 1 information. Substituting for $P_X^{takeover} = E_1[P_X^{raider}(2)]$ in (19) and using the law of iterated expectations, we get

$$X^{benchmark} = \arg \max_{X \in \{H,L\}} \underbrace{E(P_X(2))}_{expected\ payoff} + \underbrace{E\left[1_X^T \cdot \left(P_X^{raider}(2) - P_X(2)\right)\right]}_{expected\ takeover\ premium} \tag{20}$$

Equation (20) implies that, in the benchmark environment, the manager chooses the project that maximizes the total expected surplus of the firm, which is equal to the expected unconditional payoff of the project plus the expected takeover premium from selling the firm. Note that, because the firm can only be taken over if the raider offers a positive premium, the expected takeover premium term is strictly positive. The following proposition shows that the manager always chooses greater innovation in the first-best benchmark.

Proposition 2 (The Benchmark Project Choice) *In the benchmark environment with no frictions, the manager always chooses the more innovative project.*

The more innovative project has a higher unconditional expected payoff than the less innovative one. Furthermore, by (12), the likelihood of a takeover is higher when the manager chooses the more innovative project, implying that the expected *takeover premium* in the right-hand side of (20) is also higher. It is therefore optimal for the manager to choose the more innovative project.

3.2 The Project Choice in the Actual Environment

We now analyze the actual environment in which the manager's project choice is non-contractible and she derives private control benefits. At date 0, in order to maximize their expected payoffs, the shareholders design an optimal compensation contract $w^*(Q_X)$ for the manager, where Q_X is the contractible payoff defined in (18). The second best project choice $X^* \in \{H, L\}$ and the manager's

compensation contract $w^*(Q_X)$ therefore solve the following optimization problem:

$$(X^*, w^*(Q_X)) \equiv \arg\max_{X,\ w(Q_X)} E[Q_X - w(Q_X)] \tag{21}$$

subject to the manager's participation constraint,

$$E[(1 - 1_X^T) \cdot \alpha + w(Q_X)] \geq U, \tag{22}$$

and the incentive compatibility constraint,

$$X^* = \arg\max_{X' \in \{H,L\}} E[(1 - 1_X^T) \cdot \alpha + w(Q_{X'})] \tag{23}$$

where the indicator variable 1_X^T is defined above. In constraint (22), the variable U denotes the manager's reservation payoff. Constraint (23) ensures that the manager's choice of the optimal project is incentive compatible.

It is easy to see that the participation constraint (22) must be binding in the optimal contract, which implies that[3]

$$E(w^*(Q_X)) = U - E\left[(1 - 1_X^T) \cdot \alpha\right].$$

Substituting for $E(w^*(Q_X))$ in (21) and using (18) as well as the law of iterated expectations, we obtain

$$X^* = \arg\max_{X \in \{H,L\}} \underbrace{E(P_X(2))}_{expected\ payoff} + \underbrace{E\left[1_X^T \cdot \left(P_X^{raider}(2) - P_X(2)\right)\right]}_{expected\ takeover\ premium} - \underbrace{E[1_X^T \cdot \alpha]}_{expected\ loss\ in\ control\ benefits} \tag{24}$$

Note that in deriving the optimal project choice X^*, we have ignored the incentive compatibility constraint (23). We show later in Proposition 4 that, under the optimal contract, the constraint is indeed satisfied and the manager's optimal project choice solves (24). By (24), in the presence of private control benefits, the manager's optimal project choice maximizes the expected total unconditional payoff $E(P_X(2))$ of the project *plus* the expected takeover premium *less* the expected control benefits that are lost in the event of a takeover. Recall that, in the benchmark environment with no frictions,

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[3]If the participation constraint is not binding, the manager's compensation can be reduced by a constant amount that does not affect the incentive compatibility constraint (23) but strictly increases the shareholders' expected payoff.

equation (20) implies that the manager maximizes the total expected surplus of the firm given by the first two terms of (24). However, in our environment, in which the project choice is not contractible and private control benefits are present, the manager maximizes the total expected surplus of the firm minus the expected loss in control benefits due to a possible takeover at date 1.

The following proposition describes the optimal project choice of the manager.

Proposition 3 (Optimal Project Choice) *The manager's optimal project choice in the actual environment solves*

$$\max_{X \in \{H,L\}} \underbrace{2m_X}_{expected\ unconditional\ payoffs} + \underbrace{\frac{\Theta S_X}{\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\eta}{\Theta S_X}\right)^2\right]}_{expected\ takeover\ premium} - \underbrace{\alpha\left[1 - \Phi\left(\frac{\eta}{\Theta S_X}\right)\right]}_{expected\ loss\ in\ control\ benefits}, \qquad (25)$$

where $\Phi(\cdot)$ is the cumulative standard normal distribution and S_X is defined in (11).

The objective function in (25) illustrates the basic trade-off that the manager faces in choosing the degree of innovation. From Proposition 1 (c) the likelihood of being taken over is higher for the more innovative project. Hence the manager's expected loss of control benefits is also higher. However, the higher likelihood of being taken over also results in a larger expected takeover premium for the more innovative project. The manager's project choice trades off the positive effect of greater innovation on the expected takeover premium against its negative effect on the expected loss of control benefits. Furthermore, note that the expected takeover premium depends on the level of takeover pressure η that the firm faces while the expected loss in control benefits depends on both the level of takeover pressure η and the magnitude of the private control benefits α. Therefore, the above trade–off between the expected takeover premium and the expected loss in control benefits is itself influenced by the interaction between the shareholders' monitoring intensity (which affects α) and the extent of external takeover pressure the firm faces.

3.3 Optimal Contract for the Manager

We now derive an optimal contract for the manager.

Proposition 4 (Optimal Contract) *An optimal contract for the manager is one in which she always receives a fraction λ of the firm's terminal payoffs (i.e., λQ_{X^*}) and an additional payment, β,*

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if the firm is taken over where

$$\beta = (1 - \lambda)\alpha, \tag{26}$$

and λ is chosen to satisfy the manager's participation constraint at equality:

$$U = 2m_{X^*}\lambda + (1 - \lambda)\alpha + \lambda \frac{\Theta S_{X^*}}{\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\eta}{\Theta S_{X^*}}\right)^2\right] - \lambda\alpha\left[1 - \Phi\left(\frac{\eta}{\Theta S_{X^*}}\right)\right], \tag{27}$$

where X^* is the optimal project choice that satisfies (25).

The optimal allocation of payoffs to the agents (shareholders and the manager) can be implemented in different ways. In the above implementation, the manager receives a (restricted) equity stake of λ in the firm along with a severance payment of $\beta > 0$ if the firm is taken over at date 1. From an *ex ante* perspective, both the equity stake and the severance payment are optimal contractual devices that align the manager's incentives with those of the shareholders. The severance payment resembles a firm-level anti-takeover device, such as a *golden parachute* or a *poison pill,* in the sense that it makes it costlier for the raider to take over the firm.

3.4   Innovation, External Takeover Pressure, and Monitoring

We now describe the effects of takeover pressure on the degree of innovation.

Proposition 5 (Effect of Takeover Pressure on Innovation) *There exists a (possibly degenerate) interval $[\eta_{min}, \eta_{max}]$ of the external takeover pressure parameter η such that the manager chooses the more innovative project for $\eta \notin [\eta_{min}, \eta_{max}]$ and the less innovative project for $\eta \in [\eta_{min}, \eta_{max}]$. The interval $[\eta_{min}, \eta_{max}]$ is non-degenerate if and only if the private control benefits α are large enough.*

The above proposition confirms our intuition about the importance of the level of private control benefits in our second-best environment. When private control benefits α are relatively small, the manager chooses the more innovative project for any level of takeover pressure η as she would do in the benchmark environment discussed in Section 3.1. However, as private control benefits α increase, the above proposition tells us how the trade-off between the expected takeover premium and the expected loss in control benefits determines the manager's optimal project choice as takeover pressure changes. The manager chooses the more innovative project if the takeover pressure is either very

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high or very low while she chooses the less innovative project for intermediate levels of the takeover pressure.

To understand the intuition behind this result, consider first the case where the external takeover pressure is very low ($\eta > \eta_{max}$). In this case, a takeover is very unlikely, so the expected takeover premium as well as the expected loss in control benefits are insignificant (i.e., the second and third terms in (25) are relatively small). Therefore, the manager's optimal project choice is driven by the unconditional expected project payoff (the first term in (25)). The manager, therefore, chooses the more innovative project due to its higher unconditional expected payoff. Conversely, when takeover pressure is very high ($\eta < \eta_{\min}$), *regardless* of the project choice, the expected loss in control benefits is very high. Because the more innovative project generates a higher expected takeover premium, it is again optimal to choose the more innovative project. For moderate levels of takeover pressure, the effect of the expected loss of control benefits dominates so that the manager chooses the less innovative project, thus lowering the likelihood of a takeover.

The intuition underlying Proposition 5 suggests that the loss of control benefits due to a takeover plays a key role in generating the intermediate region within which lower innovation is chosen. As mentioned earlier, the control benefits the manager extracts (and, therefore, the control benefits she loses due to a takeover) depend on shareholders' monitoring intensity. The following proposition describes the effects of monitoring intensity on the degree of innovation.

Proposition 6 (Effect of Monitoring Intensity on Innovation)

The interval $[\eta_{min}(\alpha), \eta_{max}(\alpha)]$, for which the manager chooses lower innovation, increases as private control benefits α increase. More precisely,

$$[\eta_{min}(\alpha_1), \eta_{max}(\alpha_1)] \subset [\eta_{min}(\alpha_2), \eta_{max}(\alpha_2)], \text{ for } 0 < \alpha_1 < \alpha_2, \tag{28}$$

where we explicitly indicate the dependence of $\eta_{min}(.)$ and $\eta_{max}(.)$ on the private control benefits.

The intuition for the above result follows from the fact that, in the intermediate interval $[\eta_{min}(.), \eta_{max}(.)]$ the relative effect of the manager's expected loss of control benefits on her project choice is high, and thus she chooses the less innovative project. As the manager's control benefits increase, the potential losses she might incur due to a takeover also increase, and so the interval over which she chooses lower innovation increases.

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To explore how the external takeover pressure and the internal monitoring intensity interact to affect the degree of innovation, we define the *expected excess payoff from higher innovation $G(\eta, \alpha)$*, as the expected payoff from the more innovative project H less the expected payoff from the less innovative project L. From Proposition 3, the expected excess payoff is given by

$$
\begin{aligned}
G(\eta, \alpha) \;\equiv\;\; & 2m_H + \frac{\Theta S_H}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{\eta}{\Theta S_H}\right)^2\right) - \alpha\left(1 - \Phi\left(\frac{\eta}{\Theta S_H}\right)\right) \\
& -2m_L + \frac{\Theta S_L}{\sqrt{2\pi}} \exp\left(-\frac{1}{2}\left(\frac{\eta}{\Theta S_L}\right)^2\right) - \alpha\left(1 - \Phi\left(\frac{\eta}{\Theta S_L}\right)\right)
\end{aligned}
\tag{29}
$$

The following proposition describes the interactive effects of monitoring intensity and takeover pressure on the degree of innovation.

Proposition 7 (Takeover Pressure, Monitoring Intensity, and Innovation) *There exists an $\eta^* > 0$ such that*

$$
\begin{aligned}
\frac{\partial^2 G}{\partial(-\alpha)\partial\eta} \;&>\; 0 \;\text{ for } \eta < \eta^*, \\
\frac{\partial^2 G}{\partial(-\alpha)\partial\eta} \;&<\; 0 \;\text{ for } \eta > \eta^*
\end{aligned}
\tag{30}
$$

Figure 1 illustrates the result of Proposition 7 by showing the variation of the expected excess payoff from higher innovation with takeover pressure for different values of the manager's private control benefits. Proposition 5 and figure 1 show that the U-shaped relation between the degree of innovation and takeover pressure becomes "flatter" as monitoring intensity increases — that is, as α declines. The intuition is that, as the manager's private control benefits *decline*, so does the relative impact of the manager's expected loss of control benefits on the expected excess payoff from higher innovation. As a result, the expected excess payoff from higher innovation becomes *less sensitive* to changes in takeover pressure as the monitoring intensity increases. Hence, as illustrated by Figure 1, the U-shaped relation between the degree of innovation and takeover pressure becomes flatter as monitoring intensity increases.

In the model presented above, we have deliberately assumed that the projects' payoffs and qualities are normally distributed. The assumption of normality simplified the analysis, thereby, allowing us to highlight the main economic mechanisms underlying our results. In Appendix B, we show that all the main results derived above hold in a setting in which the underlying random variables are drawn from

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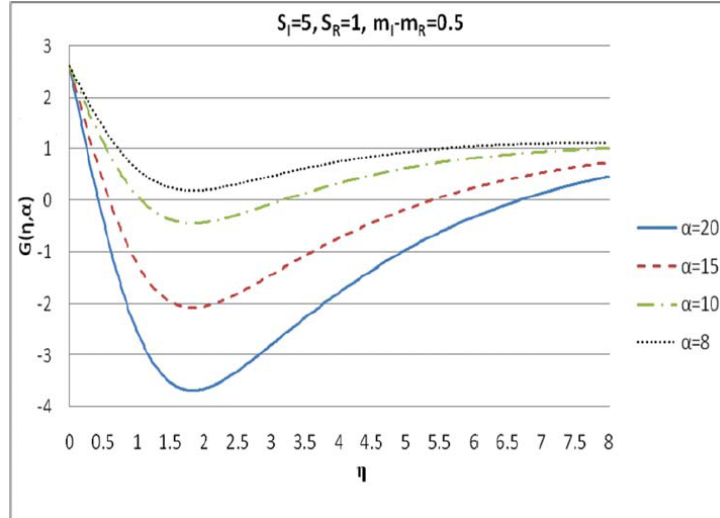
Figure 1: Variation of Expected Excess Payoff from Higher Innovation $G(\eta, \alpha)$ with Takeover Pressure η for various levels of Monitoring Intensity α.

more general distributions. We describe the necessary and sufficient conditions on the distributions of payoffs and qualities for our main testable results described by Propositions 5, 6 and 7 to hold in the general setting.

3.5 Testable Hypotheses

The preceding theoretical predictions generate the following empirically testable hypotheses.

Hypothesis 1 (External Governance and Innovation) *The degree of innovation varies in a U-shaped manner with external takeover pressure.*

Hypothesis 2 (Internal Monitoring and Innovation) *The degree of innovation increases with internal monitoring intensity.*

Hypothesis 3 (Interactive Effects of Monitoring and External Takeover Pressure) *The curvature of the U-shaped relation between the degree of innovation and external takeover pressure declines with monitoring intensity — that is, the U-shaped relation becomes "flatter".*

In the model, the choice of the degree of innovation by the manager and her compensation contract are *simultaneously* and *endogenously* determined by the takeover pressure, η, and the private benefits, α. In other words, the parameters η and α are *inputs* to the model, whereas the compensation contract

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and the degree of innovation are *outputs.* In particular, our predictions relating innovation to takeover pressure and monitoring intensity already *incorporate* the fact that the manager's compensation contract responds optimally to the takeover pressure and monitoring intensity that she faces. Moreover, as discussed in Section 3.3, the manager's contract can be implemented in different ways through combinations of financial securities and additional payoffs contingent on a takeover. Hence, our testable hypotheses also reflect the possibility that the firm could alter its financial structure and takeover provisions in response to changes in the external takeover pressure (for example, through anti-takeover laws) to implement the optimal payoffs of agents as described by Proposition 4. To closely tie our empirical analysis to the theory, and to avoid "endogeneity" problems in our econometric analysis, we examine the relationship between innovation and proxies for external takeover pressure and monitoring intensity without including *endogenous* firm-level variables such as compensation contracts, insider ownership, and capital structure.

4 Empirical Analysis

4.1 Proxies for Innovation

We employ both *ex ante* and *ex post* measures to proxy for innovation by firms. We use R&D intensity, calculated as the ratio of a firm's R&D expenditures to sales, as our *ex ante* measure of a firm's innovation. We use two broad metrics for our *ex post* measures of innovation. First, using data on patents filed by US firms with the US Patent Office (USPTO) constructed by Hall, Jaffe, and Trajtenberg (2001), we employ a simple count of the number of patents that were filed by a firm in a particular year. Second, to capture the economic importance of innovation, we measure all subsequent citations (until 2002) made to these patents (see Griliches, Pakes, and Hall, 1987). Since the year of application for a patent captures the relevant date of the innovation for which a patent is filed, we date our patents according to the year in which they were applied for. This also avoids any anomalies that may be created due to the time lag between the date the patent was applied for and the date when it was granted. Note that although we use the application year as the relevant year for our analysis, the patents appear in the database only after they are granted. Hence, for our analysis, we use the patents actually granted.[4]

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[4]Readers may question our treatment of patents that are filed by US subsidiaries of foreign firms and whether the inclusion/exclusion of such patents affects our results. We identify such patents as those where the country of the

4.2 Proxies for External Takeover Pressure

As discussed in Section 2.4, the external takeover pressure parameter η in our model captures the severity of anti-takeover laws. Accordingly, we use the state-level index of anti-takeover laws compiled by Bebchuk and Cohen (2003) as the empirical proxy for external takeover pressure. The index attaches to each state a score from 0 to 5 that is equal to its number of standard anti-takeover statutes. These statutes are called the Control Share acquisition, Fair-price, Business Combination, Poison Pill Endorsement, and Constituencies statutes.[5] Given our discussion in Section 3.5, the state-level anti-takeover index serves as a viable exogenous proxy for takeover pressure.

Figure 2 shows the evolution of the anti-takeover index for the various states in which firms are incorporated in our sample. The top panel of Figure 2 shows the evolution of the anti-takeover index due to the passage of anti-takeover laws in Delaware, New York, Ohio, Massachusetts, Pennsylvania, Minnesota, and New Jersey. The panel also shows that the anti-takeover index is zero for California since it never passed an anti-takeover law. These states collectively account for over three-quarters of our observations. The bottom panel shows the evolution of the anti-takeover index for all the states that are relevant for our sample.

Table 1 shows the states that form part of our sample and had passed anti-takeover laws during the period 1980-1995. This panel also lists the year in which the law was passed, the value of the state anti-takeover index before the passage of the law, and the change in the value of the index (which equals the number of anti-takeover statutes passed in that year).[6]

Figure 2 and Table 1 display two patterns that are important to understand in the context of our empirical strategy. First, the level of the anti-takeover index displays *substantial* variation both across time and across the various states of incorporation. Second, even the *changes* in the anti-takeover index exhibits considerable variation both across time and across the different states. This variation occurs due to two reasons. First, many states passed anti-takeover laws *sequentially* over time. Second, states chose to pass a variable number of anti-takeover laws in different years. For example, Indiana

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"assignee" is non-US but the country of the "inventor" is recorded as US. Of the 331,014 patents in our sample, we identify 6689 patents (~2.0%) issued to US subsidiaries of foreign companies. Not surprisingly, excluding these patents does not change our results.

[5] See Bebchuk and Cohen (2003) for detailed descriptions of these statutes.

[6] We compiled this list of changes by combining the anti-takeover index from Bebchuk and Cohen (2003) together the list of law passages compiled by Bertrand and Mulainathan (2003) and Karpoff and Malatesta (1989). While we rely primarily on Bebchuk and Cohen (2003) for the list of law passages, we cross-checked the year of passage of these laws using the list provided in Bertrand and Mulainathan (2003) and Karpoff and Malatesta (1989). In those instances where the year of passage of the law did not coincide across these three studies, we cross-checked the year using Lexis-Nexis' annotated state statutes.

passed four anti-takeover laws in 1986 and another anti-takeover law in 1989.

4.3 Proxy for Monitoring Intensity: Active Shareholders

Our proxies for monitoring intensity are constructed using block ownership data from CDA Spectrum as in Cremers and Nair (2005). Because the NBER patent data is available at an annual frequency, we employ the institutional shareholdings at the end of December of each year. As in Cremers and Nair (2005), we define a blockholder as a shareholder with greater than 5% ownership of the firm's outstanding shares and we employ three different proxies for monitoring intensity: (i) the number of institutional blockholders, (ii) the total percentage of shares owned by blockholders, and (iii) the number of public pension fund blockholders. We run our tests using all of the above proxies. Because the results are similar using each of the three proxies, we only report the results using the total percentage of shares owned by blockholders for brevity.

4.4 Sample Construction and Descriptive Statistics

Our sample period ranges from 1980 to 1995. We begin our sample in 1980 because blockholder ownership data are available from 1980 onwards. We terminate the sample in 1995 for two reasons. First, patents applied for in later years may not have been granted and therefore would not be present in the NBER dataset. Furthermore, because the NBER dataset extends only till 2002, citations to recent patents are not present in the data, which further exacerbates the problems stemming from "truncation bias." Second, as Table 1 shows, the last anti-takeover law was passed in 1992. Since the effects of law changes on innovation may decay over time, innovation undertaken several years after the laws are passed are more likely to be affected by other factors. We therefore follow Bertrand and Mullainathan (2003) and Giroud and Mueller (2008) in ending our sample in 1995.[7]

To be included in the sample, a firm must have filed at least one patent during our sample period. For our empirical analysis, we focus on the patents granted to US Corporations in the NBER patent dataset.[8] Each assignee in the NBER dataset is assigned a unique and time-invariant identifier. First, we match the assignee names in the NBER patent dataset to the names of divisions/ subsidiaries belonging to a Corporate family from the Directory of Corporate Affiliations. We then match the

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[7]We thank Antoinette Schoar and Luigi Zingales for bringing the above issue to our attention. We have also run our tests by extending the sample till the year 2002. The results support our hypotheses.

[8]Assignee code equal to 2 identifies US non-government assignees (mainly US Corporations).

name of the Corporate parent to Compustat. This matching process is done using name matching algorithms together with manual verification of 5% of the matched pairs. In order to remove the effect of outliers, we winsorize our sample at the 1% and 99% levels. Our final sample consists of 10,377 firm-year observations.

Table 2 shows the summary statistics for our various proxies. Note that since our main unit of observation is a firm-year, all these summary statistics are calculated for the firm-year level of aggregation. The average (median) firm in our sample invests 18% (4%) of its annual sales revenue in R&D while the average (median) firm in our sample applies for and is granted 19.5 (3) patents per year and receives about 197.8 (15) citations per year subsequently. Thus, compared to the median firm, the average firm in our sample invests 4.5 times more in R&D, applies for and is granted 6.5 times more patents and receives about 13.2 times more citations. In contrast to this skewness in the distribution of our proxies for innovation, the average and median percentage of shares owned by all blockholders together are 13.8% and 13.4% respectively.

Table 3 lists the states in which firms in our sample are incorporated as well as the number of firm-year observations contributed by the various states. Note that close to 50% of our observations come from firms incorporated in the state of Delaware.

4.5   Empirical Strategy

As we noted in Figure 2 and Table 1, the *levels* as well as *changes* in the anti-takeover index exhibit substantial cross-sectional and time-series variation. We exploit these sources of variation to conduct our empirical analysis in four steps. First, we conduct fixed effect panel regressions to examine each of our three main hypotheses. However, strict exogeneity restrictions are required to identify the coefficient estimates from these panel regressions. To weaken the identifying assumptions, we exploit the variation in the changes in the anti-takeover index to undertake fixed effects panel regressions of annual *changes* in our innovation proxies on *changes* in the explanatory variables. Third, to alleviate any residual endogeneity concerns, we exploit a unique feature of our data — patents and citations filed by subsidiaries and divisions of firms. Since other state-wide unobserved changes *accompanying* the change in anti-takeover laws may serve as the source of endogeneity, for firms incorporated in these states, we exclude all innovation done by subsidiaries and divisions located in the state of incorporation. Finally, we investigate whether our results are obtained across the broad spectrum of industries, or

are driven by a narrow group of industries.

4.6 Fixed Effects Panel Regressions

To investigate Hypotheses 1, 2, and 3, we start with the following fixed effects panel regression:

$$y_{is,t+1} = \beta_0 + \beta_i + \beta_{t+1} + \underbrace{\beta_1 TI_{st} + \beta_2 TI_{st}^2}_{\text{U-shaped Relation}} + \underbrace{\beta_3 MI_{it}}_{\text{Monitoring Intensity}} + \underbrace{\beta_4 \left(TI_{st}^2 * MI_{it} \right)}_{\text{Flattening of U-Shape}} + \beta \cdot X_{ist} + \varepsilon_{is,t+1} \quad (31)$$

where $y_{is,t+1}$ is the measure of innovation of firm i incorporated in state s in year $t+1$. The variable TI_{st} denotes the value of the anti-takeover index for state s at the end of year t, while the variable MI_{it} denotes the monitoring intensity for firm i at the end of year t. We examine the effects of monitoring intensity and the anti-takeover index with a time lag of one year. This is because states may pass anti-takeover laws in any month of the year. In addition, while institutional shareholdings may change throughout the year, we measure the proxies for monitoring intensity at the end of December of each year.

The variables β_i, β_{t+1} denote "firm" and "year" dummies respectively. The firm fixed effects captured by β_i control for time-invariant unobserved determinants of innovation at the firm level. They also control for time-invariant unobserved determinants of innovation at the state and industry levels because firms rarely change their primary industry or their state of incorporation in our sample.[9] The fact that firm fixed effects subsume industry fixed effects is important because innovation patterns vary across industries. The year fixed effects captured by β_{t+1} control for inter-temporal differences in innovation that are constant across states and firms as well as problems stemming from the truncation bias in citations.

In the above specification, X denotes a vector of control variables that are potential determinants of innovation. To control for the potential dependence of innovation on firm size, we include the logarithm of assets. Because past R&D intensity could positively affect current innovation, we include the lagged R&D to sales ratio.[10] Because innovation may be more likely when investment opportunities are greater, we include Tobin's Q to control for a firm's investment opportunities. Aghion *et al* (2005) show that innovation varies in an inverted U-shaped manner with industry competition. Accordingly,

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[9] Of the the 2151 firms in our sample, 33 change their state of incorporation during our sample period.

[10] When employing R&D to Sales as our innovation proxy, we exclude employing lagged R&D intensity as a control variable to avoid endogeneity due to a lagged dependent variable.

we include a sales-based Herfindahl measure for the 4-digit SIC industry and its square as additional controls. Finally, we also control for the potential dependence of innovation on the age of the firm.

Based on Hypothesis 1, which implies a U-shaped relation between innovation and takeover pressure, we predict that $\beta_1 < 0, \beta_2 > 0$. Based on Hypothesis 2, we predict that $\beta_3 > 0$. Based on Hypothesis 3, which implies that the U-shaped innovation-takeover pressure relation becomes "flatter" with monitoring intensity, we predict that $\beta_4 < 0$.

Table 4 reports the results of our analysis. In columns 1–3, the dependent variable is the logarithm of the ratio of R&D expenditures to sales. In columns 4–6, the dependent variable is the number of patents applied for (and eventually granted). In columns 7–9, the dependent variable is the number of subsequent citations to these patents. For each of these dependent variables, we estimate the regression with and without any of our control variables. Moreover, for each of our regression, we estimate standard errors that are robust to both heteroskedasticity and autocorrelation, and we cluster these standard errors by firm. Because firms incorporated in Delaware account for almost half of our observations (see Table 3), as an additional robustness check, we examine the results by excluding Delaware firms.[11]

Across columns 1-9 of Table 4, we find that $\beta_1 < 0$ and $\beta_2 > 0$. All the coefficients are statistically significant. An examination of the values of β_1 and β_2 in these models reveals that the value at which innovation attains its minimum, $-\beta_1/(2 * \beta_2)$, lies in the range 0-5 of possible values of the anti-takeover index. Using the coefficients in columns 2, 5, and 8, we find that when the value of the index in a state is zero (four), as it is in California (Pennsylvania in 1992), a one point increase in the value of the index decreases (increases) R&D/ sales, patents, citations for firms incorporated in the state respectively by 28%, 22%, and 23% (30%, 14%, and 19%) annually. Thus, consistent with Hypothesis 1, we find strong evidence of a U-shaped relationship between innovation and the level of the anti-takeover index.

Table 4 also shows that $\beta_3 > 0$. Across columns 1-9, the coefficients are statistically significant. A one standard deviation increase in total blockholder ownership is associated with 20% higher R&D/ Sales, 14% more annual patents, 15% more annual citations. These results are consistent with Hypothesis 2 that higher monitoring intensity is associated with greater innovation.

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[11]We have also examined the results obtained by *excluding* firms that either opted out of any of the anti-takeover statutes or decided to reincorporate to another state after the passage of the anti-takeover laws. We lose 134 firm-year observations when we exclude such firms. However, our results remain almost identical to the ones we report here.

Finally, we find that across columns 1-9, $\beta_4 < 0$. A one standard deviation increase in the total blockholder ownership flattens the curvature of annual patents, citations, and R&D/ Sales by 4.1%, 3.7%, and 3.8% respectively. Thus, consistent with Hypothesis 3, we find that higher monitoring leads to a flattening of the U-shaped relationship between takeover pressure and innovation.

Among our control variables, we find that firm size is positively associated with our innovation proxies. Furthermore, consistent with Aghion *et al.* (2005), we find evidence of an inverted U-shaped relationship between innovation and competition. Finally, we find that younger firms patent and receive citations relatively more than older firms.

4.6.1 Discussion of the fixed effects panel regressions

Given the firm fixed effects in (31) — which control for time-invariant unobserved heterogeneity at the firm, industry, and state-of-incorporation levels — and the year fixed effects, the identifying assumption in estimating (31) is that *time-varying* unobserved determinants of innovation at the firm, industry, and state levels are uncorrelated with both the level of the anti-takeover index and the level of blockholder ownership. To weaken these identifying assumptions, we next conduct "change-on-change" panel regressions.

4.7 Change-on-Change Panel Regressions

As noted in Section 4.2, changes in the anti-takeover index exhibit variation both across time as well as across states. Since blockholder ownership changes vary across time in our sample too, we exploit such rich variation to conduct fixed effects panel regressions of *changes* in our explanatory variables on *changes* in innovation (see Imbens and Wooldridge (2007), Section 4).

Since the identifying assumptions in estimating (31) centered around *time-varying*, firm, state, and industry-specific omitted variables, we consider the following equation-of-motion for our innovation-proxies:

$$
\begin{aligned}
y_{is,t+1} &= \beta_i + (t+1)\beta_s + (t+1)\beta_{ind} + \gamma_{t+1} + \beta_1 TI_{st} + \beta_2 TI_{st}^2 \\
&\quad + \beta_3 MI_{it} + \beta_4 \left(TI_{st}^2 * MI_{it} \right) + \beta \cdot X_{ist} + \eta_{is,t+1}
\end{aligned}
\tag{32}
$$

Thus, besides our variables of interest, we allow innovation to be driven by (i) time-varying state-

specific factors $(t + 1) \beta_s$; (ii) time-varying industry-specific factors $(t + 1) \beta_{ind}$; (iii) time-specific factors γ_{t+1}; and (iv) firm-specific factors β_i. First-differencing (32) yields

$$\Delta y_{is,t+1} = \beta_s + \beta_{ind} + \beta_{t+1} + \underbrace{\beta_1 \Delta TI_{st} + \beta_2 \Delta TI_{st}^2}_{\text{U-shaped Relation}} + \underbrace{\beta_3 \Delta MI_{it}}_{\text{Monitoring Intensity}} \tag{33}$$
$$+ \underbrace{\beta_4 \Delta \left(TI_{st}^2 * MI_{it} \right)}_{\text{Flattening of U-Shape}} + \beta \cdot \Delta X_{ist} + \varepsilon_{is,t+1}$$

where

$$\Delta y_{is,t+1} = y_{is,t+1} - y_{is,t}; \beta_{t+1} = \gamma_{t+1} - \gamma_t; \Delta TI_{st}$$
$$= TI_{st} - TI_{s,t-1}; \Delta TI_{st}^2 = TI_{st}^2 - TI_{s,t-1}^2.$$
$$\Delta MI_{it} = MI_{it} - MI_{i,t-1}; \Delta \left(TI_{st}^2 * MI_{it} \right) = TI_{st}^2 * MI_{it} - TI_{s,t-1}^2 * MI_{i,t-1};$$
$$\Delta X_{ist} = X_{ist} - X_{is,t-1}, \varepsilon_{is,t+1} = \eta_{is,t+1} - \eta_{ist}$$

We estimate equation (33) by including fixed effects for the state of incorporation, industry and the application year. Thus, we control for state-specific, industry-specific and inter-temporal unobserved factors driving *changes* in innovation.

Hypotheses 1, 2, and 3 predict that

$$\beta_1 < 0, \ \beta_2 > 0, \ \beta_3 > 0, \ \beta_4 < 0 \tag{34}$$

Table 5 presents the results of our time-series tests. In these regressions, we follow the suggestions in Imbens and Wooldridge (2007) and estimate robust standard errors that are clustered by state of incorporation. The specifications we employ in Table 5 mirror those employed in Table 4. Consistent with our hypotheses we find that $\beta_1 < 0$, $\beta_2 > 0$, $\beta_3 > 0$, and $\beta_4 < 0$ across all the specifications. By examining the values of β_1 and β_2 in columns 1-9, we find that the value at which innovation attains its minimum, $-\beta_1/(2 * \beta_2)$, lies in the range $0 - 5$ of possible values of the anti-takeover index.

Across Columns 1-9, we note that the coefficient estimates in Table 5 are very similar to those obtained in Table 4. Therefore, the economic magnitudes obtained in these change-on-change panel regressions are very close to those described in Section 4.6 above.

4.7.1 Discussion of the Change-on-Change Panel Regressions

Given the industry, state and year fixed effects, the assumption required to identify the coefficient estimates in (33) are considerably weaker: *time-varying* unobserved determinants of *changes* in innovation at the state or industry level are uncorrelated with *changes* in the anti-takeover index and *changes* in blockholder ownership. Nevertheless, other state-wide changes accompanying the changes in the anti-takeover index may affect our inference in (33). Our next set of tests, which exploit a unique feature of our data to examine innovation done outside the state of incorporation, are designed to address such alternative interpretations.

4.8 Subsidiary/Division-Level Change-on-change Regressions

To control for the effects of changing economic conditions that accompany the passage of an anti-takeover law in a state, we exploit a unique feature of our data. The NBER patents data records the location of the innovation through the state where a patent was filed. Thus, while Xerox may be headquartered and incorporated in Rochester, NY, its research labs are located in Rochester, NY as well as in Palo Alto, CA. The NBER patent data enable us to distinguish between patents filed by Xerox's Palo Alto Research Center and its Rochester laboratories. Anti-takeover laws passed by New York would likely affect innovation at its Palo Alto Research Center and its Rochester laboratories. However, any state-wide economic changes accompanying the law are more likely to affect the innovation at Xerox's Rochester laboratories. Therefore, if we exclude changes in innovation at Xerox's Rochester laboratories and estimate only using changes in innovation at Xerox's Palo Alto research center, then such an estimation potentially isolates the *pure* effect of changes in the anti-takeover index. In other words, in order to separate the effect of the changes in anti-takeover index law from the effect of state-wide economic changes accompanying such changes, we examine the impact on innovation in divisions/subsidiaries *outside* the state of incorporation for firms incorporated in the state.

We implement the tests using the following specification:

$$
\begin{aligned}
\Delta y_{kis,t+1} = & \ \beta_0 + \beta_{locn} + \beta_s + \beta_{t+1} + \underbrace{\beta_1 \Delta TI_{st} + \beta_2 \Delta TI_{st}^2}_{\text{U-shaped Relation}} + \underbrace{\beta_3 \Delta MI_{it}}_{\text{Monitoring Intensity}} \\
& + \underbrace{\beta_4 \Delta \left(TI_{st}^2 * MI_{it} \right)}_{\text{Flattening of U-Shape}} + \ \beta \cdot \Delta X_{ist} + \varepsilon_{kis,t+1}
\end{aligned}
\tag{35}
$$

where y_{kist} denotes the level of innovation in year t for subsidiary/division k of firm i. For firms incorporated in states in which the anti-takeover index changed during the time-period 1980-1995, y includes only those patents applied for (and eventually granted) by subsidiaries/ divisions outside the state of incorporation and citations to these patents. β_{locn} denote fixed effects for the state in which subsidiary/division k is located. Since different subsidiaries/divisions of a firm could be located in different states, we are able to include these fixed effects for the location of the subsidiary apart from fixed effects for the state in which the firm is incorporated (β_s). The other variables are defined similarly as in (33).

Table 6 reports the results of the tests; since subsidiary level information is not available for R&D intensity, we only test for patents and citations. The specifications employed for these are identical to those in Columns 4-9 of Tables 5. We note that the coefficients β_1 to β_4 retain their predicted signs and are statistically significant.

We estimate the economic magnitudes of the predicted effects using the coefficients in columns 2 and 5. First, when the value of the index in a state is zero (four), as it is in California (Pennsylvania in 1992), a one point *increase* in the value of the index *decreases (increases)* R&D/ sales, patents, citations for firms incorporated in the state respectively by 11% and 16% (32% and 26%) annually. This effect is consistent with the U-shaped relationship between innovation and the level of the anti-takeover index. Second, a one standard deviation increase in total blockholder ownership is associated with 11% more annual patents and 14% more annual citations. Finally, a one standard deviation increase in the total blockholder ownership flattens the curvature of annual patents and citations by 31% and 34% respectively.

4.9 Inter-industry Differences

Are more innovation-intensive industries driving our results? We investigate this possibility by examining inter-industry differences in the effect of takeover pressure and monitoring intensity based on the industry's propensity to innovate. We follow Acharya and Subramanian (2008) in employing the average number of patents filed by firms in a 4-digit SIC industry in a particular year to proxy

the industry's propensity to innovate. We test the following regression specification:

$$
\begin{aligned}
y_{is,t+1} \;=\; & \beta_0 + \beta_i + \beta_{t+1} + \left[\beta_1 TI_{st} + \beta_2 TI_{st}^2 + \beta_3 MI_{it} + \beta_4 \left(TI_{st}^2 * MI_{it} \right) \right] * \left[High_{ind,t} + Low_{ind,t} \right] \\
& + \beta \cdot \Delta X_{ist} + \varepsilon_{is,t+1}
\end{aligned}
$$

where $High_{ind,t}$ ($Low_{ind,t}$) equals 1 if the average number of patents filed by a firm in 4-digit SIC industry in year t is above (below) the median and 0 otherwise, where the median is calculated over all industries for the year t.

Table 7 shows the results of these tests, where we note that the predicted effects of takeover pressure and monitoring intensity are observed both in the High and Low innovation-intensive industries. Thus, the more innovation-intensive industries are not necessarily driving our above results.

5   Conclusion

We develop a parsimonious model to investigate how corporate governance mechanisms — such as monitoring intensity and takeover pressure — affect a firm's incentives to engage in innovation. Our model generates three testable predictions: (i) there is a U–shaped relationship between innovation and the takeover pressure the firm faces, (ii) the likelihood that a firm innovates increases with monitoring intensity, and (iii) the sensitivity of innovation to takeover pressure declines with monitoring intensity. Using *ex ante* and *ex post* measures of innovative activity, we show strong empirical support for the model's predictions. We identify the causal effects of governance mechanisms on innovation through fixed effects panel regressions both for levels-on-levels and for changes-on-changes.

By integrating long-term contracting and a market for corporate control, our theory shows how the interplay between takeover premia and private benefits leads to a *non-monotonic* relation between innovation and takeover pressure. From a policy standpoint, our results show that innovative activity is fostered by anti-takeover laws that are either practically non-existent or are strong enough to significantly deter takeovers. Effective monitoring not only enhances innovation, but also lowers the sensitivity of innovation to variations in external takeover pressure created by the passage of anti-takeover statutes. Monitoring is, however, most effective in enhancing innovation at intermediate levels of takeover pressure.

Appendix A – Proofs of Propositions

Proof of Proposition 1

a) The expected payoff of the firm at date 1 if it is not taken over is $E_1[P_X(2)]$. Because the incumbent manager loses her control benefits if the firm is taken over, the total payoff to the firm's stakeholders (shareholders + manager) if the firm is taken over, and (hypothetically) no takeover premium is paid, is $E_1[P_X(2)] - \alpha$. External anti-takeover laws, however, ensure that, for the takeover to be successful, the firm's stakeholders must receive a total expected payoff

$$E_1[P_X(2)] - \alpha + \eta, \text{ where } \eta > 0. \tag{36}$$

It follows directly from (1), (13), and (36) that the raider must generate a surplus for the firm. From the discussion in Sections 11.5.1 and 11.5.2 of Tirole (2006), free-riding by shareholders coupled with the fact that the raider obtains private control benefits, together ensure that it is optimal for the raider to make a tender offer that cedes the surplus he generates (less the control benefits he captures) to the firm. After the takeover, the firm's current stakeholders (shareholders + manager) therefore receive a total payoff at date 1 of

$$P_X^{takeover} = E_1\left[P_X^{raider}(2)\right] - \alpha, \tag{37}$$

where the expectation in (37) is with respect to the information available at date 1. It follows from (36) and (37) that the takeover is successful if and only if

$$E_1\left[P_X^{raider}(2)\right] \geq E_1[P_X(2)] + \eta, \tag{38}$$

In words, (38) states that the raider must increase the firm's expected payoff, conditional on the information available at date 1 by at least η. Using (1), (8), (13), (14), and (38), it follows that the raider succeeds in taking over the firm if and only if

$$\widehat{m}_X + \Theta(\widehat{m}_X - m_X) \geq \widehat{m}_X + \eta,$$
$$\Leftrightarrow \Theta(\widehat{m}_X - m_X) \geq \eta$$

b) The payoff to the firm upon a takeover follows directly from (37) and the fact that $E_1\left[P_X^{raider}(2)\right] = \widehat{m}_X + \Theta(\widehat{m}_X - m_X)$.

c), From (a), the firm is taken over if and only if $\Theta(\widehat{m}_X - m_X) \geq \eta$. Using (10), to rewrite the mean posterior quality in the preceding inequality, implies that the firm is taken over if and only if $\widehat{z} \geq \frac{\eta}{S_X \Theta}$. Therefore the probability of a takeover if the manager chooses project $X \in \{H, L\}$ is $\left[1 - \Phi\left(\frac{\eta}{S_X \Theta}\right)\right]$ where $\Phi(\cdot)$ is the cumulative standard normal distribution. Since $S_H > S_L$ by (12), it follows that the probability of a takeover is higher for the more innovative project.

Proof of Proposition 2

In an environment with no frictions, the manager maximizes the sum of the first two terms in (25). Because the expected takeover premium $\frac{\Theta S_X}{\sqrt{2\pi}} \exp\left[-\frac{1}{2}\left(\frac{\eta}{\Theta S_X}\right)^2\right]$ is increasing in S_X, (12) implies that the more innovative project results in a higher takeover premium than the less innovative project. This result coupled with the assumption $m_H > m_L$, imply that the first two terms in (25) are greater for the more innovative project making the more innovative project optimal in the benchmark environment.

Proof of Proposition 3

$$E(P_X(2)) = E(2\tilde{\mu}_X + \sigma_X \tilde{z}_1 + \sigma_X \tilde{z}_2) = 2m_X. \tag{39}$$

$$E(1_X^T \cdot \alpha) = \alpha E(1_X^T) = \alpha \left[1 - \Phi(\frac{\eta}{\Theta S_X})\right], \tag{40}$$

where $\Phi(\cdot)$ is the cumulative distribution function for standard normal distribution.

$$
\begin{aligned}
P_X^{raider}(2) - P_X(2) &= P_X(1) + \tilde{\mu}_X^{raider} + \sigma_X \tilde{z}_2 - (P_x(1) + \tilde{\mu}_x + \sigma_x \tilde{z}_3) \\
&= \tilde{\mu}_X^{raider} - \tilde{\mu}_X + \sigma_X(\tilde{z}_2 - \tilde{z}_3)
\end{aligned} \tag{41}
$$

From equation (41):

$$
\begin{aligned}
E[1_X^T \cdot (P_X^{raider}(2) - P_X(2))] &= E[1_X^T \cdot (\tilde{\mu}_X^{raider} - \tilde{\mu}_X)] + \sigma_X E[1_X^T \cdot (\tilde{z}_2 - \tilde{z}_3)] \\
&= E[1_X^T \cdot \tilde{\mu}_X^{raider}] - E[1_X^T \cdot \tilde{\mu}_X] + \\
&\quad \sigma_X E[1_X^T] \cdot E(\tilde{z}_2 - \tilde{z}_3) \\
&= \Theta E[1_X^T \cdot (\tilde{\mu}_X - m_X)]
\end{aligned} \tag{42}
$$

By the result of Proposition 1 and (10),

$$
\begin{aligned}
\Theta E\left[1_X^T \cdot E_1\left(\tilde{\mu}_X - m_X\right)\right] &= \Theta E\left[1_X^T \cdot (\hat{m}_X - m_X)\right] \\
&= \frac{\Theta}{\sqrt{2\pi S_X^2}} \int_{\frac{\eta}{S_X \Theta}}^{\infty} x e^{-\frac{1}{2}\left(\frac{x}{S_X}\right)^2} dx
\end{aligned}
$$

Making the change of variable $u = \frac{x}{S_X}$ in the integral above, we obtain:

$$\frac{\Theta S_X}{\sqrt{2\pi}} \exp[-\frac{1}{2}\left(\frac{\eta}{S_X \Theta}\right)^2] \tag{43a}$$

Proposition 3 follows from (39), (40), and (43a).

Proof of Proposition 4

The manager's objective function is

$$\alpha + E[w(Q_X) - 1_{takeover}\alpha],$$

or equivalently

$$E[w(Q_X) - 1_{takeover}\alpha].$$

The shareholder's objective function is

$$E[Q_X - w(Q_X)].$$

One way to make the project choice incentive compatible is to make the manager's objective function proportional to the shareholder's objective function, that is,

$$w(Q_x) - 1_{takeover}\alpha = m[Q_X - w(Q_X)],$$

where $0 < m < 1$ so that

$$w(Q_X) = \frac{m}{m+1} Q_X + \frac{\alpha}{m+1} 1_{takeover},$$

where m is a parameter to be determined. Let $\lambda = \frac{m}{m+1}$. Then

$$w(Q_X) = \lambda Q_X + (1-\lambda)\alpha 1_{takeover}.$$

m can then be solved from the manager's binding participation constraint, that is, $U = m[2m_X + \frac{\Theta S_X}{\sqrt{2\pi}} exp(-\frac{\eta}{2S_X\Theta})^2 - \alpha\Phi(-\frac{\eta}{S_X\Theta})] + \alpha$.

Proof of Proposition 5

Define the expected excess payoff from the more innovative project over the less innovative project by the function $G(\eta, \alpha)$ where

$$G(\eta, \alpha) \equiv 2m_H - 2m_L + F(\eta, \alpha); \tag{44}$$

and

$$F(\eta, \alpha) \equiv \frac{\Theta S_H}{\sqrt{2\pi}} \exp[-\frac{1}{2}\left(\frac{\eta}{S_H\Theta}\right)^2] - \alpha\Phi(-\frac{\eta}{S_H\Theta}) - \frac{\Theta S_L}{\sqrt{2\pi}} \exp[-\frac{1}{2}\left(\frac{\eta}{S_L\Theta}\right)^2] + \alpha\Phi(-\frac{\eta}{S_L\Theta}). \tag{45}$$

Note that as $\eta \to \infty$, $\lim F(\infty, \alpha) = 0$ so that the expected excess payoff $G(\infty, \alpha) = 2m_H - 2m_L > 0$. Conversely, as $\eta \to 0$, $\frac{\Theta S_X}{\sqrt{2\pi}} \exp[-\frac{1}{2}\left(\frac{\eta}{S_X\Theta}\right)^2] \to \frac{\Theta S_X}{\sqrt{2\pi}}$ while $\Phi(-\frac{\eta}{S_X\Theta}) \to 1$ so that $\lim F(0, \alpha) = \frac{\Theta S_H}{\sqrt{2\pi}} - \frac{\Theta S_L}{\sqrt{2\pi}} > 0$. This, in turn, implies that $G(0, \alpha) = 2m_H - 2m_L + \frac{\Theta(S_H - S_L)}{\sqrt{2\pi}} > 0$. Thus, the manager chooses the more innovative project for relatively low and relatively high levels of takeover pressure. We will now show that if the private control benefits parameter is sufficiently high, lower innovation may be optimal for moderate levels of takeover pressure..

Differentiate (45) with respect to η, to get:

$$\begin{aligned}
\frac{\partial F(\eta, \alpha)}{\partial \eta} &= \frac{1}{\sqrt{2\pi}} exp(-\frac{1}{2}(\frac{\eta}{S_H\Theta})^2)(-\frac{\eta}{S_H\Theta}) + \alpha\frac{1}{\sqrt{2\pi}} exp(-\frac{1}{2}(\frac{\eta}{S_H\Theta})^2)\frac{1}{S_H\Theta} - \frac{1}{\sqrt{2\pi}} exp(-\frac{1}{2}(\frac{\eta}{S_L\Theta})^2)(-\frac{\eta}{S_L\Theta}) \\
&\quad - \alpha\frac{1}{\sqrt{2\pi}} exp(-\frac{1}{2}(\frac{\eta}{S_L\Theta})^2)\frac{1}{S_L\Theta} \\
&= [\frac{1}{\sqrt{2\pi}S_H} exp(-\frac{1}{2}(\frac{\eta}{S_H\Theta})^2) - \frac{1}{\sqrt{2\pi}S_L} exp(-\frac{1}{2}(\frac{\eta}{S_H\Theta})^2)](\frac{\alpha}{\Theta} - \frac{\eta}{\Theta}) \\
&= [f_{S_H}(\frac{\eta}{\Theta}) - f_{S_L}(\frac{\eta}{\Theta})](\frac{\alpha - \eta}{\Theta})
\end{aligned}$$

The properties of the normal distribution imply that $f_{S_H}(\frac{\eta}{\Theta})$ and $f_{S_L}(\frac{\eta}{\Theta})$ cross only once for some $\eta \geq 0$. Let $\widehat{\eta}$ satisfy $f_{S_H}(\frac{\eta}{\Theta}) = f_{S_L}(\frac{\eta}{\Theta})$. Then $f_{S_H}(\frac{\eta}{\Theta}) < f_{S_L}(\frac{\eta}{\Theta})$ for $\eta \in [0, \widehat{\eta})$ and $f_{S_H}(\frac{\eta}{\Theta}) > f_{S_L}(\frac{\eta}{\Theta})$ for $\eta \in (\widehat{\eta}, +\infty)$ so that

$$\frac{\partial F(\eta, \alpha)}{\partial \eta} \begin{cases} < 0 & \text{if } \eta \in [0, min(\widehat{\eta}, \frac{\alpha}{\Theta})); \\ = 0 & \text{if } \eta = \widehat{\eta} \text{ or } \frac{\alpha}{\Theta} \\ > 0 & \text{if } \eta \in (min(\widehat{\eta}, \frac{\alpha}{\Theta}), max(\widehat{\eta}, \frac{\alpha}{\Theta})); \\ < 0 & \text{if } \eta > max(\widehat{\eta}, \frac{\alpha}{\Theta}). \end{cases}$$

From the behavior of $\frac{\partial F(\eta, \alpha)}{\partial \eta}$ described above, it follows that:

(i) $min(\widehat{\eta}, \frac{\alpha}{\Theta})$ is a local minimum for $F(\eta, \alpha)$;

(ii) $F(\eta, \alpha)$ is weakly decreasing in η if $\frac{\alpha}{\Theta} = \widehat{\eta}$.

We will first prove the following Remark: If $\frac{\alpha}{\Theta} \leq \widehat{\eta}$, then $F(\eta, \alpha) > 0 \; \forall \eta \in [0, +\infty)$. To see this note that since $F(\infty, \alpha) = 0$, condition (ii) implies that $F(\eta, \alpha) \geq 0$ if $\frac{\alpha}{\Theta} = \widehat{\eta}$. The Remark then follows because $\frac{\partial F(\eta, \alpha)}{\partial \alpha} = (\Phi(-\frac{\eta}{S_L\Theta}) - \Phi(-\frac{\eta}{S_H\Theta})) < 0$.

Given the preceding Remark, the necessary and sufficient condition for the interval (η_{min}, η_{max}) to exist is:

$$G(\eta, \alpha) < 0 \tag{46}$$

where $G(\eta_{\min}, \alpha) = G(\eta_{\max}, \alpha) = 0$ and $\hat{\eta} = S_H S_L \Theta \sqrt{\frac{2(lnS_H - lnS_L)}{S_H^2 - S_L^2}} > 0$ where $f_{S_H}(\hat{\eta}) = f_{S_L}(\hat{\eta})$.

Using (44) and (45), the necessary and sufficient condition described in (46) becomes:

$$\alpha > \alpha_{MIN} \equiv \frac{2(m_L - m_H) - \left(\frac{\Theta S_H}{\sqrt{2\pi}} exp(-\frac{1}{2}(\frac{\widehat{\eta}}{S_H\Theta})^2) - \frac{\Theta S_L}{\sqrt{2\pi}} exp(-\frac{1}{2}(\frac{\widehat{\eta}}{2S_L\Theta})^2)\right)}{\Phi(-\frac{\widehat{\eta}}{S_L\Theta}) - \Phi(-\frac{\widehat{\eta}}{S_H\Theta})} > 0. \qquad (47)$$

where $\widehat{\eta} = S_H S_L \Theta \sqrt{\frac{2(lnS_H - lnS_L)}{S_H^2 - S_L^2}}$

Proof of Proposition 6

Let $\bar{\eta}$ satisfy $G(\bar{\eta}, \alpha) = 0$, so that $\bar{\eta} = \eta_{\min}$ or $\eta_{\max}$ are the thresholds defined above that satisfy $G(\eta_{\min}, \alpha) = G(\eta_{\max}, \alpha) = 0$ for all $\alpha > \alpha_{MIN}$ defined in (47). Using the Implicit Function theorem:

$$\frac{d\bar{\eta}}{d\alpha} = \frac{-\frac{\partial G}{\partial \alpha}}{\frac{\partial G}{\partial \eta}}\Big|_{\eta=\bar{\eta}} = \frac{\Phi(\frac{-\eta}{S_H\Theta}) - \Phi(-\frac{\eta}{S_L\Theta})}{\frac{\partial F(\eta,\alpha)}{\partial \eta}}\Big|_{\eta=\bar{\eta}}. \qquad (48)$$

The numerator of (48) is positive. From the proof of proposition 5, the denominator of (48) is negative for $\bar{\eta} = \eta_{min}$, and positive for $\bar{\eta} = \eta_{max}$. This completes the proof.

Proof of Proposition 7

$$\frac{\partial^2 G}{\partial(-\alpha)\partial\eta} = \frac{1}{\Theta}\left(-\frac{1}{\sqrt{2\pi}}\exp[-\frac{1}{2}\left(\frac{\eta}{S_h\Theta}\right)^2]\frac{1}{S_H} + \frac{1}{\sqrt{2\pi}}\exp[-\frac{1}{2}\left(\frac{\eta}{S_L\Theta}\right)^2]\frac{1}{S_L}\right)$$

$$\underbrace{=}_{\text{using proof of proposition (5)}} \frac{1}{\Theta}\left(f_{S_L}(\frac{\eta}{\Theta}) - f_{S_H}(\frac{\eta}{\Theta})\right).$$

The properties of the normal distribution imply that $f_{S_H}(\frac{\eta}{\Theta})$ and $f_{S_L}(\frac{\eta}{\Theta})$ cross only once for some $\eta^* \geq 0$ such that $f_{S_L}(\frac{\eta}{\Theta}) - f_{S_H}(\frac{\eta}{\Theta}) > 0$ for $\eta < \eta^*$, and $f_{S_L}(\frac{\eta}{\Theta}) - f_{S_H}(\frac{\eta}{\Theta}) < 0$ otherwise.

Appendix B: A More General Model

In this Appendix, we show that the main testable implications of the theory are robust to a generalization of the model presented in Section 2 in which the projects' payoffs are drawn from more general distributions. As in the basic model, the manager chooses between a more innovative project H and a less innovative project L at date 0. The payoff of project $X \in \{H, L\}$ at date 2 is

$$P_X(2) = 2\widetilde{\mu}_X + r_{X1} + r_{X2}, \qquad (49)$$

where r_{X1} and r_{X1} are independent and identically distributed random variables drawn from a distribution R_X with mean 0.

Consistent with the basic model, there is imperfect, but symmetric, information about the project's quality $\widetilde{\mu}_X$. Agents' prior assessment of $\widetilde{\mu}_X$ is drawn from a distribution M_X that has mean m_X. We assume that

$$m_H > m_L. \qquad (50)$$

By (49) and (50), the more innovative project has a higher expected payoff.

At date 1, all agents observe a common signal given by

$$P_X(1) = \widetilde{\mu}_X + r_{X1}. \qquad (51)$$

Let $\widehat{m}_X$ denote agents' mean posterior assessment of the project's quality based on their observation of the signal $P_X(1)$. We have

$$\widehat{m}_X = m_X + s_X, \tag{52}$$

where s_X is a random variable drawn from a distribution F_X with mean 0. The distribution F_X depends on the distributions M_X and R_X.

We assume that the distribution F_X is absolutely continuous so that it has a density f_X a.e. Further, the densities f_H and f_L satisfy a "single crossing" condition, that is, there exists $\widehat{u}$ such that

$$
\begin{aligned}
f_H(u) &< f_L(u) \text{ for } u < \widehat{u} \\
f_H(u) &> f_L(u) \text{ for } u > \widehat{u}
\end{aligned} \tag{53}
$$

In addition, we assume that

$$F_H(u) \leq F_L(u), \text{ for } u \geq 0. \tag{54}$$

The above condition implies the distribution F_H "first order stochastically dominates" the distribution F_L on the positive real line. Note that we *do not assume* that F_H "first order stochastically dominates" the distribution F_L over the entire real line. The condition (54) implies that the likelihood of positive changes in the project's mean quality is higher for the more innovative project. Finally, we assume that

$$\int_0^\infty u f_H(u) du \geq \int_0^\infty u f_L(u) du, \tag{55}$$

which implies that, conditional on a positive change in the project's mean quality, the expected change is also higher for the more innovative project. Conditions (54) and (55) capture the intuitive requirements that the payoff of the more innovative project is more skewed so that it is more likely to generate high signals and payoffs.

As in the basic model, the firm can be taken over by a raider through a tender offer. The project's terminal payoff could be altered through synergies between the firm and the raider. The terminal payoff of project X under the raider is

$$P_X^{raider}(2) = P_X(1) + \widetilde{\mu}_X^{raider} + r_{X2}, \tag{56}$$

where

$$\widetilde{\mu}_X^{raider} = \widetilde{\mu}_X + \Theta\left(\widetilde{\mu}_X - m_X\right) \tag{57}$$

Proposition 1 a) and b) are valid for the more general model using exactly the same arguments, while part c) follows from condition (54). By the same arguments used in the main body of the paper, the manager's objective function in the more general model is given by (24). The manager's optimal project choice solves

$$\max_{X \in \{H,L\}} \quad \underbrace{2m_X}_{\text{expected unconditional payoffs}} + \underbrace{\int_{\frac{\eta}{\Theta}}^{\infty} \Theta u f_X(u) du}_{\text{expected takeover premium}} - \underbrace{\alpha\left[1 - F_X\left(\frac{\eta}{\Theta}\right)\right]}_{\text{expected loss in control benefits}}. \tag{58}$$

Define

$$G(\eta, \alpha) \equiv 2(m_H - m_L) + \int_{\frac{\eta}{\Theta}}^{\infty} \Theta u (f_H(u) - f_L(u)) du + \alpha\left[F_H\left(\frac{\eta}{\Theta}\right) - F_L\left(\frac{\eta}{\Theta}\right)\right], \tag{59}$$

which is the expected excess payoff from higher innovation. By (50), $G(\infty, \alpha) > 0$. By (54) and (55), $G(0, \alpha) > 0$. Next, we note that

$$\frac{\partial G(\eta, \alpha)}{\partial \eta} = \left[f_H(\frac{\eta}{\Theta}) - f_L(\frac{\eta}{\Theta}) \right] \left[\frac{\alpha - \eta}{\Theta} \right] \tag{60}$$

Let $\widehat{\eta}$ satisfy $f_H(\frac{\widehat{\eta}}{\Theta}) = f_L(\frac{\widehat{\eta}}{\Theta})$. By (53), $f_H(\frac{\widehat{\eta}}{\Theta}) < f_L(\frac{\widehat{\eta}}{\Theta})$ for $\eta < \widehat{\eta}$ and $f_H(\frac{\widehat{\eta}}{\Theta})$

$f_H(\frac{\widehat{\eta}}{\Theta}) > f_L(\frac{\widehat{\eta}}{\Theta})$ for $\eta > \widehat{\eta}$. It follows from (60) that $G(\eta, \alpha)$ is decreasing for $\eta < \min(\widehat{\eta}, \alpha)$, is increasing for $\min(\widehat{\eta}, \alpha) < \eta < \max(\widehat{\eta}, \alpha)$, and is decreasing for $\eta > \max(\widehat{\eta}, \alpha)$. It follows that there exists an interval $[\eta_{\min}, \eta_{\max}]$ (that could be degenerate) such that the manager chooses greater innovation for $\eta < \eta_{\min}$ or $\eta > \eta_{\max}$, and lower innovation for $\eta \in [\eta_{\min}, \eta_{\max}]$.

It follows directly from (54) and (59) that

$$\frac{\partial G}{\partial(-\alpha)} > 0,$$

which implies that higher monitoring has a positive effect on innovation. Finally, we note that

$$\frac{\partial^2 G}{\partial(-\alpha)\partial \eta} = \frac{1}{\Theta} \left[f_L \left(\frac{\eta}{\Theta} \right) - f_H \left(\frac{\eta}{\Theta} \right) \right]. \tag{61}$$

By (53), the result of Proposition 7 also holds for the more general model.

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Figure 2: Cross-sectional and Time-series variation in the Anti-takeover Index

The top panel shows the evolution of anti-takeover index for states of incorporation that have the majority of observations in our sample. The bottom panel shows the evolution of the anti-takeover index for all states of incorporation that comprise our sample.
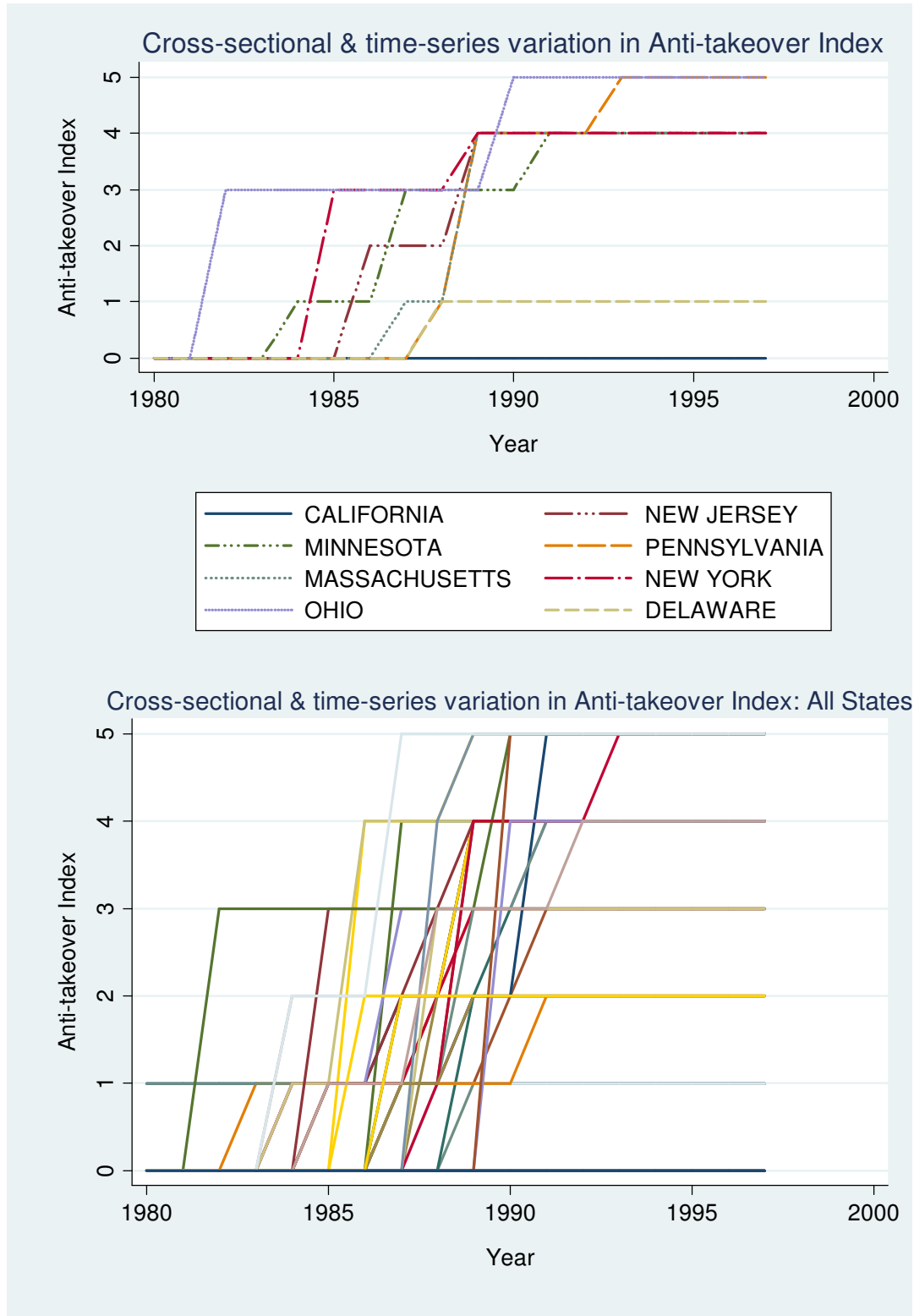
Table 1: Changes in Anti-takeover laws in various states in our Sample

This Table shows the year(s) in which anti-takeover laws were passed in each state, the value of the index before the change and the change in the index. We compile this list of changes by combining the anti-takeover index from Bebchuk and Cohen (2003) together the list of law passages compiled by Bertrand and Mulainathan (2003) and Karpoff and Malatesta (1989). While we rely primarily on Bebchuk and Cohen (2003) for the list of law passages, we cross-checked the year of passage of these laws using the list provided in Bertrand and Mulainathan (2003) and Karpoff and Malatesta (1989). In those instances where the year of passage of the law did not coincide across these three studies, we cross-checked the year using Lexis-Nexis' annotated state statutes.

State	Year	Index before	Change	State	Year	Index before	Change
Colorado	1989	0	1	North Carolina	1987	0	2
Connecticut	1984	0	1	North Carolina	1990	2	1
Connecticut	1989	1	1	Nebraska	1988	0	2
Delaware	1988	0	1	New jersey	1986	0	2
Florida	1987	0	2	New jersey	1989	2	2
Florida	1989	2	2	Nevada	1987	0	1
Georgia	1985	0	1	Nevada	1989	1	1
Georgia	1988	1	1	Nevada	1991	2	3
Georgia	1989	2	2	New York	1985	0	3
Iowa	1989	0	2	New York	1989	3	1
Illinois	1984	0	2	Ohio	1982	0	3
Illinois	1989	2	2	Ohio	1990	3	2
Indiana	1986	0	4	Oklahoma	1987	0	1
Indiana	1989	4	1	Oregon	1987	0	1
Kansas	1988	0	1	Oregon	1989	1	2
Massachusetts	1987	0	1	Oregon	1991	3	1
Massachusetts	1989	1	3	Pennsylvania	1988	0	1
Maryland	1983	0	1	Pennsylvania	1989	1	3
Maryland	1988	1	1	Pennsylvania	1993	4	1
Maryland	1989	2	1	Rhode island	1990	0	4
Michigan	1984	0	1	South Carolina	1988	0	3
Michigan	1988	1	1	Tennessee	1988	0	4
Michigan	1989	2	1	Tennessee	1989	4	1
Minnesota	1984	0	1	Utah	1987	0	1
Minnesota	1987	1	2	Utah	1989	1	1
Minnesota	1991	3	1	Virginia	1985	0	1
Missouri	1984	0	1	Virginia	1988	1	2
Missouri	1986	1	3	Virginia	1992	3	1
Mississippi	1985	0	1	Washington	1987	0	2
Mississippi	1990	1	1	Wisconsin	1984	0	2
Mississippi	1991	2	1	Wisconsin	1987	2	3

Table 2: Summary Statistics and Correlations

This table displays the summary statistics for the proxies for Innovation and the proxy for Monitoring Intensity. The variables are winsorized at the 1% and 99% levels. Since the unit of observation is a firm-year, all the summary statistics are computed at the firm-year level of aggregation.

Number of firm-year observations = 10377

Variable	Mean	Median	Standard Deviation	Minimum	Maximum
R&D/Sales	0.18	0.04	0.75	0	6.65
Number of Patents	19.5	3.0	66.5	1	1127
Number of Citations	197.8	15.0	752.6	0	15006
Total Blockholder ownership %	13.8%	13.4%	10.6%	0	79.7%

Table 3: State of Incorporation of Firms in our Sample

This Table shows the number of firm-year observations in for the various states of incorporation.

Number of firm-year observations = 10377

State	# obns	State	# obns
Delaware	4,888	Pennsylvania	392
California	1,029	Minnesota	307
New York	651	New jersey	264
Ohio	487	Others	1930
Massachusetts	429		

Table 4: Fixed Effects Panel Regressions

$$y_{is,t+1} = \beta_i + \beta_{t+1} + \beta_1 \cdot TI_{st} + \beta_2 \cdot (TI_{st})^2 + \beta_3 \cdot MI_{it} + \beta_4 \cdot \left\{ MI_{it} * (TI_{st})^2 \right\} + \beta \cdot X_{ist} + \varepsilon_{is,t+1}$$

The variable $y_{is,t+1}$ is a measure of innovation in year $t+1$ for firm i incorporated in state s. y is either the *logarithm* of (a) the ratio of R&D expenditures to sales in year t (Columns 1-3) (b) the number of patents applied for (and eventually granted) in year t (Columns 4-6), (c) the number of subsequent citations to these patents (Columns 7-9). All regressions are estimated using OLS. The sample consists of firms that applied for a patent over the period 1981-1995 (and the patent was eventually granted by the U.S. Patent Office) matched to Compustat and CDA Spectrum. The variable TI_{st} equals the value of the anti-takeover index in state s at the end of year t. The variable MI_{it} denotes the Monitoring Intensity in firm i in year t. The variables β_i and β_{t+1} denote firm & year fixed effects. The vector X denotes the set of control variables. The standard errors are robust to heteroskedasticity and autocorrelation and are <u>clustered by firm</u>. ***, **, * denote significance at 1%, 5% and 10% levels respectively.

Dependent Variable is logarithm of:	(1) R&D/ Sales	(2) R&D/ Sales	(3) R&D/ Sales	(4) Patents	(5) Patents	(6) Patents	(7) Citations	(8) Citations	(9) Citations
Anti-takeover Index (H1)	-0.467***	-0.404***	-0.450***	-0.315***	-0.298***	-0.281***	-0.335***	-0.314***	-0.283***
	(6.80)	(7.15)	(6.66)	(6.98)	(6.72)	(5.54)	(6.76)	(6.39)	(5.10)
Square of Anti-takeover Index (H1)	0.086***	0.074***	0.073***	0.051***	0.048***	0.038***	0.058***	0.054***	0.040***
	(6.91)	(7.24)	(5.26)	(5.72)	(5.44)	(3.59)	(5.98)	(5.65)	(3.48)
Minimum ($-\beta_1/2*\beta_2$)	2.715	2.730	3.082	3.088	3.104	3.697	2.888	2.907	3.538
Proxy for Monitoring Intensity (H2)	1.962***	1.696***	2.266***	1.337***	1.260***	1.430***	1.412***	1.333***	1.542***
	(6.49)	(6.98)	(5.69)	(7.90)	(7.65)	(5.54)	(7.58)	(7.37)	(5.66)
Square of Anti-takeover Index * Proxy for Monitoring Intensity (H3)	-0.082***	-0.069***	-0.092***	-0.051***	-0.047***	-0.055***	-0.053***	-0.050**	-0.057**
	(2.91)	(2.95)	(3.41)	(2.85)	(2.71)	(2.76)	(2.59)	(2.49)	(2.49)
Current Log of Assets		0.101***	0.105***		0.046***	0.041***		0.049***	0.042***
		(4.49)	(3.14)		(5.54)	(3.93)		(5.08)	(3.22)
Lagged R&D/ Sales					0.001***	0.002***		0.000	0.001*
					(2.71)	(4.00)		(0.90)	(1.95)
Lagged Tobin's Q		-0.034**	-0.010		-0.011	0.007		-0.004	0.023
		(2.58)	(0.45)		(1.54)	(0.57)		(0.52)	(1.16)
Lagged Herfindahl Index		1.802***	2.012***		0.375***	0.548***		0.615***	0.720***
		(7.16)	(5.55)		(2.96)	(3.04)		(4.64)	(3.76)
Square of Lagged Herfindahl Index		-1.663***	-1.825***		-0.629***	-0.764***		-0.502***	-0.727***
		(6.69)	(5.19)		(4.74)	(4.08)		(3.92)	(4.23)
Firm age		0.021*	0.014		-0.068***	-0.074***		-0.080***	-0.087***
		(1.71)	(0.68)		(7.45)	(5.88)		(7.93)	(6.50)
Observations	10377	10377	5489	10377	10377	5489	10377	10377	5489
R-squared	0.05	0.11	0.13	0.06	0.09	0.10	0.11	0.13	0.13
Sample	Full	Full	No Delaware	Full	Full	No Delaware	Full	Full	No Delaware
Firm Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 5: Change-on-change Panel Regressions with Fixed Effects

$$\Delta y_{is,t+1} = \beta_{industry} + \beta_s + \beta_{t+1} + \beta_1 \cdot \Delta TI_{st} + \beta_2 \cdot \Delta(TI_{st})^2 + \beta_3 \cdot \Delta MI_{it} + \beta_4 \cdot \Delta\{MI_{it} * (TI_{st})^2\} + \beta \cdot \Delta X_{ist} + \varepsilon_{is,t+1}$$

The variable $\Delta y_{is,t+1} = y_{is,t+1} - y_{ist}$, where y_{ist} is a measure of innovation in year t for firm i incorporated in state s. y is either the *logarithm of* (a) the ratio of R&D expenditures to sales in year t (Columns 1-3) (b) the number of patents applied for (and eventually granted) in year t (Columns 4-6), (c) the number of subsequent citations to these patents (Columns 7-9). All regressions are estimated using OLS. The sample consists of firms that applied for a patent over the period 1981-1995 (and the patent was eventually granted by the U.S. Patent Office) matched to Compustat and CDA Spectrum. The variable $\Delta TI_{st} = TI_{st} - TI_{s,t-1}$, where TI_{st} equals the value of the anti-takeover index in state s at the end of year t; $\Delta(TI_{st})^2 = (TI_{st})^2 - (TI_{s,t-1})^2$. $\Delta MI_{it} = MI_{it} - MI_{i,t-1}$, where MI_{it} denotes the Monitoring Intensity in firm i in year t. $\Delta\{MI_{it} * (TI_{st})^2\} = MI_{it} * (TI_{st})^2 - MI_{i,t-1} * (TI_{s,t-1})^2$. The variables $\beta_{jndustry}$, β_s and β_{t+1} denote industry, state of incorporation & year fixed effects. Note that since the *change* in the anti-takeover index for a state varies across time, we can include state of incorporation fixed effects. The vector X denotes the set of control variables. The standard errors are robust to heteroskedasticity and autocorrelation and are <u>clustered by state of incorporation</u>. ***, **, * denote significance at 1%, 5% and 10% levels respectively.

Dependent Variable is Δ of logarithm of:	(1) R&D/ Sales	(2) R&D/ Sales	(3) R&D/ Sales	(4) Patents	(5) Patents	(6) Patents	(7) Citations	(8) Citations	(9) Citations
Δ Anti-takeover Index	-0.415***	-0.374***	-0.391***	-0.345***	-0.335***	-0.306***	-0.346***	-0.337***	-0.336***
	(12.86)	(9.02)	(5.80)	(8.80)	(8.13)	(6.36)	(9.88)	(10.44)	(8.47)
Δ Square of Anti-takeover Index	0.074***	0.068***	0.073***	0.060***	0.059***	0.052***	0.064***	0.063***	0.061***
	(7.30)	(5.96)	(5.02)	(7.26)	(6.99)	(5.14)	(5.76)	(6.09)	(5.19)
Minimum (-β₁/ 2*β₂)	2.804	2.750	2.678	2.875	2.839	2.942	2.703	2.675	2.754
Δ Proxy for Monitoring Intensity	1.556***	1.418***	1.837***	1.396***	1.366***	1.305***	1.532***	1.512***	1.362***
	(7.73)	(6.12)	(6.00)	(14.29)	(15.13)	(6.07)	(12.01)	(13.94)	(6.07)
Δ Interaction of Square of Anti-takeover Index with Proxy for Monitoring Intensity	-0.030**	-0.030**	-0.052***	-0.026*	-0.026*	-0.022	-0.052***	-0.052***	-0.043**
	(2.26)	(2.09)	(3.08)	(1.82)	(1.89)	(1.42)	(3.13)	(3.43)	(2.66)
Δ Current Log of Assets		0.072*	0.062		0.017**	0.028***		0.017**	0.019
		(1.87)	(0.96)		(2.18)	(3.46)		(2.62)	(1.69)
Δ Lagged R&D/ Sales					0.001***	0.002***		0.001***	0.002***
					(4.21)	(5.71)		(3.55)	(3.34)
Δ Lagged Tobin's Q		-0.005	0.012		-0.008***	-0.002		0.006	0.029
		(0.69)	(0.62)		(2.85)	(0.25)		(0.68)	(1.02)
Δ Lagged Herfindahl Index		1.528***	1.533***		0.624***	0.719***		0.632***	0.626***
		(11.50)	(5.96)		(9.51)	(7.61)		(9.49)	(4.65)
Δ Square of Lagged Herfindahl Index		-0.833***	-0.994***		-0.207***	-0.233**		-0.165	-0.263
		(6.27)	(3.95)		(4.21)	(2.61)		(1.46)	(1.26)
Δ Firm age		0.026***	0.034***		-0.039***	-0.055***		-0.051***	-0.064***
		(3.15)	(2.91)		(4.04)	(4.16)		(5.96)	(4.69)
Observations	7099	7099	3722	7099	7099	3722	7099	7099	3722
R-squared	0.05	0.10	0.11	0.06	0.07	0.07	0.04	0.05	0.05
Sample	Full	Full	No Delaware	Full	Full	No Delaware	Full	Full	No Delaware
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
State of Incorporation Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Industry Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Table 6: Change-on-change Panel Regressions excluding innovation done by subsidiaries located in the state of incorporation for states that changed the anti-takeover laws

$$\Delta y_{kis,t+1} = \beta_{location} + \beta_s + \beta_{t+1} + \beta_1 \cdot \Delta TI_{st} + \beta_2 \cdot \Delta(TI_{st})^2 + \beta_3 \cdot \Delta MI_{it} + \beta_4 \cdot \Delta\{MI_{it} * (TI_{st})^2\} + \beta \cdot \Delta X_{ist} + \varepsilon_{is,t+1}$$

The variable $\Delta y_{kis,t+1} = y_{kis,t+1} - y_{kist}$, where y_{kist} is a measure of innovation in year t for subsidiary/ division k of firm i incorporated in state s. y is either the *logarithm of (a)* the number of patents applied for (and eventually granted) in year t (Columns 1-2) or (b) the number of subsequent citations to these patents (Columns 3-4). All regressions are estimated using OLS. The sample consists of firms that applied for a patent over the period 1981-1995 (and the patent was eventually granted by the U.S. Patent Office) matched to Compustat and CDA Spectrum. For firms incorporated in states that changed their anti-takeover laws during the time-period 1980-1995, y includes only those patents applied for (and eventually granted) by subsidiaries/ divisions outside the state of incorporation and citations to these patents. The variable $\Delta TI_{st} = TI_{st} - TI_{s,t-1}$, where TI_{st} equals the value of the anti-takeover index in state s at the end of year t; $\Delta(TI_{st})^2 = (TI_{st})^2 - (TI_{s,t-1})^2$. $\Delta MI_{it} = MI_{it} - MI_{i,t-1}$, where MI_{it} denotes the Monitoring Intensity in firm i in year t. $\Delta\{MI_{it} * (TI_{st})^2\} = MI_{it} * (TI_{st})^2 - MI_{i,t-1} * (TI_{s,t-1})^2$. The variables $\beta_{location}$, β_s and β_{t+1} denote fixed effects for the state in which the subsidiary k is located, the state in which the firm i is incorporated & the year in which the patent was applied for. Note that we can include fixed effects for both the state of location of the subsidiary and the state of incorporation of the firm since a given firm i incorporated in state s can have multiple subsidiaries located in different states. Furthermore, since the *change* in the anti-takeover index for a state varies across time, the state of incorporation fixed effects are well identified. The standard errors are robust to heteroskedasticity and autocorrelation and are clustered by state of incorporation. ***, **, * denote significance at 1%, 5% and 10% levels respectively.

Dependent Variable is Δ of logarithm of:	(1) Patents	(2) Patents	(3) Patents	(4) Citations	(5) Citations	(6) Citations
Δ Anti-takeover Index	-0.114***	-0.114***	-0.105***	-0.161**	-0.162**	-0.234***
	(3.83)	(3.85)	(3.14)	(2.58)	(2.60)	(3.39)
Δ Square of Anti-takeover Index	0.048***	0.048***	0.043***	0.047***	0.047***	0.059***
	(6.64)	(6.66)	(6.32)	(2.96)	(2.96)	(3.22)
Minimum $(-\beta_1/ 2*\beta_2)$	1.188	1.188	1.221	1.713	1.723	1.983
Δ Proxy for Monitoring Intensity	0.992***	0.994***	0.646**	1.315***	1.316***	1.317***
	(8.60)	(8.36)	(2.65)	(8.93)	(9.07)	(2.73)
Δ Interaction of Square of Anti-takeover Index with Proxy for Monitoring Intensity	-0.140***	-0.140***	-0.122***	-0.151***	-0.151***	-0.152***
	(14.15)	(14.01)	(8.01)	(10.28)	(10.37)	(5.07)
Δ Current Log of Assets		0.003**	0.003		0.003	0.015***
		(2.48)	(0.54)		(1.17)	(2.75)
Δ Lagged R&D/ Sales		0.001***	-0.000		0.001***	0.000
		(4.46)	(0.06)		(5.43)	(0.47)
Δ Lagged Tobin's Q		0.000	-0.000		-0.003***	-0.000
		(0.07)	(0.04)		(2.89)	(0.09)
Δ Lagged Herfindahl Index		0.010	0.227		0.064	0.212
		(0.19)	(1.52)		(0.92)	(0.69)
Δ Square of Lagged Herfindahl Index		0.018	-0.072		-0.046	-0.070
		(0.49)	(0.44)		(0.75)	(0.23)
Δ Firm age		0.001***	-0.000		0.000	0.000
		(2.85)	(0.12)		(0.33)	(0.11)
Observations	12610	12610	3183	12610	12610	3183
R-squared	0.04	0.04	0.13	0.02	0.02	0.06
Year Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects for State of **Firm's** Incorporation	Yes	Yes	Yes	Yes	Yes	Yes
Fixed Effects for State of **Subsidiary/ Division's** Location	Yes	Yes	Yes	Yes	Yes	Yes

Table 7: Inter-industry differences using Fixed Effect Panel Regressions

$$y_{is,t+1} = \beta_i + \beta_{t+1} + \left[\beta_1 \cdot TI_{st} + \beta_2 \cdot (TI_{st})^2 + \beta_3 \cdot MI_{it} + \beta_4 \cdot \left\{MI_{it} * (TI_{st})^2\right\}\right]\left(High_{ind,t} + Low_{ind,t}\right) + \beta \cdot X_{ist} + \varepsilon_{is,t+1}$$

The variable $y_{is,t+1}$ is a measure of innovation in year $t+1$ for firm i incorporated in state s and operating in industry j. y is either the *logarithm of (a)* the ratio of R&D expenditures to sales in year t (Columns 1) (b) the number of patents applied for (and eventually granted) in year t (Columns 2), (c) the number of subsequent citations to these patents (Column 3). All regressions are estimated using OLS. The sample consists of firms that applied for a patent over the period 1981-1995 (and the patent was eventually granted by the U.S. Patent Office) matched to Compustat and CDA Spectrum. The variable TI_{st} equals the value of the anti-takeover index in state s at the end of year t. The variable $MI_{i,t}$ denotes the Monitoring Intensity in firm i in year t. High$_{ind,t}$ (Low$_{ind,t}$) equals 1 if the average number of patents filed by a firm in industry j in year t is above (below) median and 0 otherwise, where the median is calculated over all industries for the year t. The variables β_i and β_{t+1} denote firm & year fixed effects. The vector X denotes the set of control variables. The standard errors are robust to heteroskedasticity and autocorrelation and are clustered by firm. ***, **, * denote significance at 1%, 5% and 10% levels respectively.

Dependent Variable is of logarithm of:	(1) R&D/ Sales	(2) Patents	(3) Citations
Anti-takeover Index * Low Innovation Intensity	-0.465***	-0.252***	-0.272***
	(6.88)	(5.39)	(5.32)
Anti-takeover Index * High Innovation Intensity	-0.318***	-0.361***	-0.370***
	(4.79)	(7.55)	(6.80)
Square of Anti-takeover Index * Low Innovation Intensity	0.084***	0.038***	0.044***
	(6.17)	(3.81)	(4.19)
Square of Anti-takeover Index * High Innovation Intensity	0.062***	0.062***	0.068***
	(4.79)	(6.06)	(5.59)
Proxy for Monitoring Intensity * High Innovation Intensity	1.858***	1.301***	1.339***
	(6.11)	(7.27)	(6.96)
Proxy for Monitoring Intensity * Low Innovation Intensity	1.472***	1.185***	1.318***
	(4.81)	(6.14)	(5.81)
(Proxy for Monitoring Intensity * Square of Anti-takeover Index) * Low Innovation Intensity	-0.073***	-0.035*	-0.034
	(2.59)	(1.87)	(1.60)
(Proxy for Monitoring Intensity * Square of Anti-takeover Index) * High Innovation Intensity	-0.064*	-0.070***	-0.080***
	(1.69)	(3.18)	(2.98)
Observations	10377	10377	10377
R-squared	0.11	0.09	0.13
Control Variables as in Table 3	Yes	Yes	Yes
Firm Fixed Effects	Yes	Yes	Yes
Year Fixed Effects	Yes	Yes	Yes