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Incentives and innovation: evidence from CEO compensation contracts

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Abstract

We investigate the relationship between chief executive officer (CEO) compensation and innovation. In an empirical examination of compensation contracts of S&P 400, 500, and 600 firms we find that long-term incentives in the form of options are positively related to patents and citations to patents. In addition, convexity of options has a positive effect on innovation. We also find no relationship between pay for performance sensitivity (PPS) with patents and citations to patents while we did discover a positive relationship between these and golden parachutes. Finally, we show that subsequent to project failure managers' compensation contracts are reset favourably. We provide support for the theory that compensation contracts that offer long-term commitment and protection from failure are more suitable for innovation.

Keywords: CEO compensation; innovation and incentives

JEL classification numbers: D8, O31

Minkälainen palkitsemisjärjestelmä kannustaa yritysjohtoa innovaatioihin?

Suomen Pankin keskustelualoitteita 17/2011

Bill Francis – Iftekhar Hasan – Zenu Sharma
Rahapolitiikka- ja tutkimusosasto

Tiivistelmä

Tässä työssä tarkastellaan yritysten operatiivisen johdon palkitsemisjärjestelmien ja innovaatioiden välistä vuorovaikutusta. Tutkimuksen empiiristä analyysia varten kerätty aineisto koostuu pörssiyhtiöiden (S&P 400, 500, ja 600) toimitusjohtajien palkkasopimuksia koskevista tiedoista. Tutkimustulosten mukaan optiosopimuksiin liittyvillä pitkän aikavälin kannusteilla on suotuisa vaikutus patenttien määrään ja patenttiviittauksiin. Samoin optioiden hinnan volatiliteettiin liittyvä konveksisuus lisää innovaatioita. Toisaalta patenttien määrällä ja patenttiviittauksilla ei näyttäisi olevan yhteyttä siihen, miten herkästi toimitusjohtajien palkat reagoivat heidän suoriutumiseensa. Kultaiset kädenpuristukset sen sijaan lisäävät tulosten mukaan patenttien määrää ja patenttiviittauksia. Tulokset osoittavat, että epäonnistuneiden projektien jälkeen johtajien palkkasopimuksia tarkistetaan heidän kannaltaan suotuisasti ja että pitkät palkkasopimukset, jotka sitouttavat johtajia ja antavat suojaa epäonnistumisilta, toimivat innovaatioiden kannalta hyvin.

Avainsanat: yritysjohtajien palkat, innovaatiota ja kannusteet

JEL-luokittelu: D8, O31

Contents

1. Introduction

Innovation can be crucial for firm survival. Exploration and development of new products and processes help firms to access new markets and sources of value. Innovation, however, is a high-risk activity and therefore requires commitment of a firm's resources and managerial talent (Holmstrom 1989, Aghion and Tirole 1994, Manso 2007). A risk-averse manager, whose wealth is tied to firm-value, may become myopic in outlook and get tempted to invest in projects that assure returns in the short run instead of investing innovation. Consequently, for a manager to invest in projects with long gestation periods and high rates of failure, the shareholders must provide contracts that create appropriate incentives.

Both Holmstrom (1989) and Manso (2007) argue that to motivate managers to invest in the exploration of new ideas rather than exploiting existing ones, incentive contracts should assure a long-term commitment and protection from failure. Use of stock options in public companies, for example, provides managers with necessary incentives to invest in innovation (Manso 2007). Stock options have a lengthy expiration period, which ensures long-term commitment, and they create convex pay-offs, which encourage risk-taking behavior. In addition to stock options, provisions such as golden parachutes, because they protect managers in case of involuntary turnover, may also create incentives for managers to invest in projects with higher failure rates. In this paper we empirically examine whether there is an association between managerial compensation contracts in publicly listed companies and innovation.

While investment in research and development (R&D) can be seen as investment in innovation, investment in R&D does not necessarily imply that managers have invested in new ideas. Although CEOs may have significant control over the resources allocated to R&D activities, investment of these resources in projects that ultimately lead to new products or processes is a crucial aspect of the innovation process. Patents and citations to patents, on the other hand, reflect the productivity of R&D and therefore more realistically reflect innovation. Following Aghion, Reenen and Zingales (2009) we treat R&D as an input in the production of innovation rather than the output.

In a broad sample of 1,106 firms during 1992–2005 we find that CEO compensation has a positive relationship with innovation. Our measures of innovation are the number of patents filed and citations to patents, which come from the National Bureau of Economic Research (NBER) patent data file (Hall, Jaffe and Trajtenberg 2001). We find that standard principal-agent contracts represented by pay for performance sensitivity (PPS), which captures changes in managers' wealth with, changes in firm-value, is unrelated to patents and citations to patents. In contrast, our measures of compensation, which enforce long-term commitment, including new options grants and previously granted unvested and vested options, have a positive relationship with patents and citations to patents. We also look at golden parachutes arrangements that protect the CEO in case of termination and find that they have a positive effect on patents and citations to patent.

By linking managers' wealth to the stock price, stock options affect managers' attitude towards risk (Jensen and Meckling 1976; Haugen and Senbet 1981). We expect the convexity of pay-offs created by options, which incentivize managers to assume more risk, to have a positive relationship with innovation. Following the literature on options (e.g. Agarwal and Mandelkar 1987; Coles, Daniel and Naveen 2006) we investigate the relationship between sensitivity of CEOs' wealth in options to a unit change in volatility (vega) with innovation and find that the vega has a positive relationship with innovation.

However, when a large portion of managers' wealth is tied to the stock price, managers can make significant gains when the market goes up but simultaneously they can also be exposed by downswings. Firms may choose to protect managers from reversals in stock price especially if poor firm performance makes outside opportunities more attractive (e.g., Oyer 2004; Bizjak, Lemmon and Naveen 2008). Consequently, rewarding managers for good luck and protecting them from bad luck, formally known as asymmetric benchmarking of pay, should have a positive effect on innovation. We find that asymmetric benchmarking of pay is, in fact, positively related to innovation.

In order to address the causality issue of whether innovative remunerate managers with greater options or presence of options in managers' compensation contract leads to more innovation, we look at a sub sample of pharmaceutical companies to see whether firms alter their incentive contracts in response to an exogenous shock. We treat announcement of a failure of Phase III Clinical Trial as a significant setback for firm's research and development initiatives.

We argue that if firms adjust manager's compensation schemes to absorb such a shock it would indicate that firms provide incentive contracts that are more tolerant to failure and hence more suitable for innovation. In separate regressions of golden parachutes, option repricing, and issuance of multiple grants on a dummy variable that equals one if firm announced a Phase III Clinical Trial Failure, we find positive relationship.

Our analysis provides evidence consistent with the theory that contracts that exhibit high tolerance for failure motivate managers to invest in innovation. High tolerance of failure in a manager's contract could, however, distort managerial incentives and lead to moral hazard. Holmstrom (1989) argues that such shirking might get mitigated by increasing the monitoring intensity. To explore the effect of monitoring on innovation we look at the Sarbanes Oxley Act. One of the intended consequences of the Sarbanes Oxley Act passed in 2002 was to increase the internal and external monitoring of firms. Various researchers examining the effect of the Sarbanes Oxley Act have however documented a negative effect of the Act on corporate risk taking (e.g. Shadab 2008; Cohen, Dey and Lys 2004; Bargeron, Lehn and Zutter 2008). When we examine the effect of the Sarbanes Oxley Act on innovation we also find a negative relationship.

Our study contributes to the literature examining the relationship between incentive contracts and innovation. We know of one other study by Lerner and Wulf (2007) that empirically examines this issue. The authors look at compensation arrangements of corporate R&D executives and innovation. They examine 300 US firms from 1987–1998 based on a survey conducted by Hewitt Associates. In their analysis they find that long-term incentives for R&D executives have increased over time and, long-term incentives are positively associated with more heavily cited patents, frequent awards and greater originality. Unlike Lerner and Wulf (2007) who regard innovation as a performance benchmark for R&D executives we treat innovation as a real option for CEOs. By looking at the relationship between compensation and innovation from a CEO's perspective we gain an insight as to whether specific features of the CEOs' pay package can influence their investment behavior. In addition to addressing the important distinction between long and short-term incentives and aspects of compensation arrangements that provide protection for managers we also find empirical evidence justifying the use of golden parachutes.

In the next section we describe our hypothesis with respect to vested and unvested options and golden parachutes. We provide an overview of the data, a description of variables and methodology in Section 3. In Section 4 we discuss the results and conclude in Section 5.

2. Hypothesis Development

2.1. PPS

In a standard principal-agent model the principal contracts with an agent to exert costly effort to affect an uncertain outcome. As effort is unobservable the principal in exchange of the effort offers the agent a share in the output. The best contract that is derived under these constraints seeks to lower the agent's aversion to risk and his cost of action. However, Holmstrom (1989) argues, as the riskiness of the project increases the agent's share in the outcome simultaneously decreases which induces weaker effort which then requires greater monitoring. As innovation is risky, unpredictable, long term, labor-intensive and idiosyncratic, the agent passes up innovative projects for less risky ones. Holmstrom (1989) points out, this trade-off between incentives and risk is central to innovation.

March (1991) also argues that firms undertake two kinds of activities: one is exploration, which according to the author entails risk-taking, experimentation, flexibility, discovery and innovation. The other is exploitation, which entails refinement, production, efficiency and implementation. Both of these activities compete for allocation of resources. The standard principal-agent contracts encourage agents to choose actions whose probability of failure are low. As a result, the agent would shift effort from innovative activities to activities that require exploitation of current knowledge.

Manso (2007) builds on the tension that exists between exploitation and exploration activities that are available to an agent. The author combines bandit problems in a principal-agent framework and explores how agents constantly choose between exploration, exploitation and shirking. Consistent with the predictions of Holmstrom (1989) the author finds that standard-principal agent contracts do not necessarily create incentives for the agent to engage in exploration. Standard principal-agent contracts that motivate exploitation instead resemble contracts that motivate the agent to engage in repeated effort. The uniqueness in Manso's model lies in the fact that it allows for the principal to obtain, evaluate and provide the agent with feedback on the project's performance.

Research in the psychology literature also provides some insight into the effect of incentives on the agent's motivation to innovate. For example, McGraw (1978) and McCullers (1978) argue that pay for performance encourages exploitative activities in a firm. Amabile (1996) argues, that tasks can be algorithmic (repetitive) or heuristic (inventive). For tasks that require creativity, setting up reward systems can decrease performance because they might narrowly focus the agent on a certain goal. An alternative explanation for a negative impact of performance-linked rewards on performance comes from the hidden costs of rewards (Lepper, Greene and Nisbett, 1973), corruption effect (Deci, 1975) and cognitive evaluation theory (Deci, 1975). Most of these theories discuss the "crowding out effect" which suggests that there is a constant interaction between intrinsic and extrinsic motivation. Extrinsic motivation in the form of pay for performance contracts undermines the intrinsic motivation to work.

CEOs in large organizations have multiple investment options. By linking managers' pay to firm performance the shareholders can ensure that managers make investments that increase firm-value. However, because managers are risk-averse agents they may pass up risky projects for less risky ones. If the share holders want to ensure that the CEOs maintain their focus on innovation, then it is likely that the standard principal-agent contracts may not create appropriate incentives. To investigate the relationship between standard contracts and innovation we look at the relationship between CEOs' PPS and patenting activity at firm-level. PPS captures the change in CEO pay with the change in shareholder return. Jensen and Murphy (1990) document a pay for performance relation for CEOs at $3.25 change in CEO pay for a $1,000 in firm-value. The authors further note that the change in CEO wealth is too low and it casts a doubt on the validity of principal-agent contracts. However, subsequent studies note that the pay for performance relation estimated by Jensen and Murphy (1990) is understated. For example, Hall and Liebman (1998) report a $14 increase in CEO wealth with an increase of $1,000 in shareholder value and argue that the pay for performance relation is consistent with the principal-agent models. Therefore, we consider PPS as a proxy for a standard principal-agent contract and predict a negative association between PPS and innovation.

2.2. Long-term commitment

Holmstrom (1989) and Manso (2007) further state that given the nature of innovation, incentive contracts that encourage innovation must have a high tolerance of failure. If the agent is penalized for first time failures, he is discouraged from exerting effort on activities that have a greater probability of failing. Similarly, if the agent is rewarded for first time success he is encouraged to exploit the same skills rather than explore new ideas. Therefore long-term contracts that do not promise pay-offs in the short run are more suitable for exploration. Further, with long-term contracts, Manso (2007) argues that despite the risk of agent shirking it remains less expensive for agents to innovate than to shirk. To deal with shirking the principal could design multiple short-term contracts instead of one long-term contract. Fudenberg, Holmstrom and Milgrom (1990) show that in the presence of public information and re-contracting short-term contracts can be sufficient. Manso (2007) further shows that in the case of innovation not only can the agent have a different use; he also may have superior information about the project's rate of success. Consequently, optimal incentive contracts for innovation must provide the agent with long-term commitment and protection from failure. Manso's model, therefore, provides a reasonable explanation and justification for the existence of commitment, severance packages, bankruptcy codes and excessive stock option compensation.

Kole (1997) also argues that long-term contracts encourage managers to stay with the firm and prevents them from taking myopic decisions. Therefore, for those projects, which require specialized knowledge and have long gestation periods, firms offer long-term contracts with greater restrictions. To ascertain the relationship between long-term commitment and innovation we investigate the effect of new stock option grants and previously granted options holdings of CEOs. Between the newly granted options and previously granted options, newly granted options have the largest time left before maturity and should provide the greatest incentive for long-term commitment. The previously granted options are divided into unvested and vested options. Vested options are those on which the restrictions have lifted and the managers have an option to exercise them. So between vested and unvested options, unvested options have the greater time to maturity and thus provide higher long-term commitment. Chi and Johnson (2008) find that incentive effects on firm-value are significantly larger for unvested options and they increase with the length of the vesting period. Cai and Vijh (2007) treat unvested options as those with hard illiquidity restrictions and vested options as soft illiquidity restrictions. Following the extant literature we predict a positive association between options, unvested and vested options, which represent long-term commitment and innovation.

Firms may also use deferred compensation and stock grants to ensure long-term commitment. However, the incentives created by options, stock grants and deferred compensation are different and do not necessarily induce the agent to innovate. For example, Jackson and Lazear (1991), show that deferred compensation is effective only when effort and output is observable. Between stock options and stock grants, stock options have convex pay-offs and therefore create incentives for the agent to assume more risk. Stock grants on the other hand, if the agent has enough of them, have only an incremental effect. Francis and Smith (1995) examine the relationship between ownership stake and innovative activity. In their empirical analysis of 900 firms from 1987–1990 they find that overall diffused-held firms are less innovative. However, within a diffusely held firm, given the risky nature of innovation, options could create more suitable incentives for the agent.

2.3. Protection from failure

Threat of turnover is an efficient disciplining mechanism that prevents agents from shirking. The principal can fire the agent if the agent fails to produce output. The threat of turnover, however, can be detrimental to innovation because innovative projects are characterized by a high risk of failure. To examine the effect of the threat of turnover on managerial incentives we examine one aspect of the market of corporate control – golden parachutes. Golden parachutes promise the executive a handout in case the company has a change of control, which as a result provides the agent with protection in the event of a termination. The existence of golden parachutes has been a topic of constant debate because they potentially distort managers' incentives. On one hand Lambert and Larcker (1985), Knoeber (1986) and Harris (1990) find that because golden parachutes provide compensation to managers in the event of a likely termination, they align managers' interests with those of shareholders and thus help negotiate better terms in a corporate takeover. On the other hand, Daley and Subramaniam (1995), Singh and Harianto (1989) and Wade, O'Reilly and Chandratat (1990) find that golden parachutes entrench managers from disciplining by the market for corporate control.

The existing papers that have examined the relationship between the market for corporate control and innovation include studies by Atanssov (2007) and Sapra, Subramanian and Subramanian (2007). Atanssov (2007) examines the impact of the passage of anti-takeover laws on innovation. The author argues that on one hand the threat of takeovers disciplines managers and forces them to innovate and on the other hand strong external pressure makes them myopic and as a result stifles innovation. In empirical examination of Compustat firms from 1974–2000, the author finds that the passing of the Business Combination Law is associated with lesser patents and a lesser number of citations per patent. Thus, weakening of takeover pressure affects management in the sense that they follow a quiet life. Sapra, Subramanian and Subramanian (2007) on the other hand find a U-shaped relationship between takeover pressure and innovation. They measure monitoring intensity using the presence of block-holders and public pension funds and takeover pressure using state-level anti-takeover laws and innovation using patents and citations per patents.

We specifically focus on golden parachutes because they are most pertinent when examining the implications of managerial incentives. Further in addition to the market for corporate control perspective, golden parachutes can also be viewed as deferred compensation. For example, Brusa, Lee and Shook (2009) find that firms who adopt golden parachutes perform significantly better than their peers both in the short as well as the long run. The authors argue that golden parachutes are effective in mitigating agency costs associated with perquisite consumption, under-investment and shirking. As protection from failure is crucial to the innovation process we predict a positive association between golden parachutes and innovation.

3. Data and Methodology

3.1. Data

Our data comes from three different sources. The data on compensation comes from ExecuComp. ExecuComp contains information on different components of compensation for top executives in S&P 4, 5 and 600 companies. We define CEO as defined by the CEOANN field in the ExecuComp database. Our financial information comes from Compustat. For information on innovation we get the NBER patent data put together by Hall, Jaffe and Trajtenberg (2001). The patent data contains information about United States (US) patents granted between 1963 and 2006. The authors compile a dataset, which provides information on forward citations and a match with the Compustat database.

3.2. Description of variables

Our first dependent variable is the number of patents applied by a firm in a given year. Patents are not granted immediately after applying and there is generally a two to three year lag between applying and granting patents, and sometimes even more. As our sampling criteria for patent count is application year and not when patents are granted we are less likely to suffer from the truncation problems that may arise from a lag between applying and granting patents.[1] Our next dependent variable is a measure of the quality of innovation, which is calculated as forward citations received per patent. Hall, Jaffe and Trajtenberg (2001) discuss several issues that arise when using citations as a measure of quality of innovation. First, the number of citations received by a patent is truncated in time because we do not observe citations beyond 2006. Second, not only do citation intensities vary over time, they are also likely to vary over industry classes. The authors follow two approaches to address the issues associated with measuring citation intensity.

The first method is called the fixed-effects approach in which citations per patent are adjusted for citations made in the same year and same industry class. According to the fixed-effects method one has to account for the general trend in the market. In effect, all the sources of systematic variation are removed before comparing citation intensities of different patents. Another method, called the quasi-structural method, allows for the separate identification of sources of variation related to time and cohorts. The estimates for time and cohort effects are obtained using non-linear methods. The NBER patent data file includes the corrected measure of patents using weights derived from the quasi-structural method. We use citations corrected using the quasi-structural method as our measure of the quality of innovation.[2]

We examine various elements of the compensation contract because each creates a different incentive for managers (Smith and Watts 1982). Our measure of total compensation (TDC1) is obtained from the ExecuComp database. TDC1 includes salary, bonus, Black and Scholes value of options, value of restricted stock, long-term incentive plans, and value of other perks received. We examine the non-equity and equity-based components of pay separately. The non-equity based component is a sum of salary and bonus. Our measure for long-term commitment are equity-based components which are the sum of the value of options and

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[1] As part of our robustness checks we also undertake our analysis using patents corrected for truncation bias using weights derived from application-grant lag distribution as a dependent variable.
[2] Our findings are also robust to the use of the fixed-effects method used for correcting truncation bias in citations.

restricted stock and vested and unvested options which is the Black and Scholes value of vested and unvested options held by CEOs.

We use PPS as a proxy for standard principal-agent contracts. The pay for performance relation has been explored using two main methodologies in the received literature. PPS looks at dollar measures of compensation regressed against performance measured in dollars. Pay for performance elasticity represents log of compensation compared regressed against rate of return. We follow Jensen and Murphy (1990), Hall and Liebman (1998) and Murphy (1993) and examine the pay for performance relation as dollar change in CEOs' wealth with a $1,000 change in firm-value. PPS represents the CEOs' share in value-creation. We calculate the PPS using methods by Palia (2001). PPS, is calculated as follows:

$$PPS = \{[(SharesOwnd/CSO) + (Options/CSO) \times Delta] \times 100\}, \quad (1)$$

Where, sharesowned is the number of shares granted to the CEO, CSO stands for common shares outstanding, options is the number of stock options granted to the CEO and delta represents the change in the value of options held with a unit change in stock price.

Our measure for protection from failure is golden parachutes. Data on golden parachutes comes from the Investor Responsibility and Research Institute (IRRC). Golden parachutes are a dummy variable coded as one if the CEO has a golden parachute clause in his compensation contract and zero otherwise; 59% of patenting firms had a golden parachute arrangement with their CEOs.

Various papers have examined the factors that induce innovation in a firm. Bergemann and Hege (2005) develop a theoretical model that investigates the financing models for firms' projects that have high uncertainty. As the uncertainty increases, the authors find that relationship lending becomes restricted and arm's length financing, looser. Atanassov, Nanda and Seru (2005) empirically investigate financing arrangements of publicly traded US firms from 1974–2000. The authors find that firms that rely more on arm's length financing are more innovative. The authors argue that between debt, equity and arm's length financing, choice of arm's length financing provides greater discretion to managers resulting in more innovation. We therefore include public debt dummy, which is our proxy for arm's length financing. Public debt dummy is a variable coded as one if the firm raised funds in the public debt market and zero otherwise.

Seru (2007) investigates the impact of conglomerates on innovation. He argues that firms with more than one segment tend to produce a lesser amount of, and less novel, innovation. The author further argues that the dark side of internal capital market dominates and the better performing segments end up reallocating resources to poorly performing segments. However, the author also finds that conglomerates that do produce more novel innovations have greater market valuations. Following Seru (2007) we also include the segment dummy, which is a dummy variable equal to one if a firm has more than one business segment and zero otherwise as a measure of conglomeration in our estimation. The segment data comes from Compustat segment data tapes.

In addition to the above mentioned control variables, we control for firm size, firm age, industry concentration and firms' investment in R&D, the proportion of assets financed with equity, Fama-French industry, state and year fixed- effects. For firm size we use a logarithm of sales. Industry concentration is calculated using the Herfindahl index of assets calculated at a two-digit SIC code level and R&D expenses are standardized by total assets. For firms that do not report R&D expenses we treat this as zero and include a dummy variable called R&D missing.

3.3. Methodology

Hausman, Hall and Grililiches (1984) develop generalizations of poisson models to deal with patent data, which comes in counts of non-negative numbers. Poisson models, however, assume that the mean of the distribution is equal to the variance. When the standard deviation is much larger than the mean, the data is said to be over-dispersed and negative binomial models provide a more appropriate fit. In our dataset the mean of count of patents is 38 whereas the standard deviation is 170. Further, the goodness-of-fit chi-squared statistic poisson regression rejects the null hypothesis that the dependent variable is poisson distributed at the 1% level. Whenever the dependent variable is count data we estimate our model using negative binomial regression. When the dependent variable is a continuous variable such as log of patents or log of citations we use Ordinary Least Squares (OLS).

4. Results

4.1. Summary statistics

The descriptive statistics for our sample are presented in Table 1. The firms in our sample filed at least one patent during the sample period from 1992–2006. Firms in the 99th percentile of patents filed in our sample made more than 300 patent applications and included well-known companies such as: Microsoft, 3M, Micron Technology and Sun Microsystems. IBM is the firm that made the maximum number (4,340) of patent applications in 1999. During the whole sample period IBM made as many as 34,360 patent applications. The average number of patent applications in our sample of firms during the whole period is 38; however in 50% of our firm-year observations the number of patents filed is less than five and in 23% of our firm-year observations the number of patents filed was one. The huge variation in our sample is indicative of over-dispersion. Our measure for quality of innovation is citations which has been corrected for truncation bias with the weights, estimated using the quasi-structural method, provided in the NBER patent data file. The firms in our sample received 617 citations per patent during the whole sample period.

The average total compensation received by the CEOs during the sample period is $53 million and options constitute $36 million. The average salary and bonus is $13 million. The average of vested and unvested options held by the CEOs during the whole period is $110 million and $50 million, which is much larger than the average compensation received by CEOs and is consistent with our argument that elements of CEO pay arrangement that offer a long-term commitment, are more typical for innovating firms. The PPS for the firms in our sample is 0.25, which implies that CEOs' compensation increases by $25 for every $1,000 dollar increase in firm-value.

(Insert Table 1 around here.)

Table 1 also shows descriptive statistics of our control variables; 66% of the firms in our sample are diversified. The average equity-to-assets ratio is 49% and 9% of firms made a corporate bond issuance (public debt). This is consistent with the arguments of Bergemann and Hege (2005) that innovating firms prefer arm's length financing. The patenting firms spent 6% of their assets on R&D. Finally, on average these are large firms with sales in the range of $40 billion and an average age of 40 years.

In Table 2 we present the correlation matrix of our variables of interest. Patents and citations to patents have a positive correlation with log of total compensation (TDC1), log of options, log of salary and bonus, log of vested and unvested options, and log of unvested stock. The patents, however, have a negative correlation with PPS. Both segment dummy and public debt have a positive correlation with patents and debt-equity ratio has a negative correlation. Finally R&D intensity is also positively correlated to patents. The correlation between our measures of innovation and quality of innovation and various measures of compensation are consistent with our hypothesis. Further, both R&D and public debt have a positive correlation with citations.

(Insert Table 2 around here.)

We also have growth in capital expenditures as an alternative measure for investment. Unlike patents and citations to patents, total compensation, and non-equity based compensation are negatively correlated with growth in capital expenditures, options have no correlation with capital expenditures growth; vested and unvested options, and PPS have a positive correlation with capital expenditures growth. If we consider patents as an investment opportunity with high-risk and growth in capital expenditure as an investment opportunity with low-risk then the opposite relationship between our measures of compensation and the two different types of investment opportunities suggests that incentives created by different elements of compensation contracts may have an effect on the investment behavior of managers.

Not all the firms in the ExecuComp universe of firms apply for patents. Further, firms do not apply for patents every year; however, they do more or less invest in capital expenditures. In this section we explore whether firms applying for patents are different from those that do not. Therefore, we create a dummy variable called patent dummy which equals one if the firm applied for a patent in a given year and zero otherwise. Table 3 presents the difference in means of various compensation contracts and its elements and firm-level characteristics of patenting and non-patenting firms.

(Insert Table 3 around here.)

The first item in the table is total compensation (TDC1) and it indicates that CEOs in firms that patent receive much larger compensation than CEOs in non-patenting firms and the difference is both statistically and economically significant. The difference in compensation is consistent across both equity and non-equity based components of compensation, however, the difference in the vested options is the largest. CEOs in patenting firms hold $110 million worth of vested and unvested options as opposed to CEOs in non-patenting firms who hold half that amount ($60 million). Finally, PPS for CEOs in patenting firms ($25) is only two-thirds of CEOs in non-patenting firms ($33).

Besides there being differences in compensation contracts of CEOs in patenting and non-patenting firms, patenting firms invest 6% of their assets in R&D as opposed to the 2% investment made by non-patenting firms. The non-patenting firms also have higher leverage ratios (22%) and 4% of non-patenting firms have arm's length financing as opposed to 9% of patenting firms. The non-patenting firms are relatively less diversified (57%) than the patenting firms (66%). Patenting firms are also significantly large in size, which is contrary to the notion of smaller firms being more innovative (Holmstrom, 1989).

Significant economic and statistically significant differences in both compensation and firm-level characteristics of patenting and non-patenting firms warrant further examination of the relationship between managerial incentives and investment behavior particularly with respect to innovation. In the next section we proceed to examine the relationship between compensation and innovation in a multivariate setting.

4.2. R&D intensity

Before we formally examine the relationship between compensation and patent applications made by firms, we examine the relationship between compensation and R&D. Cohen and Levinthal (1989) argue that firms' investment in R&D not only helps to generate new knowledge, it also helps to assimilate and exploit existing knowledge. The authors treat R&D spending as a measure of knowledge generation and accumulation. Hausman, Hall and Griliches (1984), however, focus on the relationship between R&D spending and patent applications and find that R&D expenditures positively correlate with patent applications. However, they also find a negative trend in firms' propensity to patent and they attribute this to the declining effectiveness of R&D productivity.

In this section we explore the relationship between compensation and R&D expense. Our dependent variable is R&D expense divided by total assets. The results for this estimation are presented in Table 4. Model 1 represents the log of total compensation (TDC1). Our control variables include a dummy variable called segment dummy, for single segment firms, a dummy variable called public debt dummy, for firms that issued public debt, net fixed assets standardized by assets, firm's equity to assets ratio, log of firm sales, Herfindahl index of total assets calculated by a two-digit SIC code level, a squared term for Herfindahl index of total assets, and log of firm age. In addition we include fixed-effects for year, state and Fama French 49 industry classifications. The equation is estimated using OLS. The results indicate that a unit change in the CEO's compensation leads to an increase of 0.5% in the R&D expense of the firm suggesting that the relationship between total compensation and R&D is both economically and statistically significant.

(Insert Table 4 around here.)

Models 2–6 look at PPS, log of options, log of non-equity based compensation, which is a sum of salary and bonus received, and log of vested and unvested options received. PPS is positively related to R&D expense (1.1%). Both newly granted options (0.6%) and unvested options (0.1%) are also positively related to R&D. Segment dummy has a negative relationship with R&D. Public debt has a positive relationship with R&D, which is consistent with Bergemann and Hege (2005) and Atassanov, Nanda and Seru (2005). Firm size (sales) and market competition (Herfindahl index of assets) have a positive relationship with R&D.

Our findings in this section suggest that after controlling various firm-level characteristics, compensation has a positive affect on a firm's R&D. Although all components of compensation have a positive effect on R&D expense, the options exhibit a larger coefficient than the non-equity based components. However, it is unclear from the literature how efficiently investment in R&D expense translates into actual innovation. Further, R&D expense can also be considered as an input rather than an output variable. Just to highlight the difference between R&D and patents and citation to patents we segregate the data into above and below median compensation received in the form of options for a given level of R&D. Table 5 shows the results for these statistics.

(Insert Table 5 around here.)

On average, for a given range of R&D, high options paying firms applied for more patents and received much higher citations. This difference in patenting behavior in different compensation groups at the same level of R&D suggests that not only does compensation affect allocation of resources to R&D but more importantly it affects how the R&D resources are utilized. As R&D can be considered a pre-requisite to patenting, we treat it as an input variable and focus on the productivity of R&D in the form of patents and citations to patents.

4.3. Patents

Patents are a useful proxy for a firm's innovativeness because they can convey information about a firm's accumulation of old, and generation of new, knowledge. Patents are an indirect measure for capturing innovation. The advantages of using patents as a measure are that they are quantifiable and thus measurable. The disadvantages are that not all innovations are patented and further patents may differ in their economic impact. Despite being an imperfect measure, patents have been widely used to capture innovation at firm-level. Caballero and Jaffe (1993) utilize patents and citations to patents as a proxy for new ideas and knowledge spillovers. Hall, Jaffe and Trajtenberg (2005) find that both R&D intensity and patents have a significant impact on firm-value. The authors further document an increase in market value of a firm by 3% with each additional citation. In this section we examine the relationship between compensation contracts of CEOs and patent applications made by firms. The dependent variable is the number of patents applied for by a firm in a given year. The results for this estimation are presented in Table 6.

(Insert Table 6 around here.)

Model 1 of Table 6 looks at the relationship between log of total compensation (TDC1) and count of patents. The results indicate that the expected increase in log of count of patents with a unit change in log of total compensation is 9%. The test statistic alpha is the logarithm of the over-dispersion coefficient. If the alpha coefficient is zero, then poisson regression provides a better fit. The associated chi-squared likelihood ratio test rejects the null hypothesis that alpha is zero. In Model 1, for example, the value of alpha coefficient is 1.235 indicating that negative binomial is appropriate. Model 2 looks at PPS, and the coefficient on PPS is negative and statistically significant. A unit change in the log of newly granted options leads to an expected increase of 12.6% in the logarithm of count of patents and a unit change in log of previously granted unvested and vested options leads to an expected increase of 5.2% and 3.3% in the log of count of patents. A unit change in the log of non-equity based components of compensation, which primarily includes salary and bonus, leads to an expected increase of 9.6% in the log of count of patents.

The relationships between count of patents and other control variables are also consistent with received literature. Diversification has a negative effect although and an insignificant relationship with patents, which is consistent with the findings of Seru (2007). Public debt has a positive effect on the expected change in the logarithm of count of patents, which is consistent with Bergemann and Hege (2001) and Atassanov, Nanda and Seru (2005). Further, firm size has a positive, and firm age a negative, effect on patents. R&D has a positive effect on the count of patents (Hausman, Hall and Grililiches 1984).

The coefficients estimated from count of patents regression with poisson as the underlying distribution (negative binomial if the data is over-dispersed) are comparable to OLS with log of count of patents as the dependent variable. The benefit of using poisson formulation is that it gives more weight to the largest observations and accounts for large numbers of zeros in the patent data. As a result, the coefficients obtained from a poisson formulation are found to have more influence on the dependent variable, in our case count of patents, as opposed to the ones obtained through OLS. The problem with using poisson is that it imposes a restriction of a distribution on the data whose mean is equal to the variance. The alternative to poisson formulation if the data is over-dispersed (i.e. variance is much larger than the mean) is negative binomial formulation, which provides estimates that are much closer to those obtained from OLS. The problem with negative binomial is that it imposes gamma distribution on the multiplicative disturbance, which if specified poorly leads to inconsistent estimates (Griliches 1981). Therefore we estimate our equation using OLS and with the logarithm of count of patents as our dependent variable, results for which are presented in Table 7.

(Insert Table7 around here.)

Model 1 of Table 7 looks at the log of total compensation. Compared to the negative binomial regression results, the effect of the change in compensation on the log of count of patents is slightly smaller. A unit change in total compensation leads to a 7.5% increase in the log of count of patents. Similar to the negative binomial regression results, PPS has a negative though insignificant relationship with the log of count of patents. Further, a unit change in log of newly granted options leads to a 9.8% increase, log of non- equity compensation leads to a 7.9% increase and log of previously granted unvested options leads to a 3.7% increase in the log of count of patents. The results of OLS estimates are comparable to those obtained from the negative binomial formulation. For the rest of the analysis, to facilitate ease of interpretation, we proceed with OLS.[3]

Our findings in this section suggest that after controlling for various firm-level characteristics and factors that have been shown in the received literature to have an effect on innovation, managerial incentives do matter when it comes to patent applications. Consistent with our hypothesis, newly granted options, previously granted unvested and vested options that promise the executive a long-term commitment also have a positive relationship with patents. Further PPS has no relationship with patent applications. PPS represents the CEO's share in improvements to firm-value and is proportional to the CEO's fractional holdings in the firm. Although options, salary and bonus individually have a positive effect on patents when we look at them from the perspective of their relation with firm performance, the effect is negative which indicates that investments that traditionally affect firm-value are different from investments in patent projects. The distinction between traditional investment and innovative investments further highlights the need for suitable managerial incentives that motivate managers to exert effort in one over the other. The findings in this section are consistent with the theories, which suggest that standard principal-agent contracts that promote managers to invest in traditional positive net present value (NPV) projects do not work for projects that require managers to innovate.

4.4. Citations

Hall, Jaffe and Trajtenberg (2001) operate under the premise that patents are a proxy for inventive output; patents citations, on the other hand represent flow of knowledge. The authors

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[3] Pakes and Griliches (1980) argue that one of the benefits of using patents as a measure of innovation is that they can help distinguish between current and past research investments. They find presence of distributional lag between patent applications and R&D expenditures. They further find that even with five years of lagged R&D expenditures in the estimation equation, truncation problems may persist. The authors compute a mean lag of 1.6 years for their sample of firms. We re-estimate the relationship between compensation and patent applications using three-year lagged values of independent variables and our results remain unchanged.

further state: "in using citations received by a patent as an indication of that patent's importance, impact or even economic value, the citations that are identified by parties other than the citing inventor may well convey valuable information about the size of the technological 'footprint' of the cited patent." We therefore use citations to patents as a measure for quality of innovation. As mentioned before, citations to patents suffer from truncation problems. To address the truncation issues we use corrected measures of patent citations using weights provided by Hall, Jaffe and Trajtenberg (2001) in the dataset available on NBER. The results for citations are presented in Table 8.

(Insert Table 8 around here.)

Model 1 of Table 8 presents OLS regression results of log of total compensation (TDC1) on log of citations. The results indicate that a unit change in total compensation leads to a 10.9% increase in the log of citations. PPS, has no relationship with log of citations and, a unit change in log of newly granted options, non-equity compensation, previously granted unvested and vested options leads to a 16.5%, 10.6%, 6.7% and 4% increase in the logarithm of citations.[4]

Our findings in this section suggest that incentives created by compensation contracts not only matter for innovation but also matter for the quality of innovation. Further, unvested and vested options matter more for the quality of innovation and contemporaneous grants matter less. Overall our findings in this section for vested and unvested options are consistent with our hypothesis.

4.5. Golden parachutes

The use of golden parachutes has risen significantly over time; however, their value implications are unclear. On one hand, golden parachutes align interests of managers with shareholders by insulating the managers from the takeover market; on the other hand, they could potentially lead to the transfer of wealth from shareholders to managers. The purpose of providing golden

[4] We re-estimate the relationship between compensation and citations using log of citations corrected for year and industry and find consistent results. We also look at the relationship between compensation and citations using three year lagged values of independent variables and find that our results do not change.
In unreported results we also find that a unit increase in the fraction of options in the total compensation mix of the CEO has a positive effect, and a unit increase in salary and bonus has a negative effect on both innovation and traditional investments.

parachutes is to protect managers in the case of termination. Even though the presence of golden parachutes can lead to managerial entrenchment, they also create room for managers to pursue projects that might have a high rate of failure. Therefore we use the provision of golden parachutes in a firm as a proxy for protection from failure and explore their effect on innovation. We include G-Index as a measure of corporate governance in our estimation equation.[5]

(Insert Table 9 round here.)

Table 9 presents regression results with golden parachutes as our main independent variable. Model 1 examines the relationship between golden parachutes and patents in an OLS setting. The dependent variable is log of count of patents. A unit change in golden parachutes leads to a 9% increase in log of count of patents. Models 2 and 3 examine the relationship between golden parachutes and citations and R&D. A unit change in golden parachutes leads to a 14.1% increase in log of citations and golden parachutes are negatively related to R&D.

Our findings in this section support our hypothesis that golden parachutes may be an effective tool for protecting managers against failure and are thus useful for promoting innovation. From the market for corporate control perspective, a positive relationship between golden parachutes and innovation implies that when managers do not face the threat of termination they may be motivated to pursue projects that may be high-risk but increase firm-value in the long run. Although protection from the threat of turnover may potentially entrench managers, it creates incentives for managers to invest in innovation. In the long run if the firm remains competitive due to new innovative products and processes, it should also face less takeover pressure. These findings provide a possible explanation and justification for the persistent use of golden parachutes by firms.

4.6. Self-selection

In analyzing the question of relationship between innovation and incentives we are likely to run into self-selection problems. Bound, Griliches, Hall and Jaffee (1982) examine the relationship

[5] Gompers, Ishii and Metrick (2003) created an index of shareholder rights of 1,500 US corporations on a scale of 1 to 24. Companies in the first decile that had a governance score less than 5 were termed as part of the democratic portfolio and firms in the last decile that had a governance score greater 14 were termed as part of the dictatorship portfolio

between R&D and patents. The authors note that a fraction of firms in the Compustat database do not report R&D expenditure and further that firms who do report R&D expense are large in size. As propensity to report R&D expenditure is associated with firm-level characteristics, it could lead to biased estimates. Similarly for our analysis, as we noted in Table 3, there are economically significant differences between the firms that file patent applications and firms that do not. In addition it is also possible that compensation contracts that we do observe between CEOs and patenting firms are a result of a match between a CEO's skills and risk preference and a firm's requirement for those skills. Therefore, it becomes important to control for biases that may arise from any self-selection of compensation contracts of firms that innovate.

To address the self-selection problem in our sample we implem ent the Heckman's two-step procedure. In the first stage we predict the probability of a firm filing for a patent. We take the entire ExecuComp universe and create a dummy variable that equals one if a firm applied for a patent and zero otherwise. Our independent and control variables in the first stage include book leverage which is a ratio of total debt and total assets; R&D intensity, which is the ratio of R&D expense and total assets; R&D missing dummy which is a dummy variable that equals one if the firm has incurred R&D expense and zero otherwise; log age, which is a log of the firm's age; log sales, which is a log of the firm's net sales; HHI-TA which is the Herfindahl index of total assets which is a measure of industry concentration at a two-digit SIC code level. The results for this estimation are reported in Table 10.

(Insert Table 10 around here.)

Model 1 of Table 10, Panel A, presents the results from the second stage of the two-step Heckman procedure and looks at the relationship between the log of total compensation and log of count of patents. The relationship between log of total com pensation and log of count of patents is positive and significant and is consistent with our findings in previous sections. The relationships between log of count of patents and our control variables are also consistent with our findings in previous sections and the received literature. In addition, the inverse mills ratio (lambda reported in panel A), which captures the private information that distinguishes patenting firms from non-patenting firms, is negative and statistically signi ficant, indicating the presence of self-selection bias. Panel B, pr esents the results from the first stage of the two-step Heckman procedure. R&D intensity, firm age and firm size have a positive effect on the probability that a firm patents. On the other hand, market competition has a negative effect on the probability to patent.

Model 2 of Table 10 examines the relationship between PPS and log of count of patents. Consistent with our OLS and negative binomial regression results the relationship between PPS and log of count of patents is negative. A unit increase in log of newly granted options leads to an increase of 9.9% in log of count of patents; a unit increase in logarithm of non-equity compensation leads to an increase of 8.4% in logarithm of count of patents; a unit increase in log of previously granted unvested and vested options leads to an increase of 3.7% and 1.9% in log of count of patents; and finally, a unit increase in golden parachutes is unrelated to log of count of patents.

4.7. Sensitivity of options

In this section we examine the sensitivity of options and innovation and specifically focus on the sensitivity of options to price (delta) and volatility (vega) of the underlying asset. Option deltas represent how sensitive the manager's pay is to stock price, and increases in option deltas have been found to induce risk-aversion in managers, whereas increasing option vegas arguably encourages risk-taking behavior. Coles, Daniel and Naveen (2006) provide empirical evidence of a relation between the structure of managerial compensation and investment policy, debt policy, and firm-risk. They find that higher sensitivity of CEO wealth to stock volatility (vega) after controlling for levels of risk-aversion (delta) motivates managers to implement riskier investment and financing options. Simultaneously they find that riskier policy choices lead to a compensation structure with a higher vega and lower delta.

We follow Core and Guay (2002) and calculate values of deltas and vegas for CEOs' wealth in options. The data for option grants is available in the ExecuComp database. Stock volatility is a standard deviation of returns calculated over 60 months. Dividend yield is the company's average dividend yield over the past three years. The risk-free rate is the seven-year Treasury note rate. We obtain all this information from ExecuComp. We obtain the year-end stock price data from Centre for Research and Security Prices (CRSP). For newly granted options time to maturity is calculated as the difference between the exercise date and the respective fiscal year. For previously granted unvested options the time to maturity is assumed to be one year less than the time to maturity of new option grants. And for previously granted vested options the time to maturity is three years less than that for unvested options. The exercise price of previously granted options is calculated as the year end stock price minus the average realizable profit; where average realizable profit is the extent to which the option is in the money (value of grants/number of grants). Option vega is therefore the sum of dollar vega for newly granted and previously granted options. Similarly, option delta is the sum of dollar deltas previously granted and newly granted options. The results for this estimation are reported in Table 11. We take logs of delta and vega to obtain a normal distribution.

(Insert Table 11 around here.)

Columns 1–4 of Table 11 show results for patents, citations and R&D. Consistent with the findings of Coles, Daniel and Naveen (2006) we find that an increase in option vega is positively associated with patents applications, citations to patents and R&D. As innovation is inherently risky, a positive relationship between sensitivity of options and innovation informs us of how compensation contracts influence the risk-taking behavior of managers. Columns 4–6 examine the effect of vega-to-delta ratio and innovation.

The delta of an option captures the change in wealth with a unit change in price. Therefore delta primarily captures the sensitivity of CEOs' pay to firm-value and an increasing delta makes managers' pay more sensitive to performance and therefore might induce risk-aversion, whereas vega captures the change in wealth with a unit change in volatility, and induces risk-taking. As options induce both incentive effects at the same time, to evaluate the effect of vega for a given level of delta we take the ratio of vega to delta of the CEOs' option portfolio. Rogers (2008) argues that vega-to-delta ratio provides a less inaccurate estimate of risk-taking incentives because it allows one to specify a model for measuring risk-taking incentives created by option vega and value-increasing incentives created by option delta. Besides, option delta and vega are highly correlated with each other and having them in the same regression model can lead to multi-collinearity. The results indicate that vega-to-delta ratio has a positive and significant effect on log of patents and citations to patents, however it is unrelated to R&D. A positive relationship between vega-to-delta ratio and innovation confirms that when managers are provided with incentives to take risks, innovation increases.

4.8. Capital expenditures growth

To examine the relationship between CEO compensation and traditional net present value projects we look at growth in capital expenditures. Kang, Kumar and Lee (2006) examine the relationship between managerial incentives and investment spending and find that incentives that align managers' interests with those of shareholders have a positive impact on firms' long-term capital investments. Specifically, the authors investigate the relationship between executive compensation, which is the sum of stock options, restricted stock and stock appreciation rights, and long-term capital investments, which is the sum of capital expenditures, R&D expenditures, and acquisitions, deflated by beginning-of-the-year property, plant, and equipment and capitalized R&D. The results for this estimation are presented in Table 12.

(Insert Table 12 around here.)

Model 1 of Table 12 presents OLS regression results of log of total compensation (TDC1) on capital expenditures growth. Consistent with the findings of Kang, Kumar and Lee (2006) we find that total compensation, non-equity compensation, newly granted options and previously granted unvested and vested options have a positive relationship with capital expenditures growth. Unlike patents and citations to patents, PPS has a positive relationship with increases in capital expenditures growth. The results indicate that a unit increase in PPS leads to a 10% increase in the growth of capital expenditures when the number of patents filed is zero.

It is worthwhile noting that PPS is unrelated to patents and citations to patents and it is positively related to capital expenditures growth in patenting firms. Consistent with the arguments made in the previous section, the findings indicate that compensation incentives do affect managers' investment behavior. Further, standard-principal agent contracts that work well for traditional NPV projects may not necessarily work for innovative projects.

4.9. Asymmetric benchmarking

So far the analysis in this paper has centered on how specific features of compensation contracts that are likely to entrench managers are better suited to innovation. In particular, we have focused on long-term commitment, protection from failure and risk-taking behavior of managers.

In this section we focus on asymmetric benchmarking of pay to good and bad firm performance and innovation.

Asymmetric benchmarking of pay means that managers are rewarded for good luck but they are not penalized as much for bad luck. Bertrand and Mullainathan (2001) and Garvey and Milbourn (2006) argue that asymmetric benchmarking of pay represents control over the pay-setting process or skimming.[6] Others argue that asymmetric benchmarking of pay is indicative of retention policies adopted by firms (Oyer, 2004; Bizjak, Lemmon and Naveen, 2008; Francis et al. 2009). The retention explanation suggests that asymmetric benchmarking of pay can result when executives have outside options.

To examine the effect of asymmetric benchmarking of pay on firm-value we calculate the presence of asymmetric benchmarking for each firm. Following Garvey and Milbourn (2006) we first calculate values of luck and skill. Luck is the predicted value derived from the regression of industry returns on individual firm returns, and skill is the residual. Luckdown is a dummy variable that equals one if values of luck are negative. Badluck is defined as the interaction between luck and luckdown. Values for luck, skill and bad luck are obtained by regressing them on total compensation for each firm separately. A positive relationship between compensation and luck and skill means that managers get paid for both luck and skill. A negative coefficient on badluck indicates that managers receive less luck-based pay when luck is bad, which means they are protected from bad luck. We then create a dummy variable called asymmetric benchmarking which is equal to one if the coefficient on the badluck variable is negative and significant. This method provides us with one measure of asymmetric benchmarking for each firm over the whole sample period. The analysis in this section represents asymmetric benchmarking for the entire top management team including the CEO. We examine the cross-sectional relationship between asymmetric benchmarking and innovation. The results for this estimation are presented in Table 13.

(Insert Table 13 around here.)

[6] Bertrand and Mullainathan (2001) define skimming as CEOs gaining control over the pay-setting process in the presence of weak boards and oversights by shareholders, especially in times of good performance.

Models 1–3 of Table 13 show results for the relationship between asymmetric benchmarking and log of patents, citations to patents and R&D. The relationship between asymmetric benchmarking, which is the dummy variable that a firm provides protection to managers from bad luck and rewards them for good luck is positive and significant. A positive relationship between asymmetric benchmarking and innovation could, based on the arguments of Bertrand and Mullainathan (2001) and Garvey and Milbourn (2006), mean that managers have control over the pay-setting process. Control over the pay-setting process is suggestive of a CEO's prowess in the firm. On the other hand, a positive relationship between asymmetric benchmarking and innovation based on the arguments made by Oyer, 2004, Bizjak, Lemmon and Naveen, 2008, and Francis, Hasan and Sharma (2010), would mean that firms are willing to pay a premium for retaining human capital. Both explanations point to one key notion, that policies possibly entrench managers or protect them from failure and have a positive effect on innovation.

4.10. Exogenous Shocks – Failure of Phase III Clinical Trials

Pharmaceutical companies spend millions of dollars in drug development and research. The process of drug development begins with investigation biological or chemical compounds in a lab setting, followed by animal trials and then three stages of clinical trials on humans. The phase III of clinical trials on humans involves a large sample of population and it is during this stage that the safety and efficacy of a drug is tested. The phase III clinical trials are considered to be a large investment for pharmaceutical companies. The per person costs for phase III clinical trial subjects was estimated at $26000 in a survey report by published by Cutting Edge Information.[7]

Girotra, Terwiesch, and Ulrich (2007) show that the value of an R&D project to firm can be estimated as the drop in stock price subsequent to the announcement of a Phase III Clinical Trial Failure. The authors show that firms lose approximately $405 million within week of announcement of a Phase III Clinical Trial Failure.

In this section, we treat announcement of a Phase III Clinical Trial Failure as a significant setback for firm's research and development activities. From the perspective of incentives, if the CEO's compensation schemes are adjusted favorably to absorb such negative shocks, then we

[7] http://www.lifesciencesworld.com/news/view/11080

can argue that incentive contracts that are tolerant towards failure are more suitable for innovation.

The data on Phase III Clinical Trial Failure announcements comes from a Factiva search of press releases made by pharmaceutical companies. In our sample of 99 pharmaceutical firms (approximately 500 firm-year observations), 27 firms announced a total of 55 failures of their Phase III Clinical trials during the whole sample period. Pfizer announced failures of 6 phase III clinical trials followed by Genetech (5), Bristol-Myers and Squibb (5) and Johnson and Johnson (4). During the last 15 years these firms completed approximately 1300 clinical trials.[8] However, in most cases results of the study were not published or released.

Within the subset of pharmaceutical firms there were significant differences in compensation contracts of firms that announced failure of their clinical trials and those that did not. For example, in unreported T-tests between the two groups we found that firms that announced failure of their clinical trials paid twice as much in form of options and vested options ($7500 thousand; $33000 thousand) as opposed to firms that did not announce (($3200 thousand; $14000 thousand). Therefore in a subset of pharmaceutical firms in our dataset we examine the impact of Phase III Clinical Trial Failures on CEO's compensation schemes. The results for the estimation are reported in Table 14.

(Insert Table 14 around here.)

Model 1 of Table 14 shows the effect of a Phase III Clinical Trial Failure on the probability of having a golden parachute arrangement. As the results show, Phase III Clinical Trial Failure has a positive effect on probability of probability of having a golden parachute.

Firms use various mechanisms such as backdoor repricing, resetting the terms of options, option backdating, and issuing fresh grants as ways through which underwater options can be made valuable to the executives (Chance, Kumar, and Todd (2000); Brenner, Sundaram and Yermack (2000); Hall (1999); Hall and Knox (2004); and Heron and Lie (2007)). For example in February 1993, Synergen, which was in research and development stage, announced the results of Phase III clinical trials of ANTRIL, a drug for sepsis. Subsequent to the announcement the

[8] Data for clinical trials is available on clinicaltrials.gov and data for results on clinical trials is available at clinicalstudyresults.com.

stock price of the firm dropped significantly. In May 1993, the company cancelled the February 1993 annual option grant and issued new grants at the market value. Model 2 shows the relationship between Phase III Clinical Trial Failure and repricing. As the results indicate, announcement of a Phase III Clinical Trial Failure has a positive effect on the probability of a repricing decision.

Model III looks at the relationship between Phase III Clinical Trial Failure and multiple grants received by the CEOs. As an alternative to repricing firms can also issue fresh grants to the managers, in addition to their annual grants as a way to restore the reduction in wealth as a result of a declining stock prices. Some pharmaceutical companies such as Bristol-Myers and Squibb, Eli Lilly, Schering-Plough expressly prohibit repricing of stock options. Instead these companies prefer to issue performance-based contracts in form of restricted grants etc. Therefore we test whether Phase III Clinical Trial Failures impact issuance of extra grants to the executives in order to maintain their pay for performance incentives. Specifically we regress the log of number of securities granted during the year on the dummy variable Phase III Clinical Trial Failure. We find that Phase III Clinical Trial Failure has a positive effect on the number of extra securities received by the CEO during the year. Roughly translated, CEOs receive approximately 80000 extra options for each failed Phase III Clinical Trial announcement.

Since failure of Phase III Clinical Trial is a significant setback for a pharmaceutical company, evidence that managerial incentives are adjusted to absorb such shocks lends support to our initial claim that incentives promote innovation. Or more specifically, compensation contracts that are tolerant to failure encourage managers to innovate.

4.11. Sarbanes Oxley

The Sarbanes Oxley Act was passed in 2002 and was intended to improve the internal and external corporate governance environment of firms. For example, the Act increased the role of independent directors in corporate governance by making them liable in cases of corporate misdeeds. The Act also mandated the CEO and the chief financial officer (CFO) to certify financial statements and imposed criminal and financial liabilities in the case of violations. Section 404 requires firms to disclose their internal control mechanisms.

Several authors have since criticized the Act for intended implications on managers' risk-taking behavior. For example Shadab (2008) argues that as the Act increases the monitoring of management by outsiders it prevented them from providing greatest value to investors and consumers and therefore stifles innovation. Innovation, as the author argues, is a decentralized activity that requires strategic internal governance that gives managers the flexibility to undertake long-term projects and not be myopic in their investment decisions. Bargeron, Lehn and Zutter (2008) compare US based firms to United Kingdom (UK) based firms before and after the passage of the Sarbanes Oxley Act. The authors find a decline in various firm-level characteristics such as: board structure, firm-size, R&D and initial public offerings (IPOs) for US based firms and they argue that the Sarbanes Oxley Act is negatively associated with risk-taking behavior of US companies. Similarly Cohen, Dey and Lys (2004) find a decrease in R&D expenditures and capital expenditures in US firms, before and after the Act. We therefore examine whether the introduction of the Sarbanes Oxley Act has had an impact on managerial incentives and as a result on innovation. The results for this estimation are presented in Table 15.

(Insert Table 15 around here.)

Table 15 examines the effect of the Sarbanes Oxley Act which is a dummy variable which equals one after 2002 and zero otherwise. The Act has a negative and significant relationship with innovation. The negative relationship between the Sarbanes Oxley Act and innovation is consistent with the arguments made by Shadab (2008), and the empirical findings of Bargeron, Lehn and Zutter (2008) and Cohen, Dey and Lys (2004) that corporate governance structures that intensify the monitoring of managers can be detrimental to innovation. The negative impact of the Sarbanes Oxley Act is more pronounced for the quality of innovation rather than innovation itself. These findings support our initial claim that policies that provide managers with the flexibility of pursuing long-term projects and venture into uncharted territory are more suitable for innovation.

We also present results for interaction between compensation and Sarbanes Oxley Act dummy. Cohen, Dey and Lys (2004) show that pay for performance sensitivity of CEO's compensation decreased after the passage of Sarbanes Oxley Act. Model 2 of Table 15 presents results for the interaction between Sarbox dummy and Log options, Model 3 shows the interaction between Sarbox and option delta and Model 4 shows results for Sarbox and option vega. The coefficient on Sarbox dummy is negative in most cases whereas the coefficient on the compensation variables themselves is positive. The interaction between Sarbox and compensation is negative and significant in case of option delta and negative and insignificant for log options and option vega. Because passage of Sarbanes Oxley Act is associated with increase in the monitoring intensity of managers, a corresponding increase in option delta in the post Sarbox environment may have induced risk aversion in managers having a negative impact on innovation.

5. Conclusion

In this paper we examine the relationship between compensation contracts and innovation. Innovative activities are characterized by high levels of risk and probability of failure. The nature of innovative activities is such that the standard principal-agent contracts fail to provide appropriate incentives. Theory suggests that the compensation contracts apt for innovation should have two important features: they should provide a long-term commitment to the agent and they should provide protection from failure.

We find that compensation contracts do effect innovation measured by patents applied for and citations to patents. When we look closely, we find that options have a positive and significant effect on our measures of innovation. Both unvested and vested options provide long-term incentives for managers in varying degrees. We find that they have a positive and significant effect on innovation. We also find that PPS sensitivity has no relationship with innovation. Finally golden parachutes, our measure for protection from failure, have a positive effect on innovation.

Our results are robust to self-selection biases that might exist between patenting and non-patenting firms. Further, we show that managerial incentive contracts are crucial to innovation as they are both statistically and economically significant even after controlling for a host of firm-level factors such as: capital structure, governance and conglomeration and other variables that are known to affect innovation.

When we examine the relationship between sensitivity of options and innovation we find option vegas, which represent risk-taking by managers, have a positive impact on patents and citations to patents. In addition we find that the vega-to-delta ratio, which captures the relationship between risk-taking incentives created by option deltas and value-increasing incentives created by option deltas have a positive relationship with patents and citations to patents and is unrelated to R&D.

When we examine the relationship of the compensation contracts with growth in capital expenditures we find that, unlike patents and citations to patents, PPS has a positive effect on capital expenditures growth for non-patenting firms. Though both unvested and vested options have a positive relationship with capital expenditures growth, golden parachutes have no relationship. We provide evidence consistent with the theories that the nature of innovation is such that it makes traditional compensation contracts ineffective.

We also find that firms that protect their management from bad luck in the stock market have a positive relationship with innovation. Asymmetric benchmarking of pay, which is protection from bad luck, could indicate skimming or firms' retention policies, both of which are likely to entrench managers. Further in a subset of pharmaceutical companies we treat their announcement of a failure of Phase III Clinical Trial as a significant setback for their research and development initiative. In separate regressions of golden parachutes, option repricing, and issuance of multiple grants on a dummy variable that equals one if firm announced a Phase III Clinical Trial Failure, we find positive relationship.

Finally, we find that the passing of the Sarbanes Oxley Act, which could stifle innovation by restricting managers from pursuing long-term projects, is associated with lesser innovation.

References

Aghion, P. and Tirole, J. 1994. The management of innovation. *The Quarterly Journal of Economics* 109, 1185–1209.

Aghion, P., Reenen, J. V. and Zingales, L. 2009. Innovation and institutional ownership. CEPR Working Paper.

Agrawal, A. and Mandelker, G. 1987. Managerial incentives and corporate investment and financing decisions. *Journal of Finance* 42, 823-37.

Amabile, T. 1996. *Creativity in context: Update to the social psychology of creativity*. Boulder, Co: Westview Press.

Atanassov, J. 2007. Quiet life or managerial myopia: Is the threat of hostile takeovers beneficial for technological innovation? Working Paper.

Atanassov, J., Nanda, V. and Seru, A. 2005. Finance and innovation: The case of publicly traded firms. Working Paper.

Bargeron, L., Lehn, K. and Zutter, C. 2008. Sarbanes-Oxley and corporate risk-taking. Working Paper.

Bergemann, D., and Hege, U. 2005. The financing of innovation: Learning and stopping. *Rand The Journal of Economics* 36, 719–752.

Bertrand, M. and Mullainathan, S. 2001. Are CEOs rewarded for luck? The ones without principals are. *The Quarterly Journal of Economics* 116, 901-932.

Bizjak, J.M., Lemmon, M.L. and Naveen, L. 2008. Does the use of peer groups contribute to higher pay and less efficient compensation? *The Journal of Financial Economics* 90. 152-168

Bound, J., Cummins, C., Griliches, Z., Hall, B. H. and Jaffe, A.B. 1982. "Who does R&D and who patents?" In *R and D, patents, and productivity*, ed. Z. Griliches. Chicago: University of Chicago Press.

Brenner, M., Sundaram, R., Yermack, D., 2000. Altering the terms of executive stock options. *The Journal of Financial Economics* 57, 103–128.

Brusa, J., Lee, W.Y., Shook, C., 2007. Golden parachutes as managerial incentives. Working paper.

Caballero, R., J. and Jaffe, A. B. 1993. How high are the giant's shoulders: An empirical assessment of knowledge spillovers and creative destruction in a model of economic growth. NBER working paper No. 4370.

Cai, J. and Vijh, A. 2007. Incentive effects of stock and option holdings of target and acquirer CEOs. *The Journal of Finance* 62, 1891-1933.

Carter, M.E., Lynch, L.J., 2001. An examination of executive stock option repricing. *The Journal of Financial Economics* 61, 207-225.

Chance, D., Kumar, R., Todd, R., 2000. The 'repricing' of executive stock options. *The Journal of Financial Economics* 57, 129–154.

Chi, J. and Johnson, S.A. 2008. The value of vesting restrictions on managerial sock and option holdings. Working Paper.

Chidambaran, N., Prabhala, N., 2000. Executive stock option repricing, internal governance mechanisms, and management turnover. Unpublished Working Paper, Tulane University, New Orleans, LA.

Cohen, D., Dey, A. and Lys, T. H. 2004. The Sarbanes Oxley Act of 2002: Implications for compensation structure and risk-taking incentives of CEOs. Working Paper.

Cohen, W.M. and Levinthal, D.A. 1989. Innovating and learning: The two faces of R&D. *The Economic Journal* 99, 569-596.

Coles, J., Daniel, N. and Naveen, L. 2006. Managerial incentives and risk-taking. *Journal of Financial Economics* 79, 431-468.

Core, J. and Wayne, G. 2002. Estimating the value of employee stock option portfolios and their sensitivities to price and volatility. *Journal of Accounting Research* 40, 613-630.

Daley, L. and Subramaniam, C. 1995. Free cash flow, golden parachutes, and the discipline of takeover activity. Working Paper.

Deci, E.L. 1975. *Intrinsic motivation.* New York: Plenum.

Francis, J. and Smith, A. 1995. Agency costs and innovation: Some empirical evidence. *The Journal of Accounting and Economics* 19, 383-409.

Francis, B., B, Hasan, I., Sharma, Z., 2010. The bright side of asymmetric benchmarking of pay: Evidence from top management team members. Working paper.

Fudenberg, D., Holmstrom, B. and Milgrom, P. 1990. Short term contracts and long term agency relationships. *The Journal of Economic Theory* 51, 1-31.

Garvey, G.T. and Milbourn, T.T. 2006. Asymmetric benchmarking in compensation: Executives are rewarded for good luck but not penalized for bad. *The Journal of Financial Economics* 82, 197-225.

Girotra, K., Terwiesch, C., Ulrich, K. T., 2007. Valuing R&D projects in a portfolio: Evidence from pharmaceutical industry. *The Management Science* 53 (9), 1452-1466.

Gompers, P., Ishii, J. and Metrick, A. 2003. Corporate governance and equity prices. *Quarterly Journal of Economics* 118, 107–155.

Griliches, Z. 1981. Market value, R&D, and patents. *The Economics Letters* 7, 183-187.

Hall, B., Jaffe, A. and Trajtenberg, M. 2001. The NBER patent citations data file: Lessons, insights and methodological tools. Working Paper 8498, NBER.

Hall, B., Jaffe, A. and Trajtenberg, M. 2005. Market value and patent citations. *The Rand Journal of Economics* 36, 16-38.

Hall, B. and Leibm an, J. 1998. Ar e CEOs paid like bureaucrats? *The Quarterly Journal of Economics* 113, 653-691.

Hall, B.H., Griliches, Z. and Hausm an, J.A. 1986. Patents and R&D: Is there a lag ? *The International Economic Review* 27.

Hall, B., 1999. The design of multi-year stock option plans. *The Journal of Applied Corporate Finance* 12, 97–106.

Hall, B., Knox, T., A., 2004. Underwater Options and the Dynamics of Executive Pay-to-Performance Sensitivities. *The Journal of Accounting Research* 42 (2), 97–106.

Harris, E. 1990. Antitakeover measures, golden parachutes, and target firm shareholder welfare. *The Rand Journal of Economics* 21, 614–625.

Haugen, R. and Senbet, L. 1981. Resolving the ag ency problems of exte rnal capital through option. *The Journal of Finance* 36, 629-47.

Hausman, J., Hall, B. H . and Griliches, Z. 198 4. Econometric models for count data with an application to the patents-R&D relationship. *The Econometrica,* 52, 909-38.

Heron, R. A. and Lie, E., 2007. Does Backdating Explain the Stock Price Pattern Around Executive Stock Option Grants?. *The Journal of Financial Economics*, Forthcoming

Holmstrom, B. 1989. Agency costs and innovation. *The Journal of Economic Behavior and Organization* 12, 305-327.

Jackson, M., Lazear, E., 1991. Stocks, option s and deferred com pensation. Research in Labor Economics, 12, 41-62

Jensen, M. and Meckling, W ., 1976. Theory of th e Firm: Managerial Behavior, Agency Costs and Ownership Structure. *The Journal of Financial Economics* 3, 305-360.

Jensen, M. and Murphy, K.J. 1990b. CEO In centives: It's not how much, but how? *The Harvard Business Review.*

Kang, S.-K., Kumar, P. and Lee, H. 2006. Age ncy cost and corporate investm ent: The role of executive compensation and corporate investment. *The Journal of Business* 79, 1127-1147

Knoeber, C. 1986. Golden parachutes, shark repellents, and hostile takeovers. *The American Economic Review* 76, 155–167.

Kole, S. 1997. The complexity of com pensation contracts. *The Journal of Financial Economics* 43, 79-104.

Lambert, R., Larcker, D. and Verrecchia, R. 1991. Portfolio considerations in valuing executive compensation. *The Journal of Accounting Research* 29, 129-149.

Lambert, R. and Larcker, D. 1985. Golden parachutes, executive decision-m aking, and shareholder wealth. *The Journal of Accounting and Economics* 7, 179–203.

Lefanowicz, C.E., Robinson, J. R. and Sm ith, R., 2000. Golden parachutes and m anagerial incentives in corporate acquisitions: Evidence from the 1980s and 1990s. *The Journal of Corporate Finance* 6, 215-239.

Lepper, M.R.G.D. 1978. "Overjustification research and beyond: Towards a means-ends analysis of intrinsic and extrinsic motivation," in *The hidden costs of reward,* ed. M.R. Lepper, and D. Greene. Hillside NJ, Lawrence Erlbaum Associates.

Lerner, J., and W ulf, J. 2007. Innnovation and in centives: Evidence from corporate R&D. *Review of Economics and Statistics* 89, 634-644.

Manso, G. 2007. Motivating innovation. Working paper, MIT Sloan School of Management.

March, J. 1991. Exploration and expl oitation in organizational learning. *The Organization Science* 2, 71-87.

McCullers, J.C. 1978. "Issues in learning and motivation," in *The hidden costs of reward*, eds. M.R. Lepper, and D. Greene. Hillside, NJ, Lawrence Erlbaum Associates.

McGraw, K.O. 1978. "Issues in learning and motivation," in *The hidden costs of reward,* eds. M.R. Lepper, and D. Greene. Hillside, NJ, Lawrence Erlbaum Associates.

Murphy, K.J.1993. Executive compensation in co rporate America. United Shareholders Association.

O'Byrne, S., 1995. Total compensation strategy. *The Journal of Applied Corporate Finance* 8, 185–197.

Oyer, P. 2004. Why do firms use incentives that have no incentive effects? *The Journal of Finance* 59, 1619-1649.

Pakes, A. and Griliches, Z. 1980. Patents and R&D at the firm level: A first report. *The Economics Letters* 4, 377-381.

Palia, D. 2001. The endogeneity of managerial compensation in firm value. *The Review of Financial Studies* 14, 735-764.

Rogers, A. D. 2008. Does executive portfolio structure affect risk management? CEO risk taking incentives and corporate derivatives dosage. Working Paper.

Sapra, H., Subramanian, A. and Subramanian, K. 2007. Corporate governance and innovation: Theory and evidence. Working Paper.

Seru, A. 2007. Do conglomerates stifle innovation. Working Paper.

Shadab, H.B. 2008. Innovation and corporate governance: The impact of Sarbanes Oxley. *The Journal of Business and Employment Law* 10, Forthcoming

Singh, H., and F. Harianto, "Management-Board Relationships, Takeover Risk, and the Adoption of Golden Parachutes," *The Academy of Management Journal*, 1989, Vol. 32, pp. 7-24.

Smith, C. and Watts, R. 1982. Incentive and tax effects of executive compensation plans. *The Australian Journal of Management* 7, 139-157.

Theivananthampillai, P., Stringer, C. and Didham, J. 2008. The "hidden costs of reward": Revisited. Working Paper.

Wade, J., O'Reilly, C. and Chandratat, I., 1990. Golden parachutes: CEOs and the exercise of social influence. *The Administrative Science Quarterly* 35, 587-603.

Table 1 – Descriptive Statistics

This table reports the descriptive statistics of key variables used in analysis for the period 1992–2006. Patent information comes from the NBER patent dataset provided by HJT (2001). Patent is the count of the number of patents. Citations corrects for citations per patent using weights derived from citation-lag distribution. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non-equity is the sum of salary and bonus. Vested options is value of exercisable-unexercised options. Unvested options is the value of unexercisable-unexercised options. Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and to tal assets. HHI-Assets is the Herfindahl index of industry concentration calculated at a two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in the CRSP database.

	Mean	Median	1st Percentile	99th Percentile	Std Dev	Obs
Patent	38.01	5.00	1.00	662.00	170.08	6946
Citation	617.51	40.85	0.00	12166.38	3469.79	6946
TDC1	5331.59	2446.54	215.00	39130.71	15830.40	6886
New Options	3577.28	990.93	0.00	33788.08	15363.34	6886
Non-Equity	1302.29	952.48	57.20	5900	1309.33	6946
PPS	0.25	0.12	0.006	2.35	0.39	5289
Previous Vested Options	11090.69	1360.29	0.00	179014.70	50621.34	6945
Previous Unvested Options	5014.76	452.60	0.00	62602.50	32848.77	6945
Unvested Stock	1753.88	0.00	0.00	25696.04	12455.72	6945
G Index	9.52	10.00	3.00	15.00	2.75	4771
Segment Dummy	0.66	1.00	0.00	1.00	0.47	6946
Public Debt	0.09	0.00	0.00	1.00	0.28	6946
Tangible/Assets	0 .26	0 .22	0 .02	0.77	0 .16	6959
Equity/Assets	0.48	0.47	-0.23	0.91	0 .23	6966
Book Leverage	0.20	0.19	0.00	0.71	0.16	6924
R&D/Assets	0.06	0.03	0.00	0.32	0.07	6946
HHI-Assets	0.11	0.06	0.04	0.55	0.10	6946
Age	40.32	31.00	2.00	88.00	24.01	6758

Table 2 – Correlation

This table reports the correlation between key variables used in analysis for the peri od 1992–2006. Patent information comes from the NBER patent dataset provided by HJT (2001). Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non-equity is the sum of salary and bonus. Vested options is the value of exercisable-unexercised options. Unvested options is the value of unexercisable-unexercised options. Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Capex growth is calculated as $(capex_{t+1}-capex_{t0})/capex_{t0}$ Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in the CRSP database.

	Log Patent	Log Citation	Capex Growth	Log TDC1 Optio	Log New ns	Log Non-Equity	PPS Op	Log Previous Vested tions	Log Previous Unvested Options	G-Index	Segment Dummy	Public Debt Dummy
Log (Patent)	1											
Log (Citation)	0.7921*	1										
Capex Growth	-0.0473*	0.0027	1									
Log (TDC1)	0.2670*	0.0946*	-0.0319*	1								
Log (New Options)	0.2667*	0.1188*	-0.0031	0.9048*	1							
Log (Non-Equity)	0.2279*	0.0516*	-0.0539*	0.6913*	0.4525*	1						
PPS	-0.1345*	-0.0378*	0.0892*	0.1136*	0.2085*	-0.2585*	1					
Log (Previous Vested Options)	0.1803*	0.1142*	0.0811*	0.4744*	0.5096*	0.4043*	-0.0426*	1				
Log (Previous Unvested Options)	0.1902*	0.1317*	0.1336*	0.5135*	0.5828*	0.3657*	0.0700*	0.6533*	1			
G Index	-0.0489*	-0.0731*	-0.0649*	0.0654*	-0.1045*	0.1523*	-0.1428*	-0.0779*	-0.1011*	1		
Segment Dummy	0.0401*	-0.0501*	-0.0986*	0.1204*	-0.0001	0.2714*	-0.2112*	-0.0217	-0.0472*	0.2078*	1	
Public Debt	0.1196*	0.1162*	-0.0613*	0.1582*	0.0960*	0.2093*	-0.1403*	0.0598*	0.0425*	0.0843*	0.1278*	1
R&D/TA	0.1379*	0.1588*	0.0682*	-0.0735*	0.0855*	-0.2741*	0.2686*	0.0528*	0.0824*	-0.2701*	-0.3040*	-0.1347*

Table 3 – Difference in Means

This table reports the t-tests between key variables used in analysis for the period 1992–2006. Patent information comes from the NBER patent dataset provided by HJT (2001). Patent dummy is a dummy variable which equals one if a firm applied for a patent in a given year and zero otherwise. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non-equity is the sum of salary and bonus. Vested options is the value of exercisable-unexercised options. Unvested options is the value of unexercisable-unexercised options. Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment

	Patent Dummy = 0	Patent Dummy = 1	Difference	T-Stat
TDC1	3317.74	5331.59	-2013.85	-11.32
New Option	1907.20	3577.28	-1670.08	-9.84
Non-Equity	1144.16	1302.29	-158.13	-7.44
PPS	32.10%	25.10%	0.07	8.87
Previous Vested Options	6322.29	11090.69	-4768.40	-8.18
Previous Unvested Options	2511.92	5014.76	-2502.84	-6.74
Segment Dummy	56.49%	65.69%	-0.09	-11.93
RD/Assets	1.93%	6.02%	-0.04	-44.18
Public Debt	4.25%	8.78%	-0.05	-11.94
Total Assets	2433.53	6908.791	-4475.37	-14.18

Table 4 – R&D

The dependent variable is R&D expense divided by total assets. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non-equity is the sum of salary and bonus. Vested options is the value of exercisable-unexercised options. Unvested options is the value of unexercisable-unexercised options. Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is the Herfindahl index of industry concentration calculated at two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in CRSP database. Additional control variables include year, state and Fama French 49 Industry fixed effects. Standard errors clustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log (TDC1)	0.005***						
	[0.001]						
PPS		0.011*					
		[0.005]					
Log (New Options)		0	.006***		0		.006***
		[	0.001]		[		0.001]
Log (Non-Equity)		0.		003		0.	001
		[		0.002]		[	0.002]
Log (Previous Unvested Options)			0		.001*		
					[0.001]		
Log (Previous Vested Options)		0				.001	
						[0.001]	
Segment Dummy	-0.010***	-0.010**	-0.010**	-0.011***	-0.011**	-0.011***	-0.010**
	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]	[0.003]
Tenure	-0.000**	-0.001**	-0.000**	-0.000**	-0.000*	-0.000**	-0.000**
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Public Debt Dummy	0.004*	0.004*	0.003	0.004*	0.004*	0.004*	0.003
	[0.002]	[0.002]	[0.002]	[0.002]	[0.003]	[0.002]	[0.002]
Tangible/TA	-0.020*	-0.016	-0.011	-0.022*	-0.016	-0.020*	-0.011
	[0.011]	[0.011]	[0.011]	[0.011]	[0.013]	[0.012]	[0.011]
Equity/TA	-0.025**	-0.015	-0.020*	-0.024*	-0.018	-0.015	-0.020*
	[0.009]	[0.011]	[0.010]	[0.009]	[0.011]	[0.011]	[0.010]
Log (Sales)	-0.012***	-0.010***	-0.013***	-0.012***	-0.011***	-0.010***	-0.013***
	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]	[0.002]
HHI-Assets	0.033	0.022	0.028	0.031	0.054	0.047	0.027
	[0.036]	[0.036]	[0.035]	[0.034]	[0.039]	[0.036]	[0.035]
HHI-Assets Squared	-0.031	-0.017	-0.023	-0.029	-0.054	-0.041	-0.023
	[0.040]	[0.043]	[0.041]	[0.036]	[0.045]	[0.041]	[0.041]
Log (Firm Age)	-0.002	-0.003	-0.002	-0.002	-0.002	-0.002*	-0.002
	[0.001]	[0.002]	[0.001]	[0.001]	[0.002]	[0.001]	[0.001]
Intercept	0.165***	0.135***	0.125***	0.168***	0.136***	0.141***	0.124***
	[0.020]	[0.020]	[0.018]	[0.021]	[0.020]	[0.019]	[0.020]
Obs	5627	4340	4601	5646	4078	4586	4577
R-squared	0.525	0.531	0.534	0.524	0.515	0.523	0.535
F test (New Options+Non Equity=0)							7.66

Table 5 – Patent Trends

This table presents the number of patents applied and citation received at every decile of R&D intensity. High represents above median option compensation within the range of R&D intensity and low represents below median option compensation. Patent information comes from the NBER patent dataset provided by HJT (2001). Patents is count of number of patents. Citations corrects for citations per patent using weights derived from citation-lag distribution. Compensation information comes from ExecuComp. Options are Black and Scholes value of options granted in a year.

RD/Assets	Options	Patents Applied	Citations Received
<0,006	High	19	198
	Low	3	36
0,06 -0,01	High	11	115
	Low	5	59
0,02 -0,03	High	19	191
	Low	6	79
0,03 - 0,04	High	29	339
	Low	12	197
0,04 - 0,06	High	40	472
	Low	14	194
0,06-0,08	High	97	1796
	Low	43	775
0,08-0,11	High	57	960
	Low	20	218
0,11-0,15	High	88	1379
	Low	26	440
>0,15	High	44	746
	Low	30	611

Table 6 – Patents (Negative Binomial)

Patent information comes from the NBER patent dataset provided by HJT (2001). Patents is the count of number of patents. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non -equity is the sum of salary ad bon us. Vested options is value of exercisable-unexercised options. Unvested options is the value of unexercisable-unexercised options. Public debt, is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is Herfindahl index of industry concentration calculated at two-digit SIC code level. Firmage is based on data from Jay Ritter's web site and first appearance made by a firm in the CRSP database. Additional control variables include year, state and Fam a French 49 Industry fixed ef fects. Standard errors cl ustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log (TDC1)	0.090**						
	[0.030]						
PPS		-0.115					
		[0.085]					
Log (New Options)			0.126***				0.121***
			[0.025]				[0.026]
Log (Non-Equity)				0.096*			0.085
				[0.052]			[0.061]
Log (Previous Unvested Options)					0.052***		
					[0.014]		
Log (Previous Vested Options)						0.033*	
						[0.015]	
Segment Dummy	-0.057	-0.047	-0.017	-0.073	-0.060	-0.071	-0.027
	[0.066]	[0.074]	[0.070]	[0.067]	[0.073]	[0.072]	[0.071]
Tenure	0.001	-0.004	-0.003	0.000	0.002	0.002	-0.003
	[0.006]	[0.006]	[0.006]	[0.006]	[0.007]	[0.006]	[0.006]
Public Debt Dummy	0.240*	0.244**	0.205*	0.236*	0.290**	0.268**	0.199*
	[0.100]	[0.091]	[0.087]	[0.100]	[0.109]	[0.103]	[0.087]
Tangible/TA	0.261	0.350	0.309	0.249	0.539*	0.587*	0.318
	[0.304]	[0.280]	[0.280]	[0.300]	[0.325]	[0.300]	[0.280]
Equity/TA	0.308*	0.235	0.242	0.337*	0.067	0.169	0.265
	[0.173]	[0.197]	[0.192]	[0.172]	[0.197]	[0.195]	[0.190]
Log (Sales)	0.620***	0.621***	0.585***	0.626***	0.611***	0.621***	0.566***
	[0.033]	[0.032]	[0.035]	[0.033]	[0.032]	[0.032]	[0.038]
R&D/TA	6.547***	6.365***	6.179***	6.533***	6.402***	6.868***	6.145***
	[0.798]	[0.811]	[0.819]	[0.788]	[0.810]	[0.736]	[0.815]
R&D Missing	0.657***	0.705***	0.597***	0.647***	0.698***	0.607***	0.588***
	[0.139]	[0.137]	[0.150]	[0.139]	[0.139]	[0.143]	[0.149]
HHI-Assets	-0.630	-0.152	-0.236	-0.264	-1.387	-0.261	-0.219
	[1.069]	[1.133]	[1.169]	[1.007]	[1.102]	[1.175]	[1.165]
HHI-Assets Squared	-0.143	-0.119	-0.027	-0.569	0.875	0.025	-0.042
	[1.164]	[1.277]	[1.307]	[1.025]	[1.227]	[1.289]	[1.308]
Log (Firm Age)	-0.035	-0.042	-0.037	-0.040	-0.031	-0.006	-0.039
	[0.038]	[0.042]	[0.040]	[0.039]	[0.039]	[0.040]	[0.040]
Intercept	-3.819***	-3.946***	-4.470***	-3.820***	-3.698***	-4.263***	-4.882***
	[0.664]	[0.728]	[0.736]	[0.709]	[0.723]	[0.674]	[0.807]
Obs	5627	4340	4601	5646	4078	4586	4577
Log Likelihood	-20604	-16167	-17088	-20674	-15189	-17049	-16986
Alpha	1.235	1.244	1.228	1.237	1.235	1.245	1.226

Table 7 – Patents (OLS)

Patent information comes from the NBER patent dataset provided by HJT (2001). Patents is count of number of patents. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non -equity is the sum of salary and bon us. Vested options is value of exercisable-unexercised options. Unvested options is value of unexercisable-unexercised options. Public debt, is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is Herfindahl index of industry concentration calculated at two-digit SIC code level. Firmage is based on data from Jay Ritter's web site and the first appearance made by a firm in CRSP database. Additional control variables include year, state and Fam a French 49 Industry fixed ef fects. Standard errors cl ustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log (TDC1)	0.075*						
	[0.029]						
PPS		-0.088					
		[0.064]					
Log (New Options)			0.098***				0.092***
			[0.022]				[0.023]
Log (Non-Equity)				0.079*			0.067
				[0.047]			[0.051]
Log (Previous Unvested Options)					0.037**		
					[0.014]		
Log (Previous Vested Options)						0.019	
						[0.014]	
Segment Dummy	-0.051	-0.037	-0.011	-0.070	-0.051	-0.055	-0.019
	[0.057]	[0.065]	[0.063]	[0.056]	[0.067]	[0.065]	[0.064]
Tenure	-0.004	-0.004	-0.004	-0.005	-0.001	-0.002	-0.004
	[0.004]	[0.005]	[0.005]	[0.004]	[0.005]	[0.005]	[0.005]
Public Debt Dummy	0.113	0.108	0.097	0.100	0.161	0.115	0.088
	[0.098]	[0.096]	[0.095]	[0.098]	[0.122]	[0.108]	[0.095]
Tangible/TA	0.450*	0.506*	0.517*	0.422*	0.648*	0.640*	0.509*
	[0.257]	[0.261]	[0.257]	[0.254]	[0.296]	[0.273]	[0.258]
Equity/TA	0.276*	0.229	0.216	0.299*	0.151	0.226	0.226
	[0.164]	[0.188]	[0.181]	[0.162]	[0.196]	[0.185]	[0.180]
Log (Sales)	0.401***	0.413***	0.378***	0.409***	0.407***	0.414***	0.362***
	[0.036]	[0.031]	[0.035]	[0.035]	[0.035]	[0.033]	[0.037]
R&D/TA	4.327***	4.361***	4.152***	4.350***	4.489***	4.588***	4.137***
	[0.582]	[0.629]	[0.617]	[0.584]	[0.661]	[0.613]	[0.621]
R&D Missing	0.422***	0.463***	0.409***	0.418***	0.457***	0.389***	0.399***
	[0.086]	[0.091]	[0.097]	[0.087]	[0.095]	[0.099]	[0.097]
HHI-Assets	-1.072	-0.916	-0.922	-0.794	-1.549	-1.353	-0.846
	[0.920]	[1.095]	[1.111]	[0.863]	[0.984]	[1.023]	[1.102]
HHI-Assets Squared	0.268	0.157	0.140	0.017	0.898	0.647	-0.002
	[1.038]	[1.353]	[1.334]	[0.899]	[1.182]	[1.170]	[1.314]
Log (Firm Age)	-0.008	-0.006	-0.001	-0.014	-0.015	0.009	-0.005
	[0.033]	[0.038]	[0.036]	[0.034]	[0.038]	[0.038]	[0.036]
Intercept	-2.170***	-2.448***	-2.693***	-2.232***	-2.343***	-2.490***	-2.971***
	[0.447]	[0.435]	[0.445]	[0.476]	[0.484]	[0.475]	[0.502]
Obs	5627	4340	4601	5646	4078	4586	4577
F test (New Options+Non Equity=0)							9.69
R-Squared	0.361	0.358	0.366	0.358	0.365	0.362	0.366

Table 8 – Citations

Patent information comes from the NBER patent dataset provided by HJT (2001). Citations corrects for citations per patent using weights derived from citation-lag distribution. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bo nus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non-equity is the sum of salary and bonus. Vested options is the value of exercisable-unexercised options. Unvested options is the value of unexercisable-unexercised options. Public debt, is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of n et fixed assets an d total assets. HHI-Assets is Herfind ahl index of industry concentration calculated at two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in CRSP database. Additional control variables include year, state and Fama French 49 Industry fixed effects. Standard errors clustered at firm level are r eported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Log (TDC1)	0.109*						
	[0.043]						
PPS		-0.010					
		[0.107]					
Log (New Options)			0.165***				0.157***
			[0.034]				[0.034]
Log (Non-Equity)				0.106*			0.089
				[0.064]			[0.067]
Log (Previous Unvested Options)					0.067**		
					[0.021]		
Log (Previous Vested Options)						0.040*	
						[0.021]	
Segment Dummy	-0.089	-0.084	-0.038	-0.119	-0.059	-0.073	-0.053
	[0.089]	[0.100]	[0.098]	[0.088]	[0.104]	[0.099]	[0.098]
Tenure	-0.007	-0.007	-0.006	-0.008	-0.002	-0.006	-0.007
	[0.006]	[0.007]	[0.007]	[0.006]	[0.007]	[0.007]	[0.007]
Public Debt Dummy	0.144	0.150	0.121	0.123	0.211	0.141	0.107
	[0.129]	[0.128]	[0.128]	[0.129]	[0.160]	[0.139]	[0.128]
Tangible/TA	0.119	0.147	0.202	0.082	0.363	0.342	0.182
	[0.358]	[0.376]	[0.369]	[0.354]	[0.414]	[0.378]	[0.370]
Equity/TA	0.594*	0.609*	0.541*	0.631**	0.512*	0.603*	0.548*
	[0.241]	[0.291]	[0.275]	[0.239]	[0.297]	[0.269]	[0.274]
Log (Sales)	0.470***	0.503***	0.431***	0.485***	0.478***	0.487***	0.411***
	[0.045]	[0.041]	[0.046]	[0.044]	[0.046]	[0.042]	[0.049]
R&D/TA	6.433***	6.114***	5.807***	6.453***	6.632***	6.669***	5.759***
	[0.851]	[0.924]	[0.903]	[0.850]	[0.965]	[0.892]	[0.904]
R&D Missing	0.661***	0.688***	0.591***	0.658***	0.716***	0.580***	0.574***
	[0.138]	[0.146]	[0.150]	[0.139]	[0.159]	[0.155]	[0.150]
HHI-Assets	0.446	1.172	1.127	0.471	-0.105	0.462	1.170
	[1.364]	[1.604]	[1.629]	[1.273]	[1.439]	[1.485]	[1.622]
HHI-Assets Squared	-1.432	-2.065	-2.062	-0.950	-0.102	-1.255	-2.018
	[1.719]	[2.067]	[1.999]	[1.492]	[1.731]	[1.886]	[1.993]
Log (Firm Age)	-0.000	0.002	0.014	-0.006	0.010	0.025	0.007
	[0.050]	[0.055]	[0.054]	[0.050]	[0.055]	[0.054]	[0.054]
Intercept	-1.281*	-1.077	-1.419*	-1.327*	-1.777**	-1.634*	-1.779*
	[0.609]	[0.698]	[0.706]	[0.641]	[0.657]	[0.638]	[0.771]
Obs	5627	4340	4601	5646	4078	4586	4577
R-Squared	0.446	0.440	0.448	0.446	0.460	0.460	0.449
F test (New Options+Non Equity=0)							12.06

Table 9 – Golden Parachutes

Patent information comes from the NBER patent dataset provided by HJT (2001). Patents is count of number of patents. Citations corrects for citations per patent using weights derived from citation-lag distribution. Data on golden parachutes and G-Index comes from the IRRC. Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is the Herfindahl index of industry concentration calculated at a two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in the CRSP database. Additional control variables include year, state and Fama French 49 Industry fixed effects. Robust standard errors are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	Log Patent (1)	Log Citation (2)	R&D/Assets (3)
Golden Parachute	0.090*	0.141*	-0.004*
	[0.051]	[0.078]	[0.002]
G Index	-0.045***	-0.068***	-0.002***
	[0.010]	[0.015]	[0.000]
Segment Dummy	-0.162***	-0.290***	-0.019***
	[0.049]	[0.078]	[0.002]
Tenure	0.081	0.025	0.004*
	[0.089]	[0.125]	[0.002]
Public Debt Dummy	0.613***	0.454*	-0.032***
	[0.174]	[0.264]	[0.007]
Tangible/TA	0.182	0.353*	0.005
	[0.118]	[0.177]	[0.007]
Equity/TA	0.515***	0.617***	-0.008***
	[0.021]	[0.030]	[0.001]
Log (Sales)	4.859***	6.005***	
	[0.468]	[0.708]	
R&D/TA	0.499***	0.687***	
	[0.059]	[0.105]	
HHI-Assets	1.419	4.110*	0.042
	[1.382]	[1.873]	[0.041]
HHI-Assets Squared	-2.070	-4.259	-0.032
	[2.407]	[2.931]	[0.042]
Log (Firm Age)	0.038	0.014	-0.005***
	[0.032]	[0.050]	[0.001]
Intercept	-2.292***	-0.877*	0.176***
	[0.316]	[0.456]	[0.013]
Obs	3758	3758	3758
R-Squared	0.348	0.458	0.411

Table 10 – Self-selection

This table present results for the two-stage Heckman procedure. Patent information comes from the NBER patent dataset provided by HJT (2001). Patents are the count of the number of patents. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non-equity is the sum of salary and bonus. Unvested options is the value of unexercisable-unexercised options. Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is the Herfindahl index of industry concentration calculated at a two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in the CRSP database. Additional control variables include year, state and Fama French 49 Industry fixed effects. The dependent variable for first stage is patent dummy, which is a dummy variable which equals one if a firm in the ExecuComp universe filed for a patent in a given year and zero otherwise. Robust Standard errors are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

Panel: 2nd Stage	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log (TDC1)	0.081***							
	[0.019]							
PPS		-0.089						
		[0.058]						
Log (New Options)			0.099***					0.093***
			[0.017]					[0.018]
Log (Non-Equity)				0.084**				0.066*
				[0.029]				[0.036]
Log (Previous Unvested Options)					0.037***			
					[0.011]			
Log (Previous Vested Options)						0.019*		
						[0.010]		
Golden Parachute							0.064	
							[0.055]	
G Index							-0.019*	
							[0.010]	
Segment Dummy	-0.05	-0.055	-0.011	-0.068*	-0.05	-0.054	-0.130*	-0.018
	[0.040]	[0.047]	[0.045]	[0.040]	[0.047]	[0.045]	[0.057]	[0.045]
Tenure	-0.004*	-0.004	-0.004	-0.005*	-0.001	-0.002	-0.004	-0.004
	[0.002]	[0.003]	[0.003]	[0.002]	[0.003]	[0.003]	[0.003]	[0.003]
Public Debt Dummy	0.110*	0.1	0.093	0.098*	0.159*	0.111*	0.082	0.084
	[0.059]	[0.067]	[0.064]	[0.059]	[0.072]	[0.065]	[0.074]	[0.064]
Tangible/Assets	0.433***	0.497**	0.499***	0.401**	0.626***	0.617***	0.265	0.491***
	[0.131]	[0.158]	[0.148]	[0.130]	[0.161]	[0.149]	[0.191]	[0.148]
Equity/Assets	0.271**	0.282**	0.235*	0.294***	0.155	0.245*	0.178	0.244*
	[0.083]	[0.103]	[0.098]	[0.083]	[0.106]	[0.101]	[0.131]	[0.099]
Log (Sales)	0.360***	0.370***	0.339***	0.369***	0.364***	0.379***	0.432***	0.325***
	[0.016]	[0.019]	[0.019]	[0.017]	[0.019]	[0.018]	[0.025]	[0.021]
R&D/Assets	3.803***	3.642***	3.628***	3.834***	3.908***	4.107***	4.534***	3.632***
	[0.364]	[0.433]	[0.411]	[0.363]	[0.446]	[0.416]	[0.569]	[0.411]
HHI-Assets	-1.025*	-1.487*	-0.742	-0.773	-1.375*	-1.196*	0.452	-0.664
	[0.596]	[0.756]	[0.674]	[0.572]	[0.714]	[0.669]	[0.873]	[0.675]
HHI-Assets Squared	0.337	1.545	0.097	0.077	0.821	0.59	-1.492	-0.048
	[0.846]	[1.195]	[0.965]	[0.766]	[0.992]	[0.937]	[1.306]	[0.970]
Log (Age)	-0.006	0.001	0.003	-0.012	-0.008	0.013	0.135**	-0.001
	[0.020]	[0.024]	[0.023]	[0.020]	[0.024]	[0.023]	[0.042]	[0.023]
Lambda	-0.318***	-0.334***	-0.294***	-0.314***	-0.311***	-0.272***	-0.283***	-0.284***
	[0.058]	[0.070]	[0.064]	[0.058]	[0.071]	[0.065]	[0.082]	[0.064]
Intercept	-1.187**	-1.182*	-1.625**	-1.247**	-1.191*	-1.367**	-1.594**	-1.939***
	[0.396]	[0.569]	[0.531]	[0.404]	[0.538]	[0.503]	[0.549]	[0.558]

Continued from Table 10

Panel B: 1st Stage	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Log (Sales)	0.228***	0.249***	0.250***	0.228***	0.246***	0.245***	0.304***	0.251***
	[0.009]	[0.009]	[0.009]	[0.009]	[0.010]	[0.009]	[0.011]	[0.009]
R&D/Assets	3.430***	3.902***	3.732***	3.428***	3.756***	3.622***	3.272***	3.739***
	[0.239]	[0.255]	[0.251]	[0.239]	[0.259]	[0.252]	[0.305]	[0.252]
HHI-Assets	-0.818***	-0.966***	-0.940***	-0.774***	-0.788***	-0.864***	-1.214***	-0.960***
	[0.120]	[0.142]	[0.133]	[0.119]	[0.134]	[0.131]	[0.162]	[0.134]
Log (Age)	-0.018	-0.035*	-0.029*	-0.018	-0.038*	-0.027*	-0.426***	-0.029*
	[0.015]	[0.016]	[0.016]	[0.015]	[0.016]	[0.016]	[0.018]	[0.016]
Book Leverage	0	0.098	0.098	-0.011	-0.043	0.01	0.079	0.093
	[0.072]	[0.080]	[0.078]	[0.072]	[0.081]	[0.078]	[0.092]	[0.078]
R&D Missing	1.483***	1.518***	1.508***	1.488***	1.509***	1.518***	1.476***	1.510***
	[0.030]	[0.033]	[0.032]	[0.029]	[0.033]	[0.032]	[0.037]	[0.032]
Intercept	-2.736***	-3.071***	-3.022***	-2.740***	-3.024***	-2.987***	-2.269***	-3.033***
	[0.093]	[0.102]	[0.099]	[0.093]	[0.102]	[0.099]	[0.110]	[0.099]
Obs	14671	13232	13653	14689	13133	13637	12236	13629
Chi-S	2545	2036	2277	2523	2011	2248	2699	2269
F test (New Options+Non Equity=0)				1				8.60

Table 11– Sensitivity of Options

Patent information comes from the NBER patent dataset provided by HJT (2001). Patents is the count of the number of patents. Citations corrects for citations per patent using weights derived from citation-lag distribution. Compensation information comes from ExecuComp. Options delta is change in the value of options with a un it change in price. Options vega is change in the value of options with a unit change in volatility. Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is the Herfindahl index of industry concentration calculated at a two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in the CRSP database. Additional control variables include year, state and Fama French 49 Industry fixed effects. Standard errors clustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	Log Patents (1)	Log Citations (2)	R&D/Assets (3)	Log Patents (4)	Log Citations (5)	R&D/Assets (6)
Wealth Vega	0.175***	0.254***	0.004**			
	[0.028]	[0.041]	[0.001]			
Wealth Vega/Wealth Delta				0.416*	0.482*	-0.009
				[0.206]	[0.288]	[0.007]
Segment Dummy	-0.022	-0.054	-0.009**	-0.048	-0.094	-0.010**
	[0.070]	[0.107]	[0.003]	[0.069]	[0.107]	[0.003]
Tenure	-0.005	-0.009	-0.001**	-0.003	-0.006	-0.001*
	[0.005]	[0.007]	[0.000]	[0.005]	[0.007]	[0.000]
Public Debt Dummy	0.013	0.023	0.005*	0.030	0.050	0.006*
	[0.101]	[0.135]	[0.003]	[0.100]	[0.134]	[0.003]
Tangible/TA	0.541*	0.184	-0.012	0.427	0.021	-0.015
	[0.264]	[0.392]	[0.012]	[0.270]	[0.399]	[0.012]
Equity/TA	0.123	0.408	-0.018*	0.192	0.513*	-0.016
	[0.198]	[0.298]	[0.011]	[0.203]	[0.307]	[0.011]
Log (Sales)	0.330***	0.376***	-0.013***	0.403***	0.488***	-0.011***
	[0.037]	[0.048]	[0.002]	[0.034]	[0.045]	[0.002]
R&D/TA	4.289***	6.081***		4.548***	6.448***	
	[0.635]	[0.927]		[0.646]	[0.943]	
R&D Missing	0.453***	0.655***		0.466***	0.674***	
	[0.096]	[0.160]		[0.098]	[0.161]	
HHI-Assets	-1.024	1.275	0.028	-1.085	1.190	0.028
	[1.146]	[1.683]	[0.038]	[1.148]	[1.681]	[0.038]
HHI-Assets Squared	0.508	-1.497	-0.025	0.561	-1.437	-0.026
	[1.484]	[2.137]	[0.044]	[1.504]	[2.168]	[0.045]
Log (Firm Age)	0.000	0.006	-0.002	-0.010	-0.006	-0.003
	[0.038]	[0.056]	[0.002]	[0.039]	[0.058]	[0.002]
Intercept	-2.479***	-1.142	0.146***	-2.473***	-1.146	0.145***
	[0.463]	[0.756]	[0.019]	[0.454]	[0.738]	[0.019]
Obs	3924	3924	3924	3924	3924	3924
R Squared	0.368	0.445	0.535	0.359	0.438	0.532

Table 12 – Capital Expenditures Growth

The dependent variable is one year future growth in capital expenditures. Capex growth is calculated as ($capex_{t+1}$-$capex_{t0}$)/$capex_{t0}$. Compensation information comes from ExecuComp. Total compensation (TDC1) includes salary, bonus, value options granted, value of restricted stock, long-term incentive plans and other perks. Options are Black and Scholes value of options granted in a year. Non-equity is the sum of salary and bonus. PPS is pay for performance sensitivity. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is the Herfindahl index of industry concentration calculated at a two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in the CRSP database. Additional control variables include year, state and Fama French 49 Industry fixed effects. Standard errors clustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	(1)	(2)	(3)	(4)	(5)
Log(TDC1)	0.059***				
	[0.014]				
PPS		0.107*			
		[0.050]			
Options/TDC1		0	.065*		
		[	0.038]		
(Salary+Bonus)/TDC1				-0.041	
				[0.042]	
Golden Parachute					-0.041*
					[0.021]
Segment Dummy	-0.072**	-0.065*	-0.077**	-0.079**	-0.076**
	[0.024]	[0.027]	[0.024]	[0.024]	[0.027]
Tenure	-0.001	-0.002	-0.001	-0.001	-0.001
	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Public Debt Dummy	-0.008	-0.003	-0.004	-0.003	-0.020
	[0.020]	[0.021]	[0.020]	[0.020]	[0.021]
Tangible/TA	-0.591***	-0.646***	-0.614***	-0.616***	-0.348***
	[0.076]	[0.090]	[0.077]	[0.077]	[0.089]
Equity/TA	0.109*	0.182*	0.120*	0.125*	-0.004
	[0.061]	[0.075]	[0.061]	[0.061]	[0.073]
Log (Sales)	-0.059***	-0.018*	-0.037***	-0.036***	-0.027**
	[0.010]	[0.010]	[0.008]	[0.008]	[0.009]
R&D/TA	-0.546*	-0.422	-0.504*	-0.489*	-0.547*
	[0.240]	[0.269]	[0.242]	[0.242]	[0.275]
R&D Missing	0.027	-0.016	0.033	0.034	0.050
	[0.031]	[0.040]	[0.030]	[0.031]	[0.036]
HHI-Assets	-0.074	-0.067	-0.075	-0.064	-0.163
	[0.286]	[0.322]	[0.289]	[0.288]	[0.269]
HHI-Assets Squared	0.200	0.292	0.192	0.187	0.118
	[0.395]	[0.575]	[0.400]	[0.397]	[0.466]
Log (Firm Age)	0.013	0.014	0.013	0.013	-0.004
	[0.011]	[0.012]	[0.011]	[0.011]	[0.013]
Intercept	0.108	0.019	0.305*	0.337*	0.301*
	[0.164]	[0.265]	[0.159]	[0.167]	[0.177]
Obs	5323	3956	5323	5323	3463
R Squared	0.091	0.090	0.086	0.086	0.073

Table 13 – Asymmetric Benchmarking

Patent information comes from the NBER patent dataset provided by HJT (2001). Patents is the count of the number of patents. Citations corrects for citations per patent using weights derived from citation-lag distribution. Compensation information comes from ExecuComp. Options are Black and Scholes value of options granted in a year. Asymmetric benchmark is a dummy variable that equals one if there is asymmetric benchmarking of pay and zero otherwise. HHI-Assets is the Herfindahl index of industry concentration calculated at a two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in CRSP database. Additional control variables include year, state and industry fixed effects at two-digit SIC code level. Standard errors clustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	Log Patents	Log Citations	R&D/Assets
	(1)	(2)	(3)
Asymmetric Benchmarking	0.076*	0.194**	0.004*
	[0.045]	[0.069]	[0.002]
Book Leverage	-0.038	-0.054	-0.023***
	[0.145]	[0.221]	[0.006]
Log(Sales)	0.423***	0.486***	-0.012***
	[0.015]	[0.022]	[0.001]
R&D/TA	4.744***	6.992***	
	[0.455]	[0.693]	
R&D Missing	0.489***	0.752***	
	[0.082]	[0.125]	
HHI-Assets	-0.898*	-0.377	0.043**
	[0.398]	[0.608]	[0.015]
Log (Firm Age)	0.002	0.013	-0.001
	[0.028]	[0.043]	[0.001]
Intercept	-1.194***	0.309	0.144***
	[0.229]	[0.350]	[0.008]
Obs	3499	3499	3499
R Squared	0.315	0.428	0.501

Table 14 –Exogenous Shocks – Failure of Phase III Clinical Trials

This table presents the regression results for subsample of pharmaceutical firms (SIC=2834). Data on Phase III Clinical Trial Failures comes from Factiva. Golden parachute is a dummy variable, which equals 1 if CEO had a golden parachute arrangement with the company. Information on golden parachutes comes from IRRC. Compensation information comes from ExecuComp. Repricing is a dummy variable, which equals one if the CEO was enlisted in the repricing Table. Option grants is the log of number of grants the CEO received in the middle of the year. Book leverage is total debt divided by total assets. Tobin's Q is total debt plus market value of equity divided by total assets. Financial and accounting information is obtained from Compustat. Additional control variables include year. Standard errors clustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*

	Golden Parachute (1)	Repricing (2)	Option Grants (#) (3)
Clinical Trial Phase III Failure	0.601**	0.881*	0.732*
	[0.226]	[0.531]	[0.425]
Log Sales	-0.093	-0.110*	0.129*
	[0.079]	[0.058]	[0.068]
Book Leverage	0.236	-1.159	-0.836
	[0.962]	[1.681]	[1.041]
Tobin's Q	-0.009	0.025	0.064
	[0.067]	[0.131]	[0.075]
Intercept	1.018	-5.877	3.740***
	[0.770]	[0.000]	[1.053]
Observations	281	193	81
R-squared	0.094	0.162	0.307

Table 15– Sarbanes Oxley

Patent information comes from the NBER patent dataset provided by HJT (2001). Patents is the count of the number of patents. Compensation information comes from ExecuComp. Options are Black and Scholes value of options granted in a year. Sarbanes Oxley is a dummy variable that equals one if the year is greater than equal to 2002 and zero otherwise. Options delta is change in the value of options with a unit change in price. Options vega is change in the value of options with a unit change in volatility. Control variables include - Public debt is a dummy variable that equals one if a firm issued public debt. Segment dummy is a dummy variable which is equal to one if the firm has more than one business segment. Tangible/TA is the ratio of net fixed assets and total assets. HHI-Assets is the Herfindahl index of industry concentration calculated at a two-digit SIC code level. Firmage is based on data from Jay Ritter's website and the first appearance made by a firm in the CRSP database. Additional control variables include year, state and Fama French 49 Industry fixed effects. Standard errors clustered at firm level are reported in parentheses, p-value 0.0001***, 0.001**, 0.01*.

	Patent				Citations			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Sarbanes Oxley	-0.146**	0.269	-0.332*	-0.246*	-1.330***	-0.042	-1.589***	-1.367***
	[0.051]	[0.255]	[0.141]	[0.122]	[0.087]	[0.443]	[0.219]	[0.194]
Sarbanes Oxley × Log Options		-0.043		-		0.141*		
		[0.033]		[		0.057]		
Log Options		0.130***		0		.252***		
		[0.024]		[		0.036]		
Sarbanes Oxley × Wealth Delta			-0.127*		-		0.201*	
		[	0.065]		[		0.103]	
Wealth Delta		0	.149**		0		.235**	
		[	0.054]		[		0.080]	
Sarbanes Oxley × Wealth Vega			-	0.063		-		0.057
				[0.048]				[0.077]
Wealth Vega		0		.086*		0		.119
				[0.049]				[0.072]
Intercept	-1.805***	-2.627***	-1.804***	-1.957***	-0.025	-0.796	0.751	0.485
	[0.409]	[0.403]	[0.438]	[0.444]	[0.563]	[0.656]	[0.703]	[0.709]
Observations	5687	4601	4334	4334	5687	4601	4334	4334
R-squared	0.337	0.344	0.337	0.335	0.396	0.399	0.390	0.389

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