Employee Stock Options and Corporate Innovation

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Abstract

We examine whether employee stock options motivate employees to contribute to corporate innovation. Our analysis shows that the innovation output in a firm measured by the numbers of total patents applied, total citations of the patents, and citations per patent significantly increases with the non-executive stock options per employee after controlling for the research and development (R&D) expenditures and CEO incentives. The positive effects of employee stock options on corporate innovation are more evident in subsamples of firms in more unionized industries, firms where employees are more difficult to retain, firms with a weaker free-riding problem among employees, firms whose stock options have a longer expiration period, and firms that organize a broad-based employee stock option plan. Finally, we show that the enhancement of corporate innovation productivity is mainly from an increase in employees' risk-taking incentives (vega) rather than employees' interest-alignment incentives (delta). Taken together, these findings suggest that employee stock options enhance employees' risk-taking incentives and failure-bearing capacities in a firm's high risk-profile innovative activities, leading to a significant improvement in the productivity of corporate innovation.

Most great ideas for enhancing corporate growth and profits aren't discovered in the lab late at night, or in the isolation of the executive suite. They come from the people who daily fight the company's battles, who serve the customers, explore new markets and fend off the competition. In other words, the employees.

The Wall Street Journal (*August 23, 2010*) – *"Who Has Innovative Ideas? Employees."*

I. Introduction

Innovation has become an increasingly important corporate strategy that boosts the long-term growth and enhances the competitiveness of a firm. On the one hand, by fostering the innovative streak, *Google*, one of the top two most innovative companies according to *Business Week*'s annual survey in 2010, has achieved phenomenal success in the last thirteen years, growing from a small firm to a company with approximately $200 billion market cap today. One of the most important factors behind *Google*'s success is that it aptly understands and adopts the credo that creativity is nurtured from individual employees. *Google* describes its innovation policy as "*Our commitment to innovation depends on everyone being comfortable sharing ideas and opinions. Every employee is a hands-on contributor, and everyone wears several hats. Because we believe that each Googler is an equally important part of our success…*"

On the other hand, according to the *New York Times*, *Google* employees and former employees are holding exercisable (vested) options that are worth roughly $2.1 billion by the end of November, 2007. In addition, unvested options and the stock that employees hold amount to $4.1 billion (The *New York Times*, November 12, 2007). Is this intensive use of employee stock options simply a generous means, on part of the employer, of sharing profits with employees or a key driving force behind *Google*'s business success? In this paper, we examine this issue from the perspective of the incentive effect created by stock options on employees' innovativeness.[1]

[1] Politicians and corporate executives generally support the positive effect of employee stock options on corporate innovations. For instance, in a news release, *Dreier and Eshoo Reintroduce Stock Options Legislation* (February 17, 2005), the Congressman David Dreier, also the Chairman of the U.S. House Rules Committee stated that "The U.S. House of Representatives overwhelmingly voted for legislation that would have ensured the continued ability of innovative companies to offer stock options to rank-and-file employees…Giving investors the ability to understand how stock options impact the value of their shares is critical. And equally important is preserving the ability of companies to use this innovative tool to attract talented employees." In addition, Cisco Systems, Inc., the world leader in the communications and information technology, stated in its high tech policy guide that "Employee stock options fuel innovation and the entrepreneurial spirit."

Innovation is about people. Innovation arises when active, motivated and engaged people generate ideas, consider and evaluate ideas, make prioritization decisions, prototype or pilot, and convert ideas into new products, services or business models. Recent literature in corporate finance examines the mechanism that motivates people to be more innovative in the corporate innovative activities. The theoretical work of Manso (2010) and the experimental study of Ederer and Manso (2011) show that incentives that do not penalize failure and promote long-term success lead to more innovative business strategies. Empirical studies discussing the mechanisms that foster innovations are generally consistent with these arguments. For instance, Chemmanur and Tian (2011) find that anti-takeover provisions increase a firm's innovation productivity by insulating managers from short-term pressures from the corporate control market, thus allowing managers to focus on long-term firm value creations. Aghion, Van Reenen, and Zingales (2009) argue that higher institutional ownership lowers the likelihood of CEOs being fired and that the alleviation of CEOs' career concern is associated with higher innovation efficiency. Tian and Wang (2011) document that IPO firms backed by more failure-tolerant venture capital investors are associated with better innovative outcomes. Francis, Hasen, and Sharma (2011) investigate the role of executives' incentive pay in fostering innovation and find that the convexity of pay-offs created by stock options incentivizes managers to assume more risk, resulting in a positive impact on the innovation productivity.

Although these studies enhance our understandings of the mechanisms that motivate managers to be more innovative, the role of non-executive employees and their compensation schemes in affecting corporate innovations receives little attention. This lack of evidence is surprising since the companies, beginning in the late 1980s, have changed the innovation process by replacing the centralized corporate research and development (R&D) laboratories with divisional laboratories, where employees emerge as the most important innovators in a firm (Lerner and Wulf (2007)).[2]

In this paper, we focus on the role of employees as the key generator of innovative ideas and examine how employee stock options influence the innovation efficiency in a firm. We hypothesize

[2] Anecdotal evidence in Harden, Kruse, and Blasi (2008) is consistent with this view that employees are the most important innovation generators in a firm: "Whirlpool credits their successful product innovations not to a couple of departments, such as engineering or marketing. Instead, they contribute their success to the 61,000 employees who have the ability to contribute and develop product, service, or processes innovations (pp. 4)."

that employee stock options, as an important group incentive scheme, improve employees' failure-bearing ability and encourage their risk-taking behaviors, and thus enhance the efficiency of corporate innovation.

Holmstrom (1989) points out that corporate innovation, unlike conventional corporate investments, involves a high probability of failure due to its dependence on various unpredictable contingent conditions. A standard pay-for-performance system created by the incentive compensation is not able to provide sufficient failure tolerance for the risk associated with the innovative activities. The award of stock options with a long vesting schedule and expiration period to employees solves this problem for three reasons. First, employee stock options encourage employees' risk-taking behaviors. Abundant literature in relation to the executive compensation documents that executive stock options encourage managers to assume more risk as managers' wealth is positively related to the stock return volatility (Smith and Stulz (1985), Guay (1999)). In the same vein, we expect that the convexity of wealth-performance relation created by employee stock options incentivizes employees to take more risk, and thus has a beneficial influence on the innovation productivity. Second, employee stock options create an effective failure-bearing mechanism. Oyer (2004) argues that the asymmetric payoff structure of the stock option rewards employees when the firm's stock performance is favorable but protects them in the event of adverse stock prices. Stock options therefore create a strong employee retention mechanism especially when the correlation between employees' outside opportunities and their firms' performance is high. Consequently, employee stock options improve employees' willingness and ability to tolerate failures in risky innovative activities. Finally, employee stock options usually have a long vesting period of more than three years and a long average time to expire (e.g., Core and Guay (2001), Murphy (2003), Graham, Lang, and Shackelford (2004)). The deferral feature of employee stock options helps overcome the problem of employee myopia and ensures a long-term commitment, diffusing the threat of departure of key employees and encouraging employees' firm-specific human capital investment (Rajan and Zingales (2000)).[3] Taken together, these arguments and empirical evidence suggest that employee stock

[3] Lerner and Wulf (2007) and Francis, Hasen, and Sharma (2011) examine the relationship between executive incentive contracts and innovation and find that only compensation components tied to long-term incentives

options can serve as an effective tool encouraging employees to participate in risky innovative activities, which yield high innovation productivity.

Using 1,672 firms (7,866 firm-years) in industries that must have at least one patent in any year from the National Bureau of Economic Research (NBER) Patent and Citation Database between 1993 and 2003, we examine whether employee stock options affect the number of patents and citations of patents, both of which, according to Griliches (1990) and Aghion, Van Reenen, and Zingales (2009), reflect the most important measure of innovative output and the productivity of R&D.[4] We rely on the ExecuComp to estimate the Black-Scholes value of non-executive stock options. Following Core and Guay (2001) and Bergman and Jenter (2007), we define non-executive employees as all employees except the top five executives in a firm. Further, we examine how employee interest alignment incentive (delta) and risk-taking incentive (vega) created by non-executive stock options affect the innovative outcomes. To this end, we use the IRRC Dilution Database to define individual employee's delta and vega for a subsample of 1,147 firms (3,614 firm-years) between 1998 and 2003.[5]

We find the results to be consistent with our hypothesis that non-executive stock options have a positive effect on the productivity of a firm's innovative activities. Specifically, the evidence indicates that the value of non-executive stock options per employee is positively related to the number of patents, the total number of citations of patents and the average number of citations per patent after we control for the R&D expenditures, CEO compensation incentives, and other determinants of innovation output documented in previous literature. Economically, holding other explanatory variables at their mean levels, a one standard deviation increase in the value of non-

have a positive impact on corporate innovations. Moreover, in addition to the employee retention and encouragement of human capital investment, Rajan and Zingales (2000) point out that employee stock options are also an important profit-sharing mechanism which prevents the agency conflict by granting employees voting power until the options are exercised.

[4] The sample period of the NBER Patent and Citation Database is from 1976 to 2006. Since we date patent according to the application year, we take a 3-year "safety lag" to address the truncation concern following Hall, Jaffe, and Trajtenberg (2001). Hence we stop the sample in 2003. See Section III for details.

[5] The IRRC collects information on year-end outstanding grants, weighted average exercise price of options outstanding, and weighted average contractual life of outstanding options, allowing us to track the characteristics of a firm's entire option portfolio. We calculate individual employees' interest alignment incentive and risk-taking incentive as the sensitivity of employee wealth to an increase in the stock price in a firm (i.e., per employee delta of the firm's outstanding non-executive option portfolio) and the sensitivity of employee wealth to an increase in the stock return volatility in a firm (i.e., per employee vega of the firm's outstanding non-executive option portfolio), respectively.

executive stock options per employee ($21,469.42) translates into a 14.8% increase in the average number of raw patents, a 23.7% and 18.1% increase in the counts of total citations adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time and technology class fixed effect, respectively and a 10.3% and 10.2% increase in the counts of average citation per patent calculated using the above-mentioned two methods, respectively.[6] These results suggest that as a risk-taking incentive and failure-bearing mechanism, non-executive stock options play a crucial role in fostering innovation output.

One concern with regard to our findings is that employee stock options may be endogenously determined. Omitted variables that are also correlated with innovation productivity may drive the observed effect of employee stock options. To address this concern, we perform two-stage least squares (2SLS) regressions by using two instrument variables, namely employee stock options in firms of other industries but in geographic proximity and the marginal tax rate of a firm. We find little evidence that the positive relation between non-executive stock options and innovation output measures is due to the endogeneity of non-executive stock options.

We perform a number of empirical tests to rule out alternative arguments that possibly explain our findings. For instance, a firm's governance environment and ownership structure are related to its employee stock option policy and are also associated with the innovative outcomes. Hence we control for multiple internal and external governance measures in the regressions. We also consider a variable, the cumulative abnormal return during the past three years of a firm's stock, as a proxy for management quality. Previous studies document that high quality managers, in an effort to retain employees, are more likely to grant stock options to the latter. In the meantime, these managers are also associated with more patents and citations. Finally, we include a financial constraint measure in the regressions to ensure that our findings are not driven by the possibility that financially constrained firms with increasing large expenditures on innovative activities are more likely to grant stock options to employees so as to save cash. We test these alternative explanations by including additional controls and find little support for them.

[6] Due to the finite length of the sample, the citations suffer from a truncation bias. Hence our citation counts are adjusted based on the quasi-structural approach and the fixed effect approach outlined in Hall, Jaffe, and Trajtenberg (2001).

We also investigate the effects on the positive relation between non-executive stock options and the innovation productivity of different firm and industry characteristics, terms of these stock options, and employee stock option plan feature. Specifically, we partition the sample according to the importance of labor retention and labor strength, the tendency of free-riding among employees, the average expiration period of stock options in a firm, and the target of the employee stock options. We find that our results are more pronounced in subsamples of firms in industries with lower employee voluntary turnover, firms with better employee treatment, and firms in more unionized industries. Moreover, our results are also more evident in subsamples of firms with a smaller number of employees and higher growth options for each employee. Finally, we observe that our results are mainly from firms whose stock options have a longer average expiration period and firms that grant options to employees on a broad-based basis rather than to selective employees.

Employee stock options increase the sensitivity of employees' wealth to both the stock price and the stock return volatility of their employers. To identify the channel through which employee stock options affect innovation productivity, we directly test the effects of delta and vega, induced by non-executive stock options, on the output of innovative activities. We include both the per employee delta and vega and the CEO delta and vega in the regressions. We find that non-executive vega per employee has a significant positive impact on innovative outcomes at less than the 1% level, while per employee delta has no significant effect. These results are consistent with Manso (2010) and support our hypothesis that non-executive stock options encourage employees' innovative activities by altering employees' risk aversion.

Our work is related to several recent studies that examine the role of senior management in promoting corporate innovation. For example, Francis, Hasan, and Sharma (2011) investigate the effect of CEO compensation incentives on innovation and find that long-term incentives, in the form of options and golden parachute that entitles CEOs to certain benefits in the event of employment termination, are positively related to patents and citations of the patents. Hirshleifer, Low, and Teoh (2011) examine the role of CEO psychological traits in corporate innovation and show that firms with overconfident CEOs obtain greater innovation success such as more patents and patent citations for given R&D expenditure. Aghion, Van Reenen, and Zingales (2009) present evidence that institutional ownership mitigates CEOs' career concern of being fired in the face of profit downturns, thereby spurring innovation output.

Our paper is different from the above-mentioned papers for an important reason. While previous studies emphasize the role of executives in the innovation process, our work focuses on non-executive employees who are the most important innovators since 1980s. To our best knowledge, this is the first paper that investigates the role of non-executive stock options as a group incentive scheme in the setting of corporate innovation by a large scale analysis. In addition, unlike prior papers that focus on executive incentives, our paper compares the effects of pay-performance sensitivity and risk-taking incentives created by employee stock options on innovation efficiency and identifies a channel through which employee stock options affect innovation productivity.

Furthermore, our paper complements previous studies that examine the motives for firms to grant stock options to non-executive employees and emphasizes how granting non-executive stock options induces employees to be more innovative, hence shedding light on the positive role of employees, as an important stakeholder, in affecting firm value via corporate innovation.[7] Last but not least, our analysis also suggests a channel through which non-executive stock options affects the firm performance and hence complements the findings of Hochberg and Lindsey (2010), who show a positive relation between non-executive stock option and firm performance.

II. Related Literature

A. Risk-taking Incentives and Employee Failure-Bearing in Corporate Innovation

The theoretical work of Manso (2010) suggests that incentives that promote long-term success but do not penalize failure lead to more innovative business strategies. The experimental findings of Ederer and Manso (2011) also support this idea. Empirical research discussing the mechanisms to spur innovations is basically along this theme.

[7] Hall (1998) surveys the papers on how the financial markets value the knowledge assets of publicly traded firms and finds strong link between patents and the firm value. He also claims that the information on firm value, as conveyed by patents is beyond that conveyed by the R&D measure. Hirshleifer, Hsu, and Li (2011) also maintain that firms with higher innovative efficiency tend to be more profitable and have better operating performance.

For instance, Chemmanur and Tian (2011) find a positive association between anti-takeover provisions and a firm's innovation productivity and argue that the protection of managers against short-term pressures from the corporate control market encourages them to focus on long-term value-enhancing innovative activities. Francis, Hasan, and Sharma (2011) show that golden parachute that ensures managers certain benefits in the event of employment termination is positively related to a firm's patents and citations. Aghion, Van Reenen, and Zingales (2009) argue that higher institutional ownership ensures CEOs a secure job and hence helps overcome CEOs' myopia and promotes innovation productivity. Tian and Wang (2011) find that venture capital-financed IPO firms with a longer average investment duration in the past failed projects exhibit higher innovation productivity. In addition, several recent papers show that legal systems that are lenient to managerial or employee failures encourage innovation productivity. For instance, Fan and White (2003) and Armour and Cumming (2008) show that 'forgiving' personal bankruptcy laws encourage entrepreneurship and innovation. Acharya, Baghai, and Subramanian (2009, 2010) find that stringent labor laws and wrongful discharge laws that do not punish employees for short-run failures foster innovations. Furthermore, Francis, Hasen, and Sharma (2011) investigate the role of incentive pay in fostering innovation and find that CEOs' new options grants and previously granted unvested and vested options have a positive relation with innovation outputs. Moreover, they also find that a higher sensitivity of CEO wealth to the stock price volatility results in better innovative outcomes.

Finally, He and Wang (2009) suggest that innovative knowledge assets lead to greater information asymmetry among managers and firm owners. Consequently, unlike conventional shareholder monitoring that limits managerial discretion in making resource deployment decisions, incentive compensation is more innovative efficient. In a similar fashion, Lerner and Wulf (2007) suggest that the incentive pay as a risk-sharing mechanism is efficient in firms that rely heavily on inputs from intellectual capital since stock prices of these firms correspond more closely to factors within managers' control. Moreover, the pay linked to firm performance mitigates managers' incentives to fund their 'pet projects'. On the contrary, Holmstrom (1989) maintains that since innovation is risky, unpredictable, long-term and labor-intensive, the conventional incentive pay does not provide sufficient failure tolerance for the innovative activities and makes the risk-averse agents pass up risky projects. Hirshleifer and Suh (1992) argue that risk-averse managers, who already have a large amount of firm-specific human capital tied to the firm, prefer less risky projects when they receive extensive equity-based compensation.

B. Economic Functions of Non-executive Stock Option

Stock options, as an incentive-based compensation, are extended to non-executive employees on a large scale basis. The value of stocks issued to employees through compensation plans exceeds the total amount raised through seasoned equity offerings (SEOs) between 1985 and 2009 (McKeon (2011)). Figure 1 presents the aggregate Black-Scholes value of stock options granted to non-executive employees each year by S&P 1500 companies in industries that have at least one patent in any year from the NBER Patent and Citation Database between 1993 and 2003. The aggregate value of non-executive stock options increased over the period 1993 to 2003 and amounted to approximately $77 billion by the end of 2003. Figure 1 also plots the time trend of the annual mean and median values of non-executive stock options per employee. The mean and median values of non-executive stock options per employee also increased over the period. However, the bigger difference in the mean and median values implies a large variation in the stock option grant policies across firms.

Abundant literature documents the motives for firms to grant stock options to non-executive employees. For instance, employee stock options can be used by cash-constrained firms as a substitute for cash wages (Core and Guay (2001), Yermack (1995)).[8] Employee stock options are tax deductible and hence are able to generate substantial non-debt tax shields (Graham, Lang, and Shackelford (2004)).[9] The theoretical work of Inderst and Muller (2004) shows that, in bad state, non-executive stock options minimize firms' expected future wage payments, thereby reducing the adverse impact of employees' rent extraction by requiring high fixed wage on firm owners' inefficient

[8] Babenko, Lemmon, and Tserlukevich (2011) suggest that cash flows generated by the exercise of employee stock options alleviate firms' financing constraints and increase investment precisely when the demand for capital is high.
[9] Babenko and Tserlukevich (2009) find that the exercise of employee stock option creates direct tax benefits because employees are more inclined to exercise stock options when corporate taxable income is high, shifting corporate tax deductions to years of high tax rates.

exit. Firms also use non-executive options to sort certain types of employees. By assuming that employees have heterogeneous beliefs, Oyer and Schaefer (2005) posit that employee stock options attract optimistic and productive employee who value firm's stock options at more than their market price. Bergman and Jenter (2007) further take into account employees' ability to purchase stocks in the financial market and show that employee sentiment drives the granting of stock options by firms, to non-executive employees.

Furthermore, although some studies argue that equity-based compensation provides little incentives to employees due to the potential free-riding behaviors among employees, several papers present evidence that substantial benefits arise if employee equity-based compensation serves as a group-based incentive mechanism (e.g., FitzRoy and Kraft (1987), Blasi, Conte, and Kruse (1996)). For instance, Hochberg and Lindsey (2010) find that the pay-for-performance system created by employee stock options reinforces the mutual monitoring and cooperation among rank-and-file employees, resulting in better firm operating performance.

More importantly, the convexity of wealth-performance relation created by stock options promotes employees' risk-taking incentives (Murphy (2003)). This feature receives extensive attention in the studies of executive compensation (e.g., Smith and Stulz (1985), Guay (1999), Coles, Daniel, and Naveen (2006)), Low (2009)). However, few studies examine this feature in the framework of non-executive employee compensation. Besides, the payoff of stock options is structured to rewards employees for 'good luck' but shields employees from 'bad luck'. Such an asymmetric payoff structure effectively enhances employees' failure tolerance especially when opportunities in the outside labor market are correlated with firm performance (Oyer (2004)). In addition, the long-term nature of employee stock options' vesting and expiration periods (Core and Guay (2001), Murphy (2003), Graham, Lang, and Shackelford (2004)) encourages employee long-term commitment and helps overcome employee myopia, benefiting employees in accumulating firm-specific human capital (Rajan and Zingales (2000)).

In this paper, we treat stock options granted to non-executive employees as a tool to enhance employees' failure-bearing ability and risk-taking incentives in firms' risky innovative activities, and test for an increase in the innovation productivity, i.e., patents and citations of patents, in response to an increase in the value of non-executive stock options per employee. Furthermore, we also evaluate the role of individual employee's interest alignment and risk-taking incentives created by non-executive stock options in encouraging innovation productivity.

III. Data, Sample, and Empirical Design

A. Data and Sample

Our main sample consists of companies included in both the NBER Patent and Citation Database and the ExecuComp Database at any point between 1993 and 2003. The NBER Patent and Citation Database provides detailed information on all U.S. patents granted by the U.S. Patent and Trademark Office (USPTO) between 1976 and 2006. According to Hall, Jaffe, and Trajtenberg (2001), the average time lag between patent application date and grant date is two years. Patents applied in 2004 and 2005 may not be completely covered by the database as it only includes patents that are eventually granted. We hence follow Hall, Jaffe, and Trajtenberg (2001) and stop our sample period in 2003.[10]

Standard and Poor's ExecuComp is used to compute the value of non-executive stock options as well as CEO pay-performance sensitivity and risk-taking incentives. Financial data are from the Compustat Industrial Annual files and the data on stock prices and returns are retrieved from the Center for Research in Security Prices (CRSP) files. Furthermore, we follow Hirshleifer, Low, and Teoh (2011) and exclude firms in industries with no patents in any year and firms in financial and utility industries (SIC code: 6000-6999 and 4900-4999). Also excluded are firms with unidentified CEOs, negative CEO tenure, missing total compensation (ExecuComp data item *tdc1*), zero total compensation, and less than two top executives in a given year.[11] Finally, our sample consists of 1,672 firms (7,866 firm-years) between 1993 and 2003. Appendix A illustrates the construction of the sample. For a subsample of firms in our main sample, for which we can compute individual

[10] We use the patent application year rather than the grant year to merge the NBER Patent and Citation Database and the ExecuComp Database since Hall, Jaffe, and Trajtenberg (2001) suggest that the application date, compared to the grant date, is closer to the actual time of inventions.

[11] If there is more than one CEO for a firm in a year, we use the average across CEOs. We exclude firms with less than two top executives because Spalt (2011) argues that the adjustment for the grants of employee stock options in these firms demonstrated in Section III.B.1 is not sufficient to rule out incentive motives for executive option grants.

employees' delta and vega using the data from the IRRC Dilution Database, we identify 1,147 firms (3,614 firm-years) between 1998 and 2003.

Other data sources utilized in the paper include the IRRC Governance and Director Databases from which we obtain the corporate governance index and board characteristics respectively and CDA/Spectrum from which we obtain institutional holding data. We also extract industry employee voluntary turnover rates from the Bureau of Labor Statistics, employee treatment ratings from the KLD Research & Analytics, Inc.'s SOCRATES Database, and the industry unionization rate at the four-digit SIC level from the *Unionstats*.[12]

B. Variables

B.1. Measuring Innovation

Our first measure of innovation is the number of patents applied by a firm in a given year (*#patent*). The patent count, however, is not able to fully capture the underlying technological and economic heterogeneity of innovation. We therefore use citations of patents to measure the quality of innovation, following Hall, Jaffe, and Trajtenberg (2001, 2005).[13] The raw citation count suffers from the truncation bias due to its lifetime-dependency. For example, a patent's post-2006 citations are not counted if 2006 is not the end of its lifetime. This truncation bias is more severe for more recent patents since they have less time to accumulate citations than patents created in earlier years. We use two methods to deal with the truncation bias. First, we adjust each patent's raw citation count by multiplying the weighting index from Hall, Jaffe, and Trajtenberg (2001, 2005), also provided in the NBER Patent and Citation Database. The weighting index is derived from a quasi-structural model, where the shape of the citation-lag distribution is econometrically estimated. *Qcitations_t* and *Qcitations* are the sum and average of the adjusted citations across all patents applied during each firm-year using this weighting scheme. Second, we adjust the raw citation counts using the fixed-

[12] *Unionstats* is complied by Hirsch and Macpherson (2003). This database reports unionization rates for industries classified using three-digit Census Industry Classification (CIC) codes. We match CIC codes with the three- or four-digit SIC codes and manually assign unionization rates to firms in our sample.

[13] We do not exclude self-citations since Hall, Jaffe, and Trajtenberg (2005) find that self-citations are more valuable than external citations. They argue that self-citations, which come from subsequent patents, represent strong competitive advantage, less need of technology acquisition, and lower risk of rapid entry.

effect approach. Specifically, we scale the raw citation counts by the average citation counts of all patents applied in the same year and technology class. The fixed-effect approach purges the data from any effect due to truncation and the different propensity of different year and technology class to cite without making any additional assumptions. However, this approach cannot identify the real part of the propensity, which is related to true knowledge and value generation, and remove it as well.[14] *TTcitations_t* and *TTcitations* are the sum and average of the adjusted citations during each firm-year for the time and technology class fixed effects.

B.2. Measuring Non-executive Employee Stock Options

We follow Bergman and Jenter (2007) and Kumar, Page, and Spalt (2011) to calculate the value of non-executive stock options (*E-option*). Firms are not required to disclose the number of option grants to non-executive employees. However, this number can be extrapolated by using the "*pcttotop*" from the ExecuComp, which indicates the percentage of each grant to top five executives in all option grants by a firm (Desai (2003), Bergman and Jenter (2007), Kumar, Page, and Spalt (2011)). Specifically, we estimate the total number of option grants in a given firm-year for each option grant to executives. Following Bergman and Jenter (2007), we use the mean of these estimates as the total number of option grants and exclude observations in which the sample standard deviation of these estimates is greater than 10% of the mean. Subsequently, we calculate the option grants to non-executive employees by subtracting the option grants to top five executives from the total options granted by a firm (Core and Guay (2001), Bergman and Jenter (2007)). Finally, we compute the Black-Scholes value of non-executive stock options and scale it by the number of employees. As the exercise price and time to maturity of non-executive options are not reported in the ExecuComp, we set the exercise price as the midpoint of the year-high and year-low stock prices from the Compustat and assume that the maturity is 7.5 years, consistent with prior literature. Other Black-Scholes inputs such as annualized volatility of the past 36 months' monthly stock returns and dividend yield are

[14] See Atanassov (2008) and Hirshleifer, Low, and Teoh (2011) for a detailed discussion for the drawback of this approach.

calculated from the Compustat and CRSP Merged Database. Risk-free rates are retrieved from the Federal Reserve files. All option values are measured at the fiscal year end each year.

To estimate employees' pay-performance sensitivity (delta) and risk-taking incentives (vega), we rely on the IRRC Dilution Database since the ExecuComp does not provide any information on the characteristics of a firm's entire portfolio of outstanding option grants, while the IRRC Dilution Database provides information on year-end outstanding grants, weighted average exercise price of options outstanding, weighted average life of outstanding options and other details of the S&P 1500 firms. Thus we are able to calculate the delta and vega for the entire option holdings in a firm.[15] By subtracting the delta and vega of the top five executives' option holdings from the delta and vega for all options outstanding, we estimate per employee delta (*E-delta*) and vega (*E-vega*) as the sensitivity of employee option value to a 1% increase in stock price divided by the number of employee and the sensitivity of employee option value to a 1% increase in the stock return volatility divided by the number of employees, respectively.

B.3. Other Explanatory Variables

To identify the effects of non-executive stock options on the innovation productivity, we control for an array of firm characteristics that have been documented as important determinants of innovation. Our first control variable is the input of innovation, R&D expenses scaled by assets (*R&D/Assets*). Furthermore, we control for firm size (*Ln*(*Assets*)), defined as the log of total assets and capital intensity (*Ln*(*PPE/#employees*)), defined as the log of the net Property, Plant, and Equipment (PPE) scaled by the number of employees since Hall and Ziedonis (2001) argue that large firms and capital-intensive firms are associated with more patents and citations. Since financially constrained firms, investing heavily in innovative activities, are associated with a greater use of stock

[15] For the purpose of consistency, we do not use the Black-Sholes inputs such as stock price, stock return volatility, dividend yield, and risk-free rates provided by the IRRC Dilution Database when calculating the incentive measures. Instead, we use the same Black-Sholes inputs as those used to calculate the value of non-executive stock options and executive incentive measures in the ExecuComp sample.

option to save cash (Core and Guay (2001)), we control for the cash holdings (*Cash/Assets*) of a firm.[16]

We also control for profitability (*ROA*), growth opportunities (*Sales growth* and *Tobin's q*) and leverage ratio (*Leverage*) to be consistent with prior literature on innovation. Additionally, Hirshleifer, Low, and Teoh (2011) find that high innovation productivity is associated with better stock performance. Hence, we include the compounded monthly stock returns over the fiscal year (*Stock return*). Since stock return volatility is positively related to innovation (Campbell et al. (2001)), we include the standard deviation of monthly stock return over the past fiscal year (*Stock volatility*) as an additional control. Core and Guay (2001) argue that non-executive stock options attract and retain high quality employees. As a consequence, it is possible that higher labor productivity leads to higher innovation productivity. We hence control for the labor quality (*Ln*(*Sales/#employees*)), which is defined as the log of sales per employee similar to Faleye, Mehrotra, and Morck (2006). Aghion et al. (2005) document an inverted-U relationship between product market competition and innovation. Accordingly, we include Herfindahl index at the three-digit SIC and its squared item as controls similar to Atanassov (2008) and Chemmanur and Tian (2011).

Francis, Hasan, and Sharma (2011) find that CEO pay-performance sensitivity (*CEO delta*) harms their innovative incentives, while CEO risk-taking incentive (*CEO vega*) encourages the innovation efficiency. We therefore control for the log of one plus CEO delta (*Ln*(*1+CEO delta*)) and the log of one plus CEO vega (*Ln*(*1+CEO vega*)) in the regressions.[17] Finally, we include the log of one plus CEO tenure (*Ln*(*1+CEO tenure*)) following Hirshleifer, Low, and Teoh (2011). All our control variables, except for stock return and stock volatility, are lagged by one period and all variables are winsorized at 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator.

C. Descriptive Statistics

[16] Ittner, Lambert, and Larcker (2003), however, document that new economy companies with greater cash flows use employee options more extensively.

[17] These CEO incentive measures are constructed based on the method outlined in Core and Guay (2002).

Table I presents the sample distribution and the annual breakdown of median and mean patent and citation counts as well as the value of non-executive stock options per employee. As shown in column (2), the number of firms gradually increases over the sample period. Columns (3) and (4) report the number of firms with non-zero patents and with non-zero citations, respectively. Each year, approximately 50% of firms apply for patents and receive citations from their patents applied. This ratio is stable over the entire sample period.

Columns (5) and (6), and (7) and (8) show the annual median and mean raw patent and raw citation counts after the removal of firms with zero patents and citations, respectively, and columns (9) and (10) show the annual median and mean raw citations per patent for firms with non-zero citations. We observe that the counts of patents and citations are higher in early periods than that in recent years. The large difference between their median and mean values indicates that these measures are highly skewed. Hence we use the log form of these measures in the regression analysis. Columns (11) and (12) report the annual median and mean values of non-executive options per employee. There is an upward trend in the dollar value of non-executive options per employee from 1993 to 2000, followed by a slight fall in 2003, possibly due to the burst of the dotcom bubbles.

Columns (1) to (3) of Table II report the summary statistics for the whole sample. In columns (4) to (7) we bifurcate firms into two groups according to the median value of *E-option* each year. Panel A summarizes firm characteristics. We find that firms with higher values of *E-option*, compared with those with lower values, are smaller and more profitable, and have a smaller number of employees, greater growth opportunities measured by *Tobin's q* and *Sales* growth, higher capital intensity and leverage, and larger cash holdings. These firms also have higher labor productivity and stock volatility, and are more likely to invest in R&D activities.

Panel B reports statistics for non-executive employee *versus* CEO compensation terms of our sample. The mean and median values of *E-option* are $8,880 and $1,192, respectively. The number of option grants to non-executive employees is on average 5.43 times as large as the number of options granted to top five executives, suggesting that the incentive pays of non-executive employees as a whole are larger than those of executives. *E-delta* and *E-vega* for our subsample from the IRRC Dilution Database are on average $490.81 and $233.58, respectively. In contrast, the mean values of

CEO delta and *CEO vega* are much larger and equal to $618,041 and $75,813, respectively. We also observe that firms in the high *E-option* subsample have higher *CEO delta* and *CEO vega* than firms in the low *E-option* subsample. A comparison of medians in both subsamples yields similar implications.

Panel C reports the summary statistics for our corporate innovation measures. On average, a firm applies for 13.87 patents each year and receives 2.70 citations for each of its patent. The total citations of patents adjusted based on the weighting scheme of Hall, Jaffe, and Trajtenberg (2001, 2005) (*Qcitations_t*) and on the year and technology class fixed effect method (*TTcitations_t*) are 515.56 and 40.14, respectively, and the corresponding mean values of average citations per patent (*Qcitations*) and (*TTcitations*) are 6.46 and 0.55 counts, respectively. Consistent with our hypothesis, firms in the high *E-option* subsample, compared with firms in low *E-option* subsample, are more innovative as measured by both patent and citation counts. Apple Computer, which has 2,159 (24.44) *Qcitations_t* (*Qcitations*) and 122.85 (1.10) *TTctiations_t* (*TTcitations*), is identified as one of the most innovative firms based on all our measures of innovations.

D. Empirical Methodology

We test the effects of non-executive stock options per employee on a firm's patenting activities and patent citations by using the following baseline model:

$$Ln(1+Innovation) = c_1 + c_2 Ln(1+E-option) + \boldsymbol{c_3 X} + \varepsilon \quad (1)$$

where *Innovation* refers to the number of patents, total citations of patents, and average citations per patent. The key explanatory variable is the log of one plus *E-option* (*Ln*(*1+E-option*)). *X* is a vector of firm characteristics, which has been described in detail in Section III.B.3. We also include industry and year dummies in the regressions to control for the industry and time fixed effect. We allow for clustering of firm observations to adjust the standard errors for serial correlation and also correct standard errors for heteroskedasticity.

The above empirical model is subject to two types of endogeneity biases. The first type is regarding the omitted variable. In particular, if one omitted variable affects both a firm's innovation productivity and its value of non-executive stock options per employee, the relation we observe is spurious. The other possible endogeneity issue is the reverse causality. For instance, it is possible that innovative firms are more likely to grant stock options to their employees rather than the other way around. In this case, the coefficient estimates from the ordinary least squares (OLS) regressions are biased and inconsistent.

To address this issue, we use the instrument variable approach in the framework of a two-stage least squares (2SLS) regression. Our first instrument variable is *E-options in near firms in other industry*, which is constructed in the spirit of Hochberg and Lindsey (2010). Hochberg and Lindsey (2010) argue that local peers' option granting behavior affects an individual firm's option granting practices through local market competition or fixed-agent peers. The local same-industry firms should be excluded since the fundamentals of local firms within same industry correlate with each other. Hence we expect that such employee compensation practices of firms in geographic proximity but in other industries only affect a firm's innovation output through the employee stock options of the firm. We define *E-options in near firms in other industry* as the average value of *Ln*(*1+E-option*) for all companies in a firm's geographic region (defined by the two-digit ZIP code) but not in the firm's industry (defined by the three-digit SIC code). We expect this instrumental variable to be positively related to *Ln*(*1+E-option*). Our second instrument variable is the marginal tax rate of a firm. In contrast to the immediate tax deduction for cash compensation, stock options result in a future tax deduction from deferred compensation. Consequently, option compensation is more costly for firms with higher marginal tax rates (Core and Guay (2001), Hochberg and Lindsey (2010)). Therefore, we expect that the marginal tax rate affects innovative outcomes only through employee stock options of a firm and predict a negative relationship between marginal tax rate and option granting.[18] Our first stage model in the 2SLS regression is specified as:

$$Ln(1 + E - option) = c_1 + \boldsymbol{c_2 L} + \boldsymbol{c_3 X} + \varepsilon \tag{2}$$

where *L* denotes instrumental variables and *X* is a vector of control from the innovation equation. In the second stage, we use the predicted value of non-executive stock options per employee

[18] Even if the marginal tax rate can affect the R&D expenditures since these expenses are tax deductible, we do not expect marginal tax rate to directly affect the innovation quality after R&D expenditures are included in the regressions.

($\overline{Ln(1+E-option)}$) from equation (2) as the key explanatory variable in equation (3) and examine the effect of $\overline{Ln(1+E-option)}$ on the innovation productivity using the specification:

$$Ln(1+Innovation) = c_1 + c_2\,\overline{Ln(1+E-option)} + \boldsymbol{c_3 X} + \varepsilon \tag{3}$$

IV. Empirical Findings

A. Main results

Table III reports the results of our baseline regressions in equation (1). In column (1), the dependent variable is the total number of patents. The coefficient of *Ln*(*1+E-option*) is positive and significant (*t*-statistic = 2.7). Economically, the coefficient of 0.057 suggests that a one standard deviation increase in *E-option* ($21469.42) represents an increase in the average number of patents by almost 14.8%, holding other variables at the mean level.[19]

In columns (2) and (3), the dependent variables are the total number citation counts, i.e., the log of one plus *Qcitations_t* and *TTcitations_t*, respectively. In columns (4) and (5), the dependent variables are the average number of citation counts per patent, i.e., the log of one plus *Qcitations* and *TTcitations*, respectively. We find that the coefficients of *Ln*(*1+E-option*) are positive and significant in all of these regressions at less than the 5% level. In terms of economic significance, a one standard deviation increase in *E-option* increases the average number of *Qcitations_t* by 23.7%, *TTcitations_t* by 18.1%, *Qcitations* by 10.3% *and TTcitations* by 10.2%.

The coefficients of other control variables are generally consistent with prior literature. We find that firms with larger R&D expenditures are associated with higher innovation productivity. Furthermore, *CEO delta* has a negative but *CEO vega* has a positive relation with the innovative outcomes. The coefficient of *Ln*(*1+CEO tenure*) is negative but insignificant. These findings are

[19] For instance, to calculate the effects of non-executive stock options per employee on the number of patent counts at the mean level, we first multiply a one standard deviation of *E-option* ($21469.42) by the coefficients on *Ln*(*1+E-option*) (0.057), and by the mean number of patents plus one (13.87+1), and then divide by the mean value of *E-option* plus one (8880.01+1). (Note: $\frac{dLn(1+y)}{dln(1+x)} = \frac{(1+x)}{(1+y)}\frac{dy}{dx}$, $\frac{dy}{dx} = \frac{(1+y)}{(1+x)}\frac{dLn(1+y)}{dln(1+x)}$). A one standard deviation increase of E-option translates into a 2.05 increase in the number of patents. Given that the average number of patents that a firm applies for in a given year is 13.87, an increase of 2.05 patents represents an increase in the average number of patents by almost 14.8% ($\frac{2.05}{13.87}$).

consistent with Francis, Hasan, and Sharma (2011). Similar to Hirshleifer, Low, and Teoh (2011), we also find that larger firms, more profitable firms, and firms with more growth opportunities and better stock performance have more patents and citations. However, we find an insignificant impact of cash holdings and capital intensity on innovative outcomes. The coefficients on labor productivity are negatively related to innovative outcomes since Hochberg and Lindsey (2010) argue that firms with higher labor productivity are often more physical-capital-intensive than human-capital-intensive.

Table IV reports the results from the 2SLS regressions using the instrumental approach. Column (1) presents the results from equation (2). We find that the coefficient on the first instrumental variable, *E-options in near firms in other industry*, is significantly and positively related to *Ln*(*1+E-option*) (*t*-statistic = 5.2), and the coefficient on the second instrumental variable, the marginal tax rate, is negative and significant (*t*-statistic = -2.2). In the second stage, the coefficient of $\overline{Ln(1+E-option)}$ is positive and significant at less than the 5% level for all measures of innovation productivity. The over-identification tests also support the validity of these instrumental variables. In untabulated tests, we estimate 2SLS models using the methods of limited information maximum likelihood (LIML) and generalized method of moments (GMM) and find that our results are not affected by these alternative model specifications.

Taken together, the results suggest that non-executive stock options not only tolerate employees' failures in the short-run but also reward employees' success in the long run, thereby forming an effective group incentive to induce employees to be innovative and strongly enhancing the innovation productivity in a firm.

B. Alternative Explanations

To the extent that our measure of per employee stock options is associated with alternative interpretations, we perform several additional tests to eliminate the alternative explanations for our findings. First, Landsman, Lang, and Yeh (2006) find that firms with better governance are more likely to grant stock options to lower level employees than to CEOs. In the meantime, Chemmanur and Tian (2011) find that firms shielded with a larger number of anti-takeover provisions are associated with better innovative outcomes by alleviating the short-term pressure on managers from the corporate control market. Moreover, Atanassov (2008) points out that an effective board structure may mitigate the negative impact of anti-takeover legislation on innovation efficiency. These results suggest that non-executive stock options may capture the effect of the governance status such as the anti-takeover defense and the board monitoring in a firm. To investigate this possibility, we add a governance index (*G-index*) compiled by Gompers, Ishii, and Metrick (2003) and two additional controls of board size and board independence (percentage of independent directors) to regressions in Table III respectively and reestimate the regressions. The results reported in Panels A and B of Table V indicate that the coefficient of *Ln*(*1+E-option*) is still positive and significant.[20]

Second, although we control for CEO delta and vega in the regressions in Table III, non-executive stock options per employee may still be correlated with the incentives of other top executives. We hence calculate the delta and vega for the top five executives from the ExecuComp and include them in the regressions in Table III.[21] The results are presented in Panel C of Table V. We find that the coefficient of *Ln*(*1+E-option*) is still positive and significant. Furthermore, the delta of the top five executives has a negative relation and the vega of the top five executives has a positive relation with the innovation efficiency, in support of Manso (2010).

Third, prior literature documents that effective monitoring and incentive pay are substitutes (Eisenhardt (1988), Zhang (2011)). Consequently, a high institutional holding reduces the demand for the employee stock options as a tool to overcome the agency problem. Additionally, Graves (1988) finds that institutional investors negatively affect innovation in computer industry due to a short-term interest.[22] It is possible that firms with larger institutional holdings are less likely to grant options to employees and meanwhile are less interested in the long-term value enhancing innovative activities. To address this issue, we include institutional ownership as an additional control variable in the

[20] The coefficient of *G-index* is positive but insignificant. This may reflect a mixed effect of *G-index* on innovation productivity since Atanassov (2008) finds that the firms create fewer patents and fewer citations of patents after the enactment of anti-takeover laws in certain states, highlighting the agency issue in the corporate innovative activities. The board size has a negative but insignificant coefficient, while board independence has a significant positive effect on the innovation productivity, which provides supportive evidence to Atanassov (2008), who highlights the agency issue in the corporate innovative activities.

[21] We drop CEO tenure in the regressions in Panel C but adding it back does not change our results.

[22] Sherman, Beldona, and Joshi (1998) further examine the roles of different institutional investors and show that pension funds with long-term investment horizon have positive effects on innovation, while mutual funds with short-term investment horizon have negative effects innovation.

regressions and report the results in Panel D of Table V. We find that our results are not affected by the inclusion of institutional holdings.[23] Furthermore, Cai et al. (2010) find that undiversified managers owning a large stake in the firm tend to transfer the risk to employees by granting them more stock options. Francis and Smith (1995) argue that a concentrated ownership positively affects R&D expenditure since it reduces agency costs. To rule out this explanation, we include the ownership of the top five executives in the regressions in Table III and report the estimates from the regressions in Panel E of Table V. We find that controlling for the managerial ownership does not affect the significance of the coefficient of *Ln*(*1+E-option*).[24]

Fourth, Core and Guay (2001) argue that the importance of retaining employees is greatest in firms requiring higher-quality managers, thus resulting in a broad-based employee stock option plan. Meanwhile, Dey and Liu (2011) find that successful managers are associated with more patents and citations of patents. To see whether it is the management quality that drives our results, we follow Milbourn (2003) by including a proxy for management quality, *CAR*(*-3 year, -1 year*), defined as the cumulative abnormal returns (CAPM adjusted) during the past three years, in the regressions in Table III.[25] The results in Panel F of Table V suggest that the significance of the coefficient on *Ln*(*1+E-option*) is not affected by including the management quality measure.[26]

Finally, it is possible that innovative firms, which spend large expenditures on innovative activities, grant options to employees to save cash due to the financial constraint (Core and Guay

[23] However, the coefficient of institutional ownership is insignificant in most regressions. This may be due to the mixed effect of institutional ownership on innovative outcomes since in addition to the negative effect of institutional investor short-termism on innovations, Aghion, Van Reenen, and Zingales (2009) also find that institutional owners can encourage innovation efficiency by reducing managers' career concern on the risky projects.

[24] We find that the ownership of the top five executives has a negative effect on patents and citations of patents but not all are significant, which is not in support of Francis and Smith (1995) but is consistent with Ederer and Manso (2011) and Francis, Hasan, and Sharma (2011) who argue that the pay-for-performance created by the equity-based compensation harms managers' innovative incentives by increasing the volatility of their wealth.

[25] We exclude the past year stock return in the regressions since our management quality measure has already absorbed its effect.

[26] Alternatively, the measure of *CAR*(*-3 year, -1 year*) can also be used as a proxy for employee sentiment. Oyer and Schaefer (2005) and Bergman and Jenter (2007) argue that one of the major functions of non-executive stock options is to sort optimistic employees, who demand to be paid by options. To the extent that non-executive stock options help sort the most optimistic employees, who are the essential inputs to the innovation process, we also observe a positive effect of employee stock options on innovative outcomes. Similar to Bergman and Jenter (2007) who use the prior two-year stock return as a proxy for employee sentiment, our measure of *CAR*(*-3 year, -1 year*) also well captures the effect of employee sentiment as Benartzi (2001) suggests that employee sentiment improves with prior stock price performance.

(2001), Yermack (1995)). Although we include cash holdings in all of our regressions, to mitigate the concern on the financial constraint to drive our findings, we include Hadlock and Pierce's (2010) constraint index as an additional control in the regressions in Table III.[27] The results reported in Panel G of Table V suggest that the financial constraint arguments cannot explain our findings.[28]

C. Additional Sensitivity Tests

First, we consider a Negative Binomial model specification to estimate the regressions given the discrete nature of patent count and citation count. A Negative Binomial model is preferable to a Poisson model because the likelihood ratio test of no over-dispersion is rejected for all the models. Panel A of Table VI show that the results are robust to this alternative estimation method. In addition, to control for the time-invariant firm characteristics that are related to the innovation productivity, we introduce a mean scaling approach similar to Blundell, Grinffith, and Van Reenen (1999) and Aghion, Van Reene, and Zingales (2011).[29] Specifically, we calculate the pre-sample average of patents and citations given that we have a long pre-sample history on patenting behavior from 1976 to 1992. We then include these mean scaling factors in the Negative Binomial models in Panel A. The results are presented in Panel B of Table VI. We find that the coefficient of *Ln*(*1+E-option*) is positive and significant in all regressions except for the regression model with *TTcitations* as the dependent variable, in which the coefficients are positive but insignificant.

Second, we use an alternative measure for non-executive stock options per employee. Oyer and Schaefer (2005) argue that Core and Guay's (2001) measure of employees as all individual employees employed by the company except for the top executives reported in the ExecuComp is problematic since this definition wrongly includes a number of executives other than the top five executives. We use a calibration method similar to Oyer and Schaefer (2005) to construct a new measure of non-

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[27] We also include Kaplan and Zingales' (1997) constraint index and Whited and Wu's (2006) constraint index. The results are qualitatively the same.

[28] By construction, higher scores of Hadlock and Pierce's (2010) index indicate that firms are more financially constrained. We find that the Hadlock and Pierce's (2010) index has a negative effect on innovation output, suggesting that financially constrained firms have lower innovation efficiency, complementing the findings of Hirshleifer, Low, and Teoh (2011) that cash-constrained firms are less likely to expand the R&D expenditures.

[29] Aghion, Van Reene, and Zingales (2011) explain that the Monte Carlo evidence shows that the pre-sample mean scaling estimator performs well compared to alternative econometric estimators for dynamic panel data models with weakly endogenous variables.

executive stock options. In particular, we assume that the high-level management other than the top five executives in a firm receives an average grant one-tenth as large as the average executive in the second through fifth compensation rank. But unlike Oyer and Schaefer (2005) who assume that the number of these high-level managers is ten percent of the total number of employees, we follow Kumar, Page and Spalt (2011) and assume that the number of high-level managers in a firm can be approximated by the square root of the total number of employees since they argue that a linear estimate is likely to overstate the number of executives in large firms. We include this new measure in the regressions in Table III and present the results in Panel C of Table VI. We find that our results do not change qualitatively by using this alternative measure of per employee stock options.

Third, our sample contains a large number of zero patent and citation counts. To examine whether our results are driven by a structure break stemming from zero patents (citations) to at least one patent (citation), we remove all firm-year observations with zero patents (citations) and reestimate the regressions. In addition, to mitigate the sample selection bias, we employ a long-tenure approach by keeping only firms that organize the non-executive stock option plan for more than five years. We present the results in Panels D and E of Table VI and find that our results remain similar.

Fourth, to the extent that diversified firms, compared with single-segment firms, can self-cite across the different lines of business, we exclude a firm's self-citations from the total citation counts and reestimate the regressions. Furthermore, non-executive stock options usually have a long vesting period and a long expiration period (Core and Guay (2001), Murphy (2003), Graham, Lang, and Shackelford (2004)). To the extent that there is a considerable lag before the incentive generated by employee stock options turn into innovative outcomes, we add a two-year lag on the measure of non-executive stock options per employee and controls in the regression models. We report the results in Panels F and G in Table VI and observe that the results are not affected by the alternative variables and model specifications.

Fifth, Hirshleifer, Low, and Teoh (2011) argue that the innovative outcomes are more important in industries in which good opportunities for innovation are available. We hence create a dummy to denote the difference in industry innovativeness following the method outlined in Hirshleifer, Low, and Teoh (2011). Specifically, the innovative industry indicator takes a value of one if the industry level (two-digit SIC) *Qcitations* are above the sample median each year, and zero otherwise. Subsequently, we add an interaction term of *Ln*(*1+E-option*) and the innovative industry dummy together with *Ln*(*1+E-option*) in the regressions.[30] The results presented in Panel H of Table VI indicate that the coefficient on the interaction term is highly significant, which suggests that the effects of non-executive stock options on innovation efficiency are much stronger in innovative industries than in non-innovative industries.

Finally, in untabulated results, we also use total sales or the number of employees as alternative proxies of firm size; limit our sample period by removing the 98-00 due to tech bubbles; and control for the number of segments. Our results are insensitive to these parsimonious tests.

V. Further Analysis

A. Effects of Firm and Industry Characteristics and the Stock Option Terms

In this section, we examine the effects of firm and industry characteristics and the stock option terms on the cross-sectional relation between non-executive stock options and innovative outcomes. The control variables are the same as those in Table III. To save space, only coefficients estimated on key variables of interest are reported.

A.1. Importance of Employee Retention and Labor Strength

Bae, Kang, and Wang (2011) argue that employees who work in lower employee turnover industries are better educated and are more difficult to be retained and meanwhile firms are more likely to adopt employee friendly policy if they value employees' firm-specific human capital. In addition, extant literature documents that organized labor is easier to be coordinated as the union acts on behalf of individual employees as a group and a strong union also ensures that employees benefit from human capital investments by increasing employees' bargaining power (Klasa, Maxwell, and Ortiz-Molina (2009), Chen, Kacperczyk, and Ortiz-Molina (2011)). Given that employees' firm-specific skills are the fundamental input to innovation production, we expect that employee incentives

[30] Since we already control industry dummies in the regressions, we do not include the innovative industry dummy separately in the regressions.

provided by stock options have a stronger impact on the innovation productivity in firms where employees are more difficult to be retained and firms where labor strength is stronger.

To examine these effects, we partition the sample into high labor importance/strength (*High*) and low labor importance/strength (*Low*) subsamples according to three measures: (1) industry level employee voluntary turnover rate at the three-digit SIC from the Bureau of Labor Statistics; we classify firms with lower than the sample median of industry level employee voluntary turnover rate as *High* and firms with higher than the sample median of industry level employee voluntary turnover rate as *Low*;[31] (2) employee treatment index from the KLD Database;[32] we classify firms with larger than zero employee treatment index as *High* and firms with zero employee treatment index as *Low*; (3) industry unionization rate at the four-digit SIC level from the *Unionstats*; we classify firms with higher than the sample median of industry union coverage as *High* and firms with lower than the sample median of industry union coverage as *Low*. We reestimate the regressions in Table III for the two subsamples separately and report the results in Panel A of Table VIII. The results show that our findings are more pronounced in subsamples of firms in industries with lower employee voluntary turnover rate, firms with higher employee treatment index, and firms in more unionized industries. These results further confirm our conjecture that employee stock options can better improve the innovation productivity if employees are more difficult to be retained and the labor force is more organized.

A.2. Free-riding among Employees

Employee stock options form a strong group-based incentive device to promote the innovative outcomes. However, these incentives are diluted if free-riding problems are serious. Hochberg and Lindsey (2010) argue that the positive impact of non-executive stock options on firms' operating

[31] In Panels A1 and A3 of Table VII, the sample size for *High* is larger than that for *Low* because we include firms whose industry level turnover rate or unionization rate is equal to the sample median in *High* subsample. Including these firms in *Low* subsample does not change our results.
[32] We follow Bae, Kang, and Wang (2011) to construct the employee treatment index that ranges from zero and five. The employee treatment index covers the strength in five categories of employee relations including union relations, cash profit-sharing, employee involvement, retirement benefits strength, and health and safety strength. A higher value of employee treatment index indicates better employee treatment. See Bae, Kang, and Wang (2011) for a detailed description of these strengths.

performance is more likely to occur in firms with a weaker free-riding problem. Specifically, they argue that free-riding is weaker in smaller firms where the overall performance of the firm is more sensitive to the actions of individual workers and in firms with substantial individual growth opportunities where the ability of individual employees is more likely to influence the firm valuation. In the same vein, we expect that employee stock options in firms with a weaker free-riding problem have stronger effect on the innovation productivity.

Similar to Hochberg and Lindsey (2010), we divide our sample into two subsamples with high tendency of free-riding problem (*High*) and lower tendency of free-riding problem (*Low*) according to two measures: 1) the number of employees; we classify firms with higher than the sample median of the number of employees as *High* and firms with lower than the sample median of the number of employees as *Low*; 2) growth options per employee, which is defined as the market value of equity minus the book value of equity divided by the number of employees according to Core and Guay (2001); we classify firms with lower than the sample median value of growth option per employee as *High* and firms with higher than the sample median value of option per worker as *Low*. We repeat the regressions in Table III for both subsamples and present the results in Panel B of Table VII. The results indicate that our results are more evident in subsamples of firms with a smaller number of employees and higher growth options per employee. Collectively, these results provide supportive evidence for our prediction that non-executive stock options in firms with a weaker free-riding problem more effectively encourage risk-taking behaviors among employees, resulting in higher innovation efficiency.

A.3. Average Stock Option Expiration Period

Manso (2010) maintains that in the innovation process, the agents have superior information about the success rate of the projects. As a consequence, the optimal incentive contract for innovations must provide the agent with a long-term commitment. Francis, Hasan, and Sharma (2011) argue that stock options ensure a long-term commitment since they have a lengthy expiration period. Noting these arguments, we expect that the positive relation between employee stock options and innovative outcomes is stronger if a firm's options have a longer expiration period.

To explore this possibility, we split our sample into two subsamples with a long expiration period (*Long*) and a short expiration period (*Short*) according to the average expiration period for all stock options in a firm. Specifically, we classify firms whose stock options have a longer than the sample median of expiration period as *Long* and firms whose stock options have a shorter than the sample median of expiration period as *Short*. We reestimate the regressions in Table III for both subsamples. The results presented in Panel C of Table VII show that our results are more pronounced in subsamples of firms whose stock options have a longer expiration period. These results suggest that employee stock options with a longer expiration period create a long-term commitment for employees and prevent employees' myopic behaviors, thus enhancing innovation efficiency.

A.4. Targeted vs. Broad-based Non-executive Stock Option Plan

There is a large literature debating on the targeting of the non-executive stock option plan. On the one hand, Oyer and Shaefer (2005) and Bergman and Jenter (2007) document that attraction and retention of certain key employees are the major purpose of the non-executive stock option plan. On the other hand, Hochberg and Lindsey (2010) provide evidence that firms adopting a broad-based non-executive stock option plan, compared with firms merely granting stocks to certain key employees, experience a greater improvement in firm operating performance since broad-based plan creates an environment for mutual monitoring among employees where workers know all their co-workers have similar incentives.

To distinguish these two arguments, we construct a broad-based stock option plan dummy, which takes a value of one if the number of non-executive stock options over shares outstanding is greater than the sample median each year, and zero otherwise. We then use this variable to partition our sample into *Targeted* and *Broad-based* employee stock option plans. Since in Section V.A.2 we show that our results are mainly driven by firms with a smaller number of employees, we reestimate the regressions in Table III for the *Targeted* and *Broad-based* subsamples respectively in these firms.. We report the results in Panel D of Table VI. We find that our findings are more evident for subsamples of firms with *Broad-based* rather than *Targeted* plans. These results suggest that to attract and retain certain employees is not the major motive for firms to grant non-executive stock options. In contrast, mutual monitoring among rank-and-file employees induced by non-executive stock options is the major source of the effect of employee stock options on innovation productivity.

B. R&D Activities

Although we have examined the effects of non-executive stock options on innovation outputs such as patents and citations of patents, how non-executive stock options affect R&D activities, the inputs of innovations, is still unclear. In this section, we use R&D scaled by assets and R&D intensity measured as the log of one plus the R&D expenditure per employee as dependent variables to test the relation between non-executive stock options and R&D activities in a firm.

The results in Table VIII present the estimates from the OLS regressions. The models in columns (1) and (2) show a significant positive effect of non-executive stock options on both R&D expenditures and R&D intensity as the coefficients on *Ln*(*1+E-option*) are significant at less than the 1% level.[33] The results also suggest that firms with more investment opportunities measured by *Tobin's q*, poorer operating performance, and lower leverage are associated with higher R&D expenditures and R&D intensity. Consistent with Coles, Daniel, and Naveen (2006), we also find that lower CEO delta and higher CEO vega are associated with higher R&D activities. Similar to Hirshleifer, Low, and Teoh (2011), we find that firm with larger cash holdings spend more on R&D activities.

A caveat to the analysis is that we do not intend to establish a causal link between non-executive stock options and R&D activities in a firm. On the one hand, the management and the board of directors usually have significant discretions on the resources allocated to R&D activities (Francis, Hasan, and Sharma (2011)). The grant of non-executive stock options and the expansion of R&D expenditures can be an integrated strategy in a firm's innovation practice. On the other hand, it is also possible that non-executive stock options attract more innovative employees to engage in R&D activities.

[33] In untabulated tests, we reestimate the regressions in Table VIII by deleting firms with missing R&D expenditure and find similar results.

C. Employee Interest Alignment and Risk-taking Incentives and Innovation Productivity

Classical agency theory has argued that equity-based compensation aligns the interest between firm owners and managers, hence improving firm performance (Jensen and Meckling (1976), Holmstrom and Milgrom (1987)). One of the most motives for firms to adopt incentive-based forms of remunerations to employees is that conventional managerial monitoring is difficult in firms with high levels of intellectual capital. Furthermore, in these firms employees have better control over performance outcomes, consequently it is efficient to transfer risk to employees via incentive pay (Rajan and Zingales (2000)). Ample empirical evidence shows that employee equity-based pay can form an efficient risk-sharing channel. FitzRoy and Kraft (1987) and Blasi, Conte, and Kruse (1996) maintain that employee equity-based compensation induces co-monitoring and encourages cooperation among rank-and-file employees. Jones (1984) and Kandel and Lazear (1992) argue that employee incentive pay motivates employees to actively report the slack efforts of co-worker to managers and enforces group's attitudes towards shirking by exposing individual employees to peer pressure. He and Wang (2009) and Lerner and Wulf (2007) claim that the pay-for-performance system created by stock options can alleviate the managerial incentive to obtain private benefits at the expense of shareholders, e.g., funding 'pet projects' or selecting their own favorable labs. In a similar fashion, non-executive stock options, by aligning the interest of employees with that of shareholders, could reduce inefficient R&D investments and enhance the innovation productivity.

Notwithstanding, Holmstrom (1989) points out that the conventional pay-for-performance system that intends to solve the agency problem is inefficient in the high-risk innovative activities since the increased firm risk increases the volatility of manager's total firm-specific wealth. Thus, risk-averse managers may switch to less risky projects and pass up the value-enhancing innovative projects. The findings of Smith and Stulz (1985) and Hirshleifer and Suh (1992) provide supportive evidence for this argument. In addition, Ederer and Manso's (2011) experimental study also finds that a standard pay-for-performance incentive scheme does not encourage the discovery of a novel business strategy by the lab subjects. Taken together, whether the delta from non-executive stock options promotes or discourages innovation outputs is inconclusive.

Vega created by non-executive stock options is calculated as employees' wealth dollar change in their stock option holdings for one percent change in the volatility of the stock returns. Hence vega compared with delta is a more straightforward measure of employees' risk-taking incentives. Murphy (2003) maintains that the convex payoffs from options can induce otherwise risk-averse agents to take riskier projects. Guay (1999) also finds an increase in firms' stock return volatility in response to an increase of the CEO vega. Low (2009) shows that Delaware firms raise CEO vega after the passage of the anti-takeover law in mid-1990s to overcome the adverse effect of increasing protections on managers' risk-taking incentives. Moreover, Francis, Hasan, and Sharma (2011) present evidence that CEO vega has a positive relation with the number of patents and citations. Overall, these findings predict that vega from non-executive stock options is positively associated with innovative outcomes.

To comprehensively evaluate these arguments, we examine the per employee delta and vega from non-executive stock options simultaneously in the regressions analysis. The choice of control variables is similar to that in Section IV.[34] Table IX presents the estimates from the regressions. In Panels A and B, we control for CEO delta and vega, and the delta and vega of the top five executives in a firm, respectively. The results in Panels A and B indicate that non-executive delta per employee has an insignificant effect on the patens and citations in a firm, while non-executive vega per employee is significantly and positively associated with the innovation output measures at less than the 5% level.[35] Additionally, we also observe a positive sign on the coefficient of executive vega on the innovation productivity but a negative sign on the coefficient of executive delta on the innovation productivity of a firm, which are consistent with Francis, Hasan, and Sharma (2011) and Ederer and Manso (2011). However, none of the effects of executive incentive measures dominate the strong effect of vega from non-executive stock options on the innovative outcomes. Taken together, these results suggest that risk-taking incentive rather than the interest-alignment incentive created by non-executive stock options plays a crucial role in fostering innovation output.

[34] We drop CEO tenure in the regression where we include delta and vega of the top five executives. However, adding it back does not affect our results.

[35] In terms of economic significance, for Panel A, a one standard deviation increase in non-executive vega per employee increases the average number of patents by 23.5%, *Qcitations_t* by 35.2%, *TTcitations_t* by 22.8%, *Qcitations* by 14.4% and *TTcitations* by 13.0%. For panel B, these values are 19.5% for the number of patents, 29.8% for *Qcitations_t*, 19.3% for *TTcitations_t*, 11.7% for *Qcitations* and 11.6% for *TTcitations.*

VI. Summary and Conclusion

Innovation has become a core strategy to enhance a firm's competitiveness in the new millennium. How to design an appropriate incentive mechanism to foster innovation productivity constitutes a challenge to a firm's innovation practice. Despite abundant literature discusses various mechanisms to spur innovations, few studies examine the role of employees and employees' incentive scheme in the innovation production. Our paper fills this gap. Using a large sample of firms covered by both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003, we empirically examine the effects of non-executive employee stock options on the innovative outcomes.

We find that the value of non-executive stock options per employee has a significant positive relation with the number of patents, the total number of citations of the patents, and the average number of citations per patent even after we control for the R&D expenditure in a firm. These results are robust to several model specification tests and are more pronounced in subsamples of firms in industries with higher employee voluntary turnover rates, firms with better employment treatment, and firms in more unionized industries. We also find that the results are more evident in subsamples of firms with weaker free-riding problems and firms whose options have a longer expiration period. Finally, our results suggest that promoting mutual monitoring among employees rather than targeting certain key employees is the major purpose for firms to grant employee stock options to induce employees to be more innovative.

More importantly, for a subsample of firms for which we can calculate the pay-performance sensitivity (delta) and the risk-taking taking incentive (vega) created by non-executive options from the IRRC Dilution Database, we evaluate the effects of these incentive measures together with the executive incentives and find that only vega per employee is positively associated with the innovative outcomes, while delta per employee has no significant impact.

Overall, these results suggest that non-executive stock options as a group incentive scheme enhance employees' risk-taking incentives, improving the innovation efficiency. Meanwhile, the asymmetric payoff structure of stock option that protects employees from the adverse stock performance and rewards employees for favorable stock performance and the long-term vesting and expiration period of stock options create an effective failure-bearing mechanism, form a strong employee retention incentive, and encourage employees' firm-specific human capital investment, a fundamental input to the innovation production.

Our findings highlight the positive role of employee stock options as an effective tool to promote employees' innovation productivity and shed some light on the bright side of employees as an important innovation generator, hence enriching the stakeholder theory. Furthermore, our findings complement Hochberg and Lindsey (2010) by identifying a channel through which employee stock options exert a beneficial influence on firm performance.

Appendix A
Sample construction

This table contains the observation counts by fiscal year for the sample at different stages of construction. We start from all ExecuComp firms reported during 1992 to 2006 and merge the ExecuComp with Compustat and CRSP. The combined dataset is then merged with the NBER Patent and Citation Database. For the ExecuComp data, we remove firms, from which we are not able to identify CEOs and firms with negative CEO tenure, missing total compensation (*tdc1*) in ExecuComp and zero total compensation. In addition, if there is more than one CEO for a firm in a year (e.g., when there is a CEO turnover), the averages across CEOs are reported. For the NBER Patent and Citation data, the sample selection criterion is to exclude firms in industries that have no patent in any year.

Order	Key variables/selection criteria	Data source	Period	Number of observations
(1)	*numsecur* and *pcttotopt*: remove error observations and missing variables	ExecuComp - Stock Option Grants	1992 - 2006	129,062 executive-firm-years
(2)	Remove firm-years with standard deviation of the total number of option grants estimated from each executive option grant greater than 10% of the mean	ExecuComp - Stock Option Grants	1992 - 2006	113,106 executive-firm-years and 18,574 firm-years
(3)	Remove firm-years with less than two executives	ExecuComp - Stock Option Grants	1992 - 2006	17,344 firm-years
(4)	Remove firms without year-high and year-low prices from Compustat, 36 months of stock return data from CRSP to calculate stock return volatility, or other Black-Scholes (BS) formula inputs (the same as CEO options' BS inputs)	ExecuComp - Stock Option Grants, Compustat, and CRSP	1992 - 2006	16,682 firm-years
(5)	Remove missing lagged non-executive options and merge with Compustat, CRSP, and NBER Patent and Citation Database	ExecuComp - Stock Option Grants, Compustat, CRSP, and NBER Patent and Citation Database	1993 - 2003	11,991 firm-years
(6)	Merge with CEO delta and vega. Remove firms with no CEO, cannot identify CEO age, tenure, *tdc1* etc.	ExecuComp, Compustat, CRSP, and NBER Patent and Citation Database	1993 - 2003	11,446 firm-years
(7)	Drop financial and utilities and firm-years with missing dependent variables	ExecuComp, Compustat, CRSP, and NBER Patent and Citation Database	1993 - 2003	8,336 firm-years
(8)	Require non-missing control variables	ExecuComp, Compustat, CRSP, and NBER Patent and Citation Database	1993 - 2003	7,866 firm-years

Appendix B
Variable definitions

Variables	Definitions
#employees	Number of employees in thousands.
Assets	Total assets in millions.
Average Stock Option Expiration Period	Average expiration period for all stock options in a firm from IRRC Dilution Database.
Board Size	Number of board members from IRRC Director Database.
Broad-based Stock Option Plan Dummy	A dummy variable takes a value of one if the number of non-executive stock options over the total shares outstanding is above the sample median each year, and zero otherwise.
CAR(*-3 year, -1 year*)	Cumulative abnormal returns (CAPM adjusted) during the past three years.
Cash/Assets	Cash/total assets.
CEO Delta	Dollar change in CEO stock and option portfolio for 1% change in stock price, following Core and Guay (2002).
CEO Tenure	Number of years since he/she became the CEO of a firm from ExecuComp.
CEO Vega	Dollar change in CEO option holdings for a 1% change in stock return volatility, following Core and Guay (2002).
Citations (*raw*)	Total number of citations summed across all patents applied by the firm during the year.
E-delta	Dollar change in non-executive (other than top five executives) option portfolio for 1% change in stock price divided by the number of employees from IRRC Dilution Database, following Hochberg and Lindsey (2010).
E-option	Black-Scholes value of non-executive stock options per employee.
E-option in Near Firms in Other Industry	The log of one plus non-executive stock options per employee averaged across firms in the same two-digit ZIP code excluding the firm itself and others in its industry
E-vega	Dollar change in non-executive option holdings for a 1% change in stock return volatility divided by the number of employees from IRRC Dilution Database, following Hochberg and Lindsey (2010).
G-index	Gompers, Ishii and Metrick (2003) from IRRC Governance Database.
Growth Option per Employee	Market value of equity minus the book value of equity divided by the number of employees, following Core and Guay (2001).
Hadlock and Pierce's (*2010*) *Index*	-0.737 * Ln(Assets) + 0.043* Ln(Assets)]2 + 0.04*Age, from Hadlock and Pierce (2010).
Herfindahl Index	Industry Herfindahl index based on all Compustat firms, where industries are defined by 3-digit SIC.
Independent Directors (*%*)	Number of independent directors / board size from IRRC Director Database.
Industry Employee Voluntary Turnover Rate	Industry-level voluntary employee turnover rate during 2001 - 2006 from the U.S. Department of Labor.
Innovative Industry	An industry is innovative if the industry level (2-digit SIC) Qcitation is above the sample median each year.
Institutional Ownership	Shares owned by institutional investors/total shares outstanding from CDA/Spectrum Institutional (13f) Holdings.
KLD Employee Treatment Index	Summation of KLD ratings on firms' employee relations, including union relations, cash profit-sharing, employee involvement, retirement benefits strength, and health and safety strength, following Bae, Kang, and Wang (2011).
Leverage	(Short-term debt + long-term debt) / total assets.
Managerial Ownership	Shares owned by top five executives/total shares outstanding from ExecuComp.
Marginal Tax Rate	Simulated marginal tax rates obtained from John Graham. If missing, fill with marginal tax rates computed using coefficients reported in Table 4 (Panel B and Model C) of Graham and Mills (2008).
Non-executive Employees vs. Top Five Executive Option Grant Ratio	Number of options granted to non-executives employees/number of options granted to top five executives.
Patents (*raw*)	Number of patents applied for during the year.
PPE/#employees	Net property, plant, and equipment per employee in thousands.
Qcitations	Average number of citations of all patents applied by the firm during the year. Each patent's number of citations is multiplied by the weighting index from Hall, Jaffe and Trajtenberg (2001, 2005).
Qcitations_t	Total number of citations summed across all patents applied by the firm during the year. Each patent's number of citations is multiplied by the weighting index from Hall, Jaffe and Trajtenberg (2001, 2005).
R&D/Assets	R&D expenses/the total assets.
R&D Intensity	The log of one plus R&D expenses per employee.
ROA	Operating income before depreciation and amortization (EBITDA)/total assets.
Sales Growth	Ln(1+change in net sales scaled by the lagged net sales).
Sales/#employees	Sales per employee in thousands.
Stock Return	Compounded monthly stock returns over the fiscal year.
Stock Volatility	Annualized standard deviation of monthly stock return over the fiscal year.
Tobin's q	(Total assets + market value of equity - book value of equity) / total assets.
Top Five Executive Delta	Dollar change in top five executives' stock and option portfolio for 1% change in stock price,

	following Core and Guay (2002).
Top Five Executive Vega	Dollar change in top five executives' option holdings for a 1% change in stock return volatility, following Core and Guay (2002).
TTcitations	Average number of citations of all patents applied by the firm during the year. Each patent's number of citations is divided by the average citation count of all patents in the same technology class and applied in the same year.
TTcitations_t	Total number of citations summed across all patents applied by the firm during the year. Each patent's number of citations is divided by the average citation count of all patents in the same technology class and applied in the same year.
Union	Percentage of workforce in an industry employed by unions. The data is downloaded from the website maintained by Barry Hirsch and David Macpherson (www.unionstats.com).

Reference

Acharya, Viral V., Ramin Baghai, and Krishnamurthy Subramanian, 2009, Labor laws and innovation, NBER Working Paper.

Acharya, Viral V., Krishnamurthy Subramanian, and Ramin Baghai, 2010, Wrongful discharge laws and innovation, Working Paper, New York University.

Aghion, Philippe, Nick Bloom, Richard Blundell, Rachel Griffith, and Peter Howitt, 2005, Competition and innovation: An inverted-U relationship, *Quarterly Journal of Economics* 120, 701-728.

Aghion, Philippe, John Van Reenen, and Luigi Zingales, 2009, Innovation and institutional ownership, NBER Working Paper.

Armour, John, and Douglas Cumming, 2008, Bankruptcy law and entrepreneurship, *American Law and Economics Review* 10, 303-350.

Atanassov, Julian, 2008, Do hostile takeovers stifle innovation? Evidence from antitakeover legislation and corporate patenting, Working Paper, University of Oregon.

Babenko, Ilona, and Yuri Tserlukevich, 2009, Analyzing the tax benefits from employee stock options, *Journal of Finance* 64, 1797-1825.

Babenko, Ilona, Michael Lemmon, and Yuri Tserlukevich, 2011, Employee stock options and investment, *Journal of Finance* 66, 981-1009.

Bae, Kee-Hong, Jun-Koo Kang, and Jin Wang, 2011, Employee treatment and firm leverage: A test of the stakeholder theory of capital structure, *Journal of Financial Economics* 100, 130-153.

Bebchuk, Lucian A., K. J. Martijn Cremers, and Urs C. Peyer, 2011, The CEO pay slice, *Journal of Financial Economics* 102, 199-221.

Benartzi, Shlomo, 2001, Excessive extrapolation and the allocation of 401(k) accounts to company stock, *Journal of Finance* 56, 1747-1764.

Bergman, Nittai K., and Dirk Jenter, 2007, Employee sentiment and stock option compensation, *Journal of Financial Economics* 84, 667-712.

Blasi, Joseph, Michael Conte, and Douglas L. Kruse, 1996, Employee stock ownership and corporate performance among public companies, *Industrial and Labor Relations Review* 50, 60-79.

Blundell, Richard, Rachel Griffith, and John Van Reenen, 1999, Market share, market value and innovation in a panel of British manufacturing firms, *Review of Economic Studies* 66, 529-554.

Cai, Ye, Merih Sevilir, Edward D. Van Wesep, and Sean Wang, 2010, Managerial ownership and employee risk bearing, Working Paper, Indiana University.

Campbell, John Y., Martin Lettau, Burton G. Malkiel, and Yexiao Xu, 2001, Have individual stocks become more volatile? An empirical exploration of idiosyncratic risk, *Journal of Finance* 56, 1-43.

Chemmanur, Thomas J., and Xuan Tian, 2011, Do anti-takeover provisions spur corporate innovation? Working Paper, Boston College.

Chen, Huafeng (Jason), Marcin T. Kacperczyk, and Hernan Ortiz-Molina, 2011, Do non-financial stakeholders affect the pricing of risky debt? Evidence from unionized workers, *Review of Finance, forthcoming*.

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

Core, John E., and Wayne R. Guay, 2001, Stock option plans for non-executive employees, *Journal of Financial Economics* 61, 253-287.

Desai, Mihir A., 2003, The divergence between book income and tax income, *Tax Policy and the Economy* 17, 169-206.

Dey, Aiyesha, and Xiaohui Liu, 2011, CEO tenure, board composition and innovation, Working Paper, University of Minnesota.

Ederer, Florian P., and Gustavo Manso, 2011, Is pay-for-performance detrimental to innovation? Working Paper, MIT.

Eisenhardt, Kathleen M., 1988, Agency- and institutional-theory explanations: The case of retail sales compensation, *Academy of Management Journal* 31, 488-544.

Faleye, Olubunmi, Vikas Mehrotra, and Randall Morck, 2006, When labor has a voice in corporate governance, *Journal of Financial and Quantitative Analysis* 41, 489-510.

Fan, Wei, and Michelle J. White, 2003, Personal bankruptcy and the level of entrepreneurial activity, *Journal of Law and Economics* 46, 543-567.

FitzRoy, Felix R., and Korenelius Kraft, 1987, Cooperation, productivity, and profit sharing, *Quarterly Journal of Economics* 102, 23-35.

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

Francis, Bill B., Iftekhar Hasan, and Zenu Sharma, 2011, Incentives and innovation: Evidence from CEO compensation contracts, Working Paper, Bank of Finland.

Gompers, Paul, Joy Ishii, and Andrew Metrick, 2003, Corporate governance and equity prices, *Quarterly Journal of Economics* 118, 107-155.

Graham, John R., Mark H. Lang, and Douglas A. Shackelford, 2004, Employee stock options, corporate taxes, and debt policy, *Journal of Finance* 59, 1585-1618.

Griliches, Zvi, 1990, Patent statistics as economic indicators: A survey, *Journal of Economic Literature* 28, 1661-1707.

Guay, Wayne R, 1999, The sensitivity of CEO wealth to equity risk: An analysis of the magnitude and determinants, *Journal of Financial Economics* 53, 43-71.

Hadlock, Charles J., and Joshua R. Pierce, 2010, New evidence on measuring financial constraints: Moving beyond the KZ index, *Review of Financial Studies* 23, 1909-1940.

Hall, Bronwyn H., 1998, Innovation and market value, Working Paper, University of California at Berkeley.

Hall, Bronwyn H., Adam B. Jaffe, and Manuel Trajtenberg, 2001, The NBER patent and citation data file: Lessons, insights and methodological tools, NBER Working Paper.

Hall, Bronwyn H., Adam B. Jaffe, and Manuel Trajtenberg, 2005, Market value and patent citations, *RAND Journal of Economics* 36, 16-38.

Hall, Bronwyn H., and Rosemarie Ham Ziedonis, 2001, The patent paradox revisited: An empirical study of patenting in the U.S. semiconductor industry, 1979-1995, *RAND Journal of Economics* 32, 101-128.

Hamilton, Barton H., Jack A. Nickerson, and Hideo Owan, 2003, Team incentives and worker heterogeneity: An empirical analysis of the impact of teams on productivity and participation, *Journal of Political Economy* 111, 465-497.

Harden, Erika, Douglas L. Kruse, and Joseph R. Blasi, 2008, Who has a better idea? Innovation, shared capitalism, and HR policies, NBER Working Paper.

He, Jinyu, and Heli C. Wang, 2009, Innovative knowledge assets and economic performance: The asymmetric roles of incentives and monitoring, *Academy of Management Journal* 52, 919-938.

Hirsch, Barry T., and David A. Macpherson, 2003, Union membership and coverage database from the current population survey: Note, *Industrial and Labor Relations Review* 56, 349-354.

Hirshleifer, David, and Yoon Suh, 1992, Risk, managerial effort, and project choice, *Journal of Financial Intermediation* 2, 308-345.

Hirshleifer, David A., Po-Hsuan Hsu, and Dongmei Li, 2011, Innovative efficiency and stock returns, Working Paper, University of California, Irvine.

Hirshleifer, David A., Siew Hong Teoh, and Angie Low, 2010, Are overconfident CEOs better innovators? Working Paper, University of California, Irvine.

Hochberg, Yael V., and Laura Lindsey, 2010, Incentives, targeting, and firm performance: An analysis of non-executive stock options, *Review of Financial Studies* 23, 4148-4186.

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

Holmstrom, Bengt, and Paul Milgrom, 1987, Aggregation and linearity in the provision of intertemporal incentives, *Econometrica* 55, 303-328.

Inderst, Roman, and Holger M. Mueller, 2005, Benefits of broad-based option pay, NBER Working Paper.

Jensen, Michael C., and William H. Meckling, 1976, Theory of the firm: Managerial behavior, agency costs and ownership structure, *Journal of Financial Economics* 3, 305-360.

Jones, Stephen R. G, 1984, The economics of conformism, Oxford: Blackwell.

Kandel, Eugene, and Edward P. Lazear, 1992, Peer pressure and partnerships, *Journal of Political Economy* 100, 801-817.

Kaplan, Steven N., and Luigi Zingales, 1997, Do investment-cash flow sensitivities provide useful measures of financing constraints? *Quarterly Journal of Economics* 112, 169-215.

Klasa, Sandy, William F. Maxwell, and Hernan Ortiz-Molina, 2009, The strategic use of corporate cash holdings in collective bargaining with labor unions, *Journal of Financial Economics* 92, 421-442.

Kroumova, Maya K., and James C. Sesil, 2006, Intellectual capital, monitoring, and risk: What predicts the adoption of employee stock options? *Industrial Relations* 45, 734-752.

Kumar, Alok, Jeremy K. Page, and Oliver G. Spalt, 2011, Religious beliefs, gambling attitudes, and financial market outcomes, *Journal of Financial Economics* 102, 671-708.

Landsman, Wayne, Mark Lang, and Yeh Shu, 2007, Governance and the split of options between executive and nonexecutive employees, *Journal of Accounting, Auditing and Finance* 22, 109-138.

Lerner, Josh, and Julie Wulf, 2007, Innovation and incentives: Evidence from corporate R&D, *Review of Economics and Statistics* 89, 634-644.

Low, Angie, 2009, Managerial risk-taking behavior and equity-based compensation, *Journal of Financial Economics* 92, 470-490.

Manso, Gustavo, 2011, Motivating innovation, *Journal of Finance* 66, 1823-1860.

McKeon, Stephen B., 2011, Internal equity issuances and financing decisions, Working Paper, University of Oregon.

Milbourn, Todd, T, 2003, CEO reputation and stock-based compensation, *Journal of Financial Economics* 68, 233-262.

Murphy, Kevin J, 2003, Stock-based pay in new economy firms, *Journal of Accounting and Economics* 34, 129-147.

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

Oyer, Paul, and Scott Schaefer, 2005, Why do some firms give stock options to all employees? An empirical examination of alternative theories, *Journal of Financial Economics* 76, 99-133.

Rajan, Raghuram, and Luigi Zingales, 2000, The governance of the new enterprise, NBER Working Paper.

Sandy, Klasa, F. Maxwell William, and Ortiz-Molina Hernán, 2009, The strategic use of corporate cash holdings in collective bargaining with labor unions, *Journal of Financial Economics* 92, 421-442.

Sherman, Hugh, Sam Beldona, and Maheshkumar Joshi, 1998, Institutional investor heterogeneity: Implications for strategic decisions, *Corporate Governance: An International Review* 6, 166.

Smith, Clifford W., and René M. Stulz, 1985, The determinants of firms' hedging policies, *Journal of Financial and Quantitative Analysis* 20, 391-405.

Spalt, Oliver G., 2011, Probability weighting and employee stock options, Working Paper, Tilburg University.

Tian, Xuan, and Tracy Y. Wang, 2011, Tolerance for failure and corporate innovation, *Review of Financial Studies, forthcoming.*

Whited, Toni M., and Guojun Wu, 2006, Financial constraints risk, *Review of Financial Studies* 19, 531-559.

Yermack, David, 1995, Do corporations award CEO stock options effectively? *Journal of Financial Economics* 39, 237-269.

Zhang, Wenrui, 2011, The tradeoff between employee ownership and CEO compensation: Evidence from defined contribution pension plans, Working Paper, Nanyang Technological University.

Figure 1

The aggregate value of non-executive stock options and mean and median values of non-executive stock options per employee over time

The sample consists of firms **covered in both the** ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. The left Y-axis corresponds to the aggregate value of non-executive stock options in billions of dollars. The right Y-axis corresponds to the mean and median values of non-executive stock options per employee in thousands of dollars. The detailed definitions of variables are described in Appendix B.

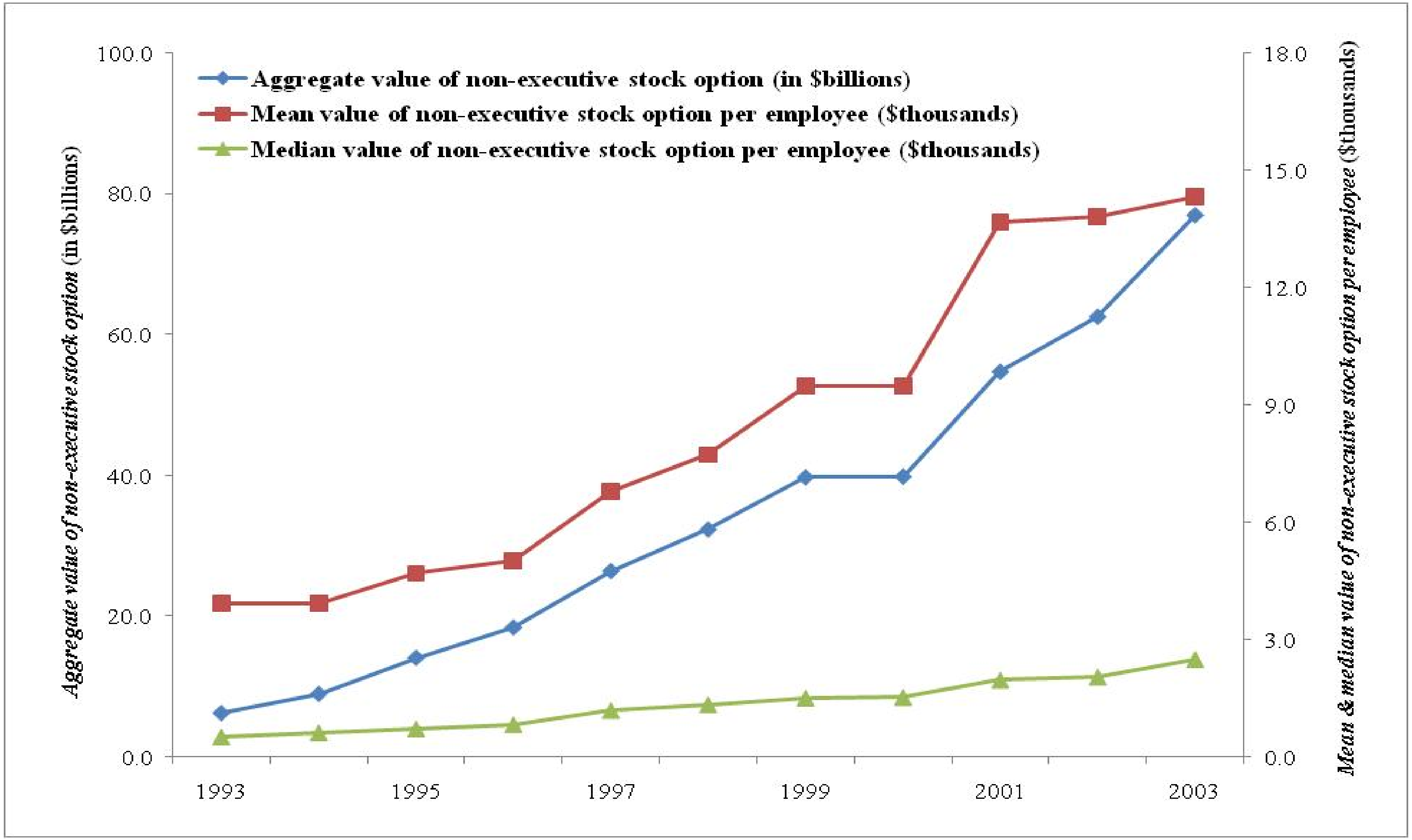

Table I

Sample distribution and median and mean counts of patents and citations and values of the non-executive stock options per employee

The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. The sample construction is listed in Appendix A and detailed definitions of variables are described in Appendix B.

Year	No. of total firms	No. of firms with non-zero patents	No. of firms with non-zero citations	Patent count (raw) (non-zero patents)		Total counts of patent citation (raw) (non-zero citations)		Average citation per patent count (raw) (non-zero citations)		Non-executive stock option per employee ($dollars)	
				Median	Mean	Median	Mean	Median	Mean	Median	Mean
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
1993	324	160	159	14.00	31.84	158.00	781.92	8.86	10.91	495.17	3082.62
1994	555	281	278	10.00	29.79	126.50	857.98	9.69	12.29	572.36	4044.70
1995	636	330	328	12.00	31.25	117.00	851.60	8.27	10.50	631.31	3873.49
1996	676	338	333	10.00	29.53	77.00	797.90	7.20	9.44	735.88	4664.54
1997	721	380	373	9.00	29.86	71.00	757.91	6.40	8.05	902.06	5788.44
1998	740	376	364	9.00	27.19	49.00	539.25	5.00	6.49	1225.80	7914.25
1999	820	421	405	9.00	25.93	38.00	301.23	3.75	4.81	1377.98	9590.35
2000	823	419	388	10.00	25.78	29.00	224.90	2.33	3.07	1673.63	15513.24
2001	798	389	334	10.00	27.16	17.00	142.50	1.31	1.78	2078.25	13880.49
2002	864	423	337	9.00	27.11	10.00	72.48	0.67	0.90	2386.80	13825.00
2003	909	412	274	8.00	24.34	6.00	27.76	0.33	0.47	1528.45	8038.39
Mean	-	-	-	9.00	27.77	39.00	469.00	4.00	5.95	1192.30	8880.01
Total	7866	3929	3573	-	-	-	-	-	-	-	-

Table II
Summary statistics

The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. High (low) *E-option* subsample is the sample of firms with higher (lower) than the sample median of non-executive stock options per employee each year. *E-delta* and *E-vega* are the sensitivity of non-executive stock option to 1% change in stock price divided by the number of employees and the sensitivity of non-executive stock option to 1% change in stock return volatility divided by the number of employees, calculated from the IRRC Dilution Database from 1998 to 2003. The sample size for *E-delta*/*E-vega* in the high and low *E-option* subsamples is 1,745 and 1,869 firm-years, respectively. To be included in the sample, firms in the same industry must have at least one patent in any year. *Qcitations* and *TTcitations* are adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time-technology class fixed effect, respectively. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. *T*-tests (Wilcoxon-Mann-Whitney tests) are conducted to test for differences between the means (medians) for the high *E-option* subsample and low *E-option* subsample. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	The whole sample			High *E-option* subsample		Low *E-option* subsample	
	N = 7866			*N =3931*		*N = 3935*	
	Mean	Median	SD	Mean	Median	Mean	Median
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Firm characteristics							
Assets ($millions)	3929.77	993.46	8770.73	3419.48***	742.57***	4439.55	1348.76
Employees (thousands)	16.51	5.70	26.23	9.64***	2.50***	23.37	10.75
Tobin's q	2.22	1.65	1.81	2.87***	2.15***	1.56	1.38
Sales growth	0.11	0.08	0.27	0.15***	0.13***	0.06	0.06
PPE/#employees ($thousands)	135.70	41.30	373.38	192.60***	49.12***	78.85	36.98
Leverage	0.22	0.22	0.17	0.18***	0.15***	0.26	0.26
Cash/Assets	0.14	0.06	0.18	0.21***	0.14***	0.06	0.03
Sales/#employees ($thousands)	275.10	192.17	314.47	348.64***	229.00***	201.64	160.42
Stock volatility	0.03	0.03	0.02	0.03***	0.03***	0.03	0.02
Stock return	0.18	0.10	0.59	0.20***	0.09	0.16	0.10
ROA	0.09	0.10	0.13	0.09***	0.11***	0.10	0.10
R&D/Assets	0.04	0.01	0.08	0.07***	0.04***	0.01	0.00
Herfindahl index	0.19	0.13	0.17	0.15***	0.10***	0.22	0.17
Panel B: Employee vs. CEO compensation terms							
E-option ($dollars)	8880.01	1192.30	21469.42	17257.07***	5489.43***	511.47	378.68
E-delta ($dollars)	490.81	111.25	1052.31	947.92***	394.37***	64.03	42.39
E-vega ($dollars)	233.58	78.48	423.44	426.55***	216.25***	53.42	36.58
Non-executive employee over top five executive option grant ratio	5.43	3.06	10.63	6.94***	3.73***	3.92	2.52
CEO delta ($dollars)	618041.30	174847.40	1614981.00	827958.60***	234524.60***	408337.40	133250.40
CEO vega ($dollars)	75813.57	30265.58	129747.70	86648.87***	33326.27***	64989.29	27433.71
CEO tenure (Years)	7.17	5.00	7.13	7.26	5.00***	7.08	5.00
Panel C: Corporate innovation measures							
#patents (raw)	13.87	0.00	28.55	15.81***	1.00***	11.94	0.00
#citations (raw)	2.70	0.00	5.24	3.37***	0.00***	2.04	0.00
#Qcitations_t	515.56	0.00	3208.09	735.32***	0.00***	296.03	0.00
#TTcitations_t	40.14	0.00	203.42	55.13***	0.00***	25.17	0.00
#Qcitations	6.46	0.00	10.68	8.22***	0.00***	4.71	0.00
#TTcitations	0.55	0.00	0.81	0.65***	0.00***	0.45	0.00

Table III

Effect of non-executive stock options per employee on corporate innovation productivity

The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. *Qcitations* and *TTcitations* are adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time-technology class fixed effect, respectively. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Ln(*1+#patent*)	*Ln*(*1+Qcitations_t*)	*Ln*(*1+TTcitations_t*)	*Ln*(*1+Qcitations*)	*Ln*(*1+TTcitations*)
	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Ln(1+E-option)	0.057***	0.098***	0.073***	0.037**	0.015**
	(2.7)	(2.8)	(3.2)	(2.1)	(2.4)
R&D/Assets	4.006***	7.187***	4.151***	3.416***	0.934***
	(7.3)	(7.4)	(7.3)	(6.9)	(5.9)
Ln(1+CEO delta)	-0.038**	-0.060**	-0.033*	-0.022	-0.004
	(-2.2)	(-2.0)	(-1.8)	(-1.4)	(-0.7)
Ln(1+CEO vega)	0.011*	0.020*	0.008	0.010*	0.002
	(1.9)	(1.9)	(1.3)	(1.9)	(1.0)
Ln(1+CEO tenure)	-0.012	-0.024	-0.024	-0.012	-0.007
	(-0.5)	(-0.6)	(-0.9)	(-0.5)	(-0.9)
Ln(PPE/#employees)	-0.001	0.015	-0.006	0.019	0.002
	(-0.0)	(0.2)	(-0.1)	(0.5)	(0.2)
Leverage	-0.808***	-1.438***	-0.858***	-0.616***	-0.160***
	(-4.9)	(-5.3)	(-4.9)	(-4.6)	(-3.4)
Cash/Assets	0.086	0.194	0.028	0.167	0.045
	(0.5)	(0.6)	(0.1)	(1.1)	(0.8)
Ln(Sales/#employees)	-0.114**	-0.150*	-0.110**	-0.037	-0.012
	(-2.5)	(-1.9)	(-2.3)	(-0.9)	(-0.9)
Ln(Assets)	0.562***	0.809***	0.567***	0.244***	0.073***
	(20.5)	(19.1)	(19.6)	(13.1)	(11.1)
Sales growth	-0.240***	-0.395***	-0.255***	-0.122**	-0.035*
	(-4.4)	(-4.0)	(-4.2)	(-2.3)	(-1.8)
Tobin's q	0.051***	0.080***	0.051***	0.029**	0.011**
	(3.9)	(3.4)	(3.4)	(2.2)	(2.5)
Stock volatility	3.613**	6.927**	4.925**	3.180**	0.876*
	(2.0)	(2.3)	(2.6)	(2.2)	(1.7)
Stock return	0.064***	0.109***	0.080***	0.044*	0.011
	(3.0)	(2.8)	(3.4)	(1.9)	(1.4)
ROA	1.053***	1.988***	1.217***	0.957***	0.263***
	(4.8)	(5.4)	(5.2)	(5.0)	(3.9)
Herfindahl index	-0.060	0.712	0.063	0.732*	0.190
	(-0.1)	(0.9)	(0.1)	(1.9)	(1.4)
Herfindahl index^2	0.199	-0.594	0.032	-0.745	-0.192
	(0.4)	(-0.6)	(0.1)	(-1.6)	(-1.2)
Constant	-3.652***	-5.534***	-3.872***	-1.879***	-0.607***
	(-11.3)	(-10.5)	(-11.1)	(-7.3)	(-6.7)
Industry FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	7866	7866	7866	7866	7866
R-squared	0.53	0.50	0.49	0.40	0.30

Table IV
Reestimation of regressions in Table III using the instrumental variable approach

The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. Column (1) reports the estimate of the first-stage regression using the two-stage least squares (2SLS) model and columns (2) to (6) report the estimates of the second-stage regressions using the 2SLS model. *Qcitations* and *TTcitations* are adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time-technology class fixed effect, respectively. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	Ln(*1+E-option*)	*Ln*(*1+#patent*)	*Ln*(*1+Qcitations_t*)	*Ln*(*1+TTcitations_t*)	*Ln*(*1+Qcitations*)	*Ln*(*1+TTcitations*)
	1st stage	2nd stage	2nd stage	2nd stage	2nd stage	2nd stage
	(1)	(2)	(3)	(4)	(5)	(6)
Ln(1+E-option)	N/A	0.527**	1.054***	0.566**	0.539***	0.145**
		(2.3)	(2.7)	(2.3)	(2.8)	(2.3)
E-options in near firms in other industry	0.069***	N/A	N/A	N/A	N/A	N/A
	(5.2)					
Marginal tax rate	-0.437**	N/A	N/A	N/A	N/A	N/A
	(-2.2)					
R&D/Assets	2.804***	2.624***	4.375***	2.697***	1.938***	0.552**
	(5.0)	(3.1)	(3.0)	(3.1)	(2.7)	(2.4)
Ln(1+CEO delta)	0.236***	-0.151***	-0.288***	-0.151**	-0.142***	-0.035**
	(12.4)	(-2.6)	(-2.9)	(-2.5)	(-2.9)	(-2.2)
Ln(1+CEO vega)	0.006	0.008	0.014	0.005	0.007	0.001
	(1.1)	(1.3)	(1.3)	(0.8)	(1.2)	(0.6)
Ln(1+CEO tenure)	-0.138***	0.052	0.106	0.043	0.057	0.011
	(-6.1)	(1.3)	(1.5)	(1.0)	(1.6)	(1.0)
Ln(PPE/#employees)	0.349***	-0.162*	-0.314**	-0.176*	-0.153**	-0.043*
	(12.7)	(-1.7)	(-2.0)	(-1.8)	(-2.0)	(-1.7)
Leverage	-0.501***	-0.584***	-0.982***	-0.623***	-0.377**	-0.098*
	(-3.3)	(-2.8)	(-2.8)	(-2.8)	(-2.2)	(-1.7)
Cash/Assets	2.570***	-1.185*	-2.393**	-1.309*	-1.192**	-0.307*
	(17.2)	(-1.8)	(-2.1)	(-1.9)	(-2.2)	(-1.8)
Ln(Sales/#employees)	0.597***	-0.401***	-0.736***	-0.413***	-0.345***	-0.092**
	(15.1)	(-2.7)	(-2.9)	(-2.7)	(-2.7)	(-2.3)
Ln(Assets)	-0.198***	0.656***	1.000***	0.665***	0.344***	0.098***
	(-10.3)	(12.4)	(11.1)	(11.9)	(7.9)	(6.9)
Sales growth	0.430***	-0.449***	-0.820***	-0.474***	-0.344***	-0.092***
	(5.6)	(-3.7)	(-3.9)	(-3.7)	(-3.2)	(-2.7)
Tobin's q	0.157***	-0.024	-0.071	-0.027	-0.050	-0.009
	(9.0)	(-0.6)	(-1.0)	(-0.6)	(-1.5)	(-0.8)
Stock volatility	9.067***	-1.121	-2.707	-0.053	-1.880	-0.435
	(4.9)	(-0.4)	(-0.5)	(-0.0)	(-0.7)	(-0.5)
Stock return	-0.060***	0.089***	0.159***	0.106***	0.070***	0.018**
	(-2.7)	(3.4)	(3.3)	(3.7)	(2.7)	(2.0)
ROA	0.293	0.962***	1.804***	1.121***	0.860***	0.238***
	(1.2)	(4.1)	(4.3)	(4.5)	(3.8)	(3.2)
Herfindahl index	-1.612***	0.661	2.179**	0.821	1.502***	0.389**
	(-4.5)	(1.1)	(2.0)	(1.2)	(2.8)	(2.2)
Herfindahl index^2	1.545***	-0.465	-1.946	-0.666	-1.455**	-0.376*
	(3.6)	(-0.7)	(-1.6)	(-0.9)	(-2.4)	(-1.8)
Constant	1.355***	-3.566***	-5.154***	-3.656***	-1.622***	-0.569***
	(4.9)	(-9.0)	(-7.7)	(-8.7)	(-5.0)	(-5.3)
Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
J-Statistics (p-value)	N/A	0.66	0.42	0.14	0.40	0.15
N	7866	7866	7866	7866	7866	7866
R-squared	0.73	0.45	0.37	0.41	0.26	0.21

Table V
Reestimation of regressions by controlling for potential omitted variables

This table reestimates the regressions related to non-executive stock options per employee and the corporate innovation productivity by including additional control variables. All regressions include the same control variables as those used in Table III except for Panel C where CEO incentive measures and CEO tenure are excluded, Panel E where CEO incentive measures are replaced with incentive measures of top five executives and CEO tenure is excluded, and Panel F where stock return are excluded, but the coefficients on these variables are not tabulated. The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. *Qcitations* and *TTcitations* are adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time-technology class fixed effect, respectively. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln(1+#patent)*	*Ln(1+Qcitations_t)*	*Ln(1+TTcitations_t)*	*Ln(1+Qcitations)*	*Ln(1+TTcitations)*
	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Panel A: Controlling for G-index					
Ln(1+E-option)	0.066**	0.117***	0.084***	0.053**	0.019***
	(2.5)	(2.7)	(2.9)	(2.6)	(2.7)
G-index	0.011	0.014	0.004	0.006	0.001
	(0.9)	(0.7)	(0.3)	(0.7)	(0.3)
N	6040	6040	6040	6040	6040
Panel B: Controlling for board characteristics					
Ln(1+E-option)	0.068**	0.111**	0.082***	0.046**	0.018**
	(2.5)	(2.6)	(2.8)	(2.4)	(2.5)
Board size	-0.008	-0.014	-0.012	-0.005	-0.002
	(-0.6)	(-0.6)	(-0.8)	(-0.5)	(-0.6)
Independent directors (%)	0.484***	0.704**	0.437**	0.318**	0.107**
	(2.7)	(2.5)	(2.3)	(2.5)	(2.3)
N	4688	4688	4688	4688	4688
Panel C: Controlling for top five executive incentives					
Ln(1+E-option)	0.058***	0.098***	0.072***	0.038**	0.014**
	(2.6)	(2.7)	(3.1)	(2.1)	(2.2)
Ln(1+top five executive delta)	-0.101***	-0.165***	-0.092***	-0.069***	-0.015**
	(-4.2)	(-4.0)	(-3.6)	(-3.2)	(-2.1)
Ln(1+top five executive vega)	0.080***	0.143***	0.077***	0.061***	0.019***
	(3.2)	(3.3)	(2.9)	(2.8)	(2.6)
N	7866	7866	7866	7866	7866
Panel D: Controlling for institutional ownership					
Ln(1+E-option)	0.064***	0.105***	0.078***	0.038**	0.015**
	(3.0)	(2.9)	(3.4)	(2.1)	(2.4)
Institutional ownership	-0.287**	-0.279	-0.253**	0.008	0.001
	(-2.4)	(-1.4)	(-2.0)	(0.1)	(0.0)
N	7862	7862	7862	7862	7862
Panel E: Controlling for top five executive ownership					
Ln(1+E-option)	0.056***	0.094***	0.071***	0.033*	0.013**
	(2.6)	(2.7)	(3.2)	(1.9)	(2.2)
Managerial ownership	-0.002	-0.006	-0.002	-0.007***	-0.002**
	(-0.6)	(-1.2)	(-0.5)	(-2.6)	(-2.5)
N	7866	7866	7866	7866	7866
Panel F: Controlling for management quality					
Ln(1+E-option)	0.065***	0.115***	0.080***	0.047***	0.017***
	(2.9)	(3.1)	(3.4)	(2.6)	(2.7)
CAR (-1 year,-3 year)	-0.025	-0.061**	-0.029	-0.039***	-0.009*
	(-1.5)	(-2.2)	(-1.6)	(-2.7)	(-1.7)
N	7546	7546	7546	7546	7546
Panel G: Controlling for financial constraint					
Ln(1+E-option)	0.081***	0.134***	0.092***	0.050***	0.017***
	(3.7)	(3.6)	(3.9)	(2.8)	(2.8)
Hadlock and Pierce's (2010) index	-0.244***	-0.356***	-0.192***	-0.129***	-0.025
	(-3.8)	(-3.5)	(-2.9)	(-2.7)	(-1.6)
N	7866	7866	7866	7866	7866

Table VI
Additional sensitivity tests

This table reports the regression results of various robustness tests. All regressions include the same control variables as those used in Table III, but the coefficients on these variables are not tabulated. The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. *Qcitations* and *TTcitations* are adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time-technology class fixed effect, respectively. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Dependent variables	*Ln*(*1+#patent*)	*Ln*(*1+Qcitations_t*)	*Ln*(*1+TTcitations_t*)	*Ln*(*1+Qcitations*)	*Ln*(*1+TTcitations*)
	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Panel A: Negative binomial estimation (*Dependent variables are not in log form*)					
Ln(1+E-option)	0.094***	0.250***	0.196***	0.106***	0.071***
	(2.7)	(5.0)	(3.9)	(3.5)	(3.4)
N	7866	7866	7866	7866	7866
Panel B: Negative binomial estimation using mean scaling approach (*Dependent variables are not in log form*)					
Ln(1+E-option)	0.152***	0.259***	0.218***	0.072**	0.009
	(4.3)	(4.9)	(4.3)	(2.2)	(0.4)
N	6995	6995	6995	6995	6995
Panel C: Using an alternative measure of non-executive stock option per employee					
Ln(1+E-option)	0.032***	0.055***	0.037***	0.022***	0.007***
	(3.5)	(3.6)	(3.8)	(3.0)	(2.7)
N	7103	7103	7103	7103	7103
Panel D: Excluding zero patents or citations					
Ln(1+E-option)	0.106***	0.193***	0.147***	0.075***	0.028***
	(4.6)	(5.9)	(5.3)	(5.4)	(3.8)
N	3929	3573	3573	3573	3573
Panel E: Using only firms granting non-executive options for more than five years					
Ln(1+E-option)	0.052**	0.089**	0.067**	0.035*	0.015**
	(2.0)	(2.1)	(2.4)	(1.8)	(2.0)
N	4998	4998	4998	4998	4998
Panel F: Excluding self-citations					
Ln(1+E-option)	-	0.098***	0.071***	0.036**	0.014**
	-	(2.9)	(3.3)	(2.2)	(2.5)
N	-	7866	7866	7866	7866
Panel G: Lagged independent variables for two periods					
Ln(1+E-option)	0.090***	0.159***	0.107***	0.064***	0.023***
	(3.4)	(3.6)	(3.8)	(2.9)	(3.0)
N	5312	5312	5312	5312	5312
Panel H: Innovative and non-innovative industries					
Ln(1+E-option)	0.044**	0.072**	0.052**	0.020	0.006
	(2.0)	(2.0)	(2.3)	(1.1)	(1.0)
Ln(1+E-option) × Innovative industry indicator	0.018***	0.035***	0.027***	0.023***	0.011***
	(2.8)	(3.0)	(3.8)	(3.7)	(4.9)
N	7866	7866	7866	7866	7866

Table VII
Effects of firm and industry characteristics and expiration period of stock options

This table reestimates the regressions related to non-executive stock options per employee and the corporate innovation quality for subsamples of firms classified in each year according to the importance of employee retention and industry level unionization, tendency of free-riding problem, stock option expiration period, and broad versus targeted plans. All partition variables are measured a priori. All regressions include the same control variables as those used in Table III, but the coefficients on these variables are not tabulated. The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. *Qcitations* and *TTcitations* are adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time-technology class fixed effect, respectively. In Panel A, a firm facing high importance of employee retention or high unionization rate is classified as *High* and low importance of employee retention or low unionization rate is classified as *Low* if variables measuring the importance of employee retention or the unionization rate are above or below the sample median respectively. In Panel B, a firm is classified as high tendency of free-riding problem (*High*) if the number of employees is above the sample median or the growth options per employee are below the medians, and low tendency firms (*Low*) otherwise. In Panel C, a firm having a longer than the sample median of weighted average stock option expiration period is classified as (*Long*) and a firm having a shorter than the sample median of weighted average stock option expiration period is classified as (*Short*). In Panel D, a firm is classified as a targeted plan (*Target*) if the number of option grants to non-executives over the total shares outstanding is below the sample median each year and a broad plan (*Broad*) if the number of option grants to non-executives over the total shares outstanding is above the sample median each year. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table VII (cont'd)
Effects of firm and industry characteristics and expiration period of stock options

Dependent variables	*Ln(1+#patent)* OLS (1)		*Ln(1+Qcitations_t)* OLS (2)		*Ln(1+Ttcitations_t)* OLS (3)		*Ln(1+Qcitations)* OLS (4)		*Ln(1+TTcitations)* OLS (5)	
Panel A: Partitioning sample according to the importance of employee retention and labor strength										
	Low	High	Low	High	Low	High	Low	High	Low	High
Panel A1: Partitioning sample according to industry employee voluntary turnover rate (2-digit SIC)										
Ln(1+E-option)	-0.065*	0.183***	-0.077	0.241***	-0.057	0.184***	-0.000	0.076**	0.004	0.039***
	(-1.8)	(4.0)	(-1.3)	(3.3)	(-1.4)	(3.5)	(-0.0)	(2.6)	(0.3)	(2.6)
N	750	1013	750	1013	750	1013	750	1013	750	1013
Panel A2: Partitioning sample according to KLD employee treatment index										
Ln(1+E-option)	0.017	0.158***	0.031	0.265***	0.046	0.186***	0.003	0.117***	0.006	0.045***
	(0.3)	(2.8)	(0.4)	(3.0)	(0.9)	(3.1)	(0.1)	(3.0)	(0.5)	(3.1)
N	2260	1233	2260	1233	2260	1233	2260	1233	2260	1233
Panel A3: Partitioning sample according to the industry unionization rate										
Ln(1+E-option)	0.023	0.078**	0.028	0.151***	0.022	0.109***	0.005	0.067***	0.003	0.030***
	(0.8)	(2.6)	(0.6)	(3.1)	(0.8)	(3.4)	(0.2)	(2.8)	(0.3)	(3.5)
N	3719	3997	3719	3997	3719	3997	3719	3997	3719	3997
Panel B: Partitioning sample according to the tendency of free-riding problem										
	High	Low	High	Low	High	Low	High	Low	High	Low
Panel B1: Partitioning sample according to the number of employees										
Ln(1+E-option)	0.039	0.076***	0.062	0.131***	0.064*	0.086***	0.015	0.053**	0.008	0.019**
	(1.1)	(3.3)	(1.1)	(3.1)	(1.8)	(3.3)	(0.6)	(2.3)	(1.0)	(2.3)
N	3923	3943	3923	3943	3923	3943	3923	3943	3923	3943
Panel B2: Partitioning sample according to growth options per employee										
Ln(1+E-option)	0.007	0.088***	0.016	0.171***	0.013	0.112***	0.007	0.078***	0.002	0.027***
	(0.3)	(2.8)	(0.4)	(3.3)	(0.5)	(3.4)	(0.3)	(3.1)	(0.3)	(3.1)
N	3931	3935	3931	3935	3931	3935	3931	3935	3931	3935
Panel C: Partitioning sample according to average stock option expiration period										
	Short	Long	Short	Long	Short	Long	Short	Long	Short	Long
Ln(1+E-option)	0.046	0.086**	0.080	0.151**	0.063	0.116***	0.042	0.045*	0.020*	0.021**
	(1.1)	(2.3)	(1.2)	(2.6)	(1.4)	(2.9)	(1.5)	(1.7)	(1.8)	(2.0)
N	1776	1859	1776	1859	1776	1859	1776	1859	1776	1859
Panel D: Targeted vs. broad plans (Subsamples of firms with a smaller number of employees only)										
	Targeted	Broad	Targeted	Broad	Targeted	Broad	Targeted	Broad	Targeted	Broad
Ln(1+E-option)	0.033	0.098***	0.083	0.169***	0.046	0.114***	0.055	0.071**	0.021	0.029**
	(1.0)	(2.8)	(1.3)	(2.7)	(1.4)	(3.0)	(1.4)	(2.0)	(1.6)	(2.3)
N	1624	2319	1624	2319	1624	2319	1624	2319	1624	2319

Table VIII
Effect of non-executive stock options per employee on R&D activities

The sample consists of firms covered in both the ExecuComp and the NBER Patent and Citation Database between 1993 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. Column (1) reports the estimates of OLS regression with *Ln*(*R&D/#employees*) as the dependent variable. In column (2), the dependent variable is *R&D/Assets*. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

	R&D intensity	*R&D/Assets*
	OLS	OLS
	(1)	(2)
Ln(1+E-option)	0.228***	0.009***
	(12.9)	(8.1)
Ln(1+CEO delta)	-0.071***	-0.004***
	(-4.9)	(-4.8)
Ln(1+CEO vega)	0.021***	0.001***
	(4.8)	(5.0)
Ln(1+CEO tenure)	-0.003	0.001
	(-0.2)	(0.8)
Ln(PPE/#employees)	0.057	-0.001
	(1.5)	(-0.3)
Leverage	-0.817***	-0.025**
	(-6.7)	(-2.4)
Cash/Assets	2.000***	0.095***
	(13.1)	(6.1)
Ln(Sales/#employees)	-0.025	-0.009***
	(-0.6)	(-3.0)
Ln(Assets)	0.158***	0.001
	(8.5)	(0.6)
Sales growth	-0.206***	-0.004
	(-3.9)	(-0.6)
Tobin's q	0.052***	0.005***
	(4.2)	(2.6)
Stock volatility	8.186***	0.144
	(5.1)	(0.9)
Stock return	0.077***	-0.001
	(4.0)	(-0.4)
ROA	-1.161***	-0.194***
	(-6.2)	(-5.1)
Herfindahl index	-1.654***	-0.088***
	(-4.3)	(-5.6)
Herfindahl index^2	1.802***	0.088***
	(4.1)	(5.3)
Constant	-1.651***	0.041**
	(-6.3)	(2.2)
Industry FE	Y	Y
Year FE	Y	Y
N	7866	7866
R-squared	0.72	0.53

Table IX
Effect of employee incentives on innovation productivity

This table estimates the regressions related to non-executive delta per employee (*E-delta*) and non-executive vega per employee (*E-vega*) and the corporate innovations. Panel A reports the estimates of regressions after controlling for CEO incentives. Panel B reports the estimates of regressions after controlling for top five executive incentives. The sample consists of firms jointly covered in the ExecuComp, the NBER Patent and Citation Database, and the IRRC Dilution Database between 1998 and 2003. To be included in the sample, firms in the same industry must have at least one patent in any year. *E-delta* and *E-vega* are the sensitivity of non-executive stock option to 1% change in stock price divided by the number of employees and the sensitivity of non-executive stock option to 1% change in stock return volatility divided by the number of employees calculated from the IRRC Dilution Database during 1998 to 2003. *Qcitations* and *TTcitations* are adjusted using the weighting index of Hall, Jaffe, and Trajtenberg (2001) and the method of time-technology class fixed effect, respectively. The detailed definitions of variables are described in Appendix B. All variables are winsorized at the 1% level at both tails of the distribution. Dollar values are converted into 2000 constant dollars using the GDP deflator. The *t*-statistics in parentheses are calculated from the Huber/White/Sandwich heteroskedastic consistent errors, which are also corrected for correlation across observations for a given firm. The symbols ***, **, and * denote significance at the 1%, 5%, and 10% levels, respectively.

Table IX (cont'd)
Effect of employee incentives on innovation productivity

Panel A: Employee incentives and corporate innovation productivity by controlling for CEO incentives

	Ln(1+#patent)	*Ln(1+Qcitations_t)*	*Ln(1+TTcitations_t)*	*Ln(1+Qcitations)*	*Ln(1+TTcitations)*
	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Ln(1+E-delta)	0.004	0.011	0.019	0.005	0.002
	(0.1)	(0.2)	(0.5)	(0.2)	(0.2)
Ln(1+E-vega)	0.128***	0.205***	0.126***	0.073***	0.027***
	(4.6)	(4.4)	(4.1)	(3.2)	(3.3)
R&D/Assets	4.525***	7.181***	4.403***	2.797***	0.854***
	(4.8)	(4.5)	(4.5)	(3.7)	(3.2)
Ln(1+CEO delta)	-0.016	-0.028	-0.015	-0.008	-0.002
	(-0.6)	(-0.7)	(-0.6)	(-0.4)	(-0.3)
Ln(1+CEO vega)	0.008	0.013	0.002	0.008	0.001
	(1.1)	(1.0)	(0.2)	(1.3)	(0.4)
Ln(1+CEO tenure)	-0.002	-0.020	-0.022	-0.018	-0.012
	(-0.1)	(-0.3)	(-0.6)	(-0.7)	(-1.1)
Ln(PPE/#employees)	-0.012	-0.011	-0.016	0.009	-0.001
	(-0.2)	(-0.1)	(-0.3)	(0.3)	(-0.0)
Leverage	-0.741***	-1.244***	-0.803***	-0.350**	-0.091
	(-3.2)	(-3.4)	(-3.2)	(-2.0)	(-1.3)
Cash/Assets	-0.012	-0.129	-0.069	-0.018	0.018
	(-0.0)	(-0.3)	(-0.3)	(-0.1)	(0.2)
Ln(Sales/#employees)	-0.134**	-0.146	-0.125*	-0.024	-0.017
	(-2.2)	(-1.5)	(-1.9)	(-0.5)	(-0.9)
Ln(Assets)	0.568***	0.821***	0.585***	0.219***	0.079***
	(16.9)	(16.3)	(16.5)	(11.0)	(10.0)
Sales growth	-0.321***	-0.536***	-0.347***	-0.187**	-0.058*
	(-3.7)	(-3.6)	(-3.5)	(-2.5)	(-1.9)
Tobin's q	0.042**	0.095***	0.062***	0.047***	0.019***
	(2.3)	(3.0)	(3.0)	(2.7)	(2.9)
Stock volatility	2.463	7.965*	4.727	4.832**	1.607**
	(0.9)	(1.8)	(1.6)	(2.4)	(2.0)
Stock return	0.086**	0.171***	0.107***	0.084***	0.021*
	(2.6)	(3.0)	(2.9)	(2.7)	(1.7)
ROA	1.260***	1.964***	1.193***	0.793***	0.230**
	(4.2)	(3.8)	(3.6)	(3.1)	(2.3)
Herfindahl index	-0.091	0.374	0.068	0.313	0.068
	(-0.2)	(0.4)	(0.1)	(0.8)	(0.4)
Herfindahl index^2	0.453	0.232	0.269	-0.010	0.033
	(0.7)	(0.2)	(0.4)	(-0.0)	(0.2)
Constant	-4.404***	-7.371***	-4.788***	-2.784***	-0.879***
	(-7.5)	(-7.8)	(-7.6)	(-6.5)	(-5.2)
Industry FE	Y	Y	N	Y	Y
Year FE	Y	Y	Y	Y	Y
N	3614	3614	3614	3614	3614
R-squared	0.56	0.53	0.51	0.41	0.30

Table IX (cont'd)
Effect of employee incentives on innovation productivity

Panel B: Employee incentives and corporate innovation productivity by controlling for top five executive incentives

	Ln(*1+#patent*)	*Ln*(*1+Qcitations_t*)	*Ln*(*1+TTcitations_t*)	*Ln*(*1+Qcitations*)	*Ln*(*1+TTcitations*)
	OLS	OLS	OLS	OLS	OLS
	(1)	(2)	(3)	(4)	(5)
Ln(1+E-delta)	0.021	0.041	0.035	0.020	0.006
	(0.5)	(0.7)	(0.9)	(0.7)	(0.6)
Ln(1+E-vega)	0.106***	0.174***	0.110***	0.059**	0.024***
	(3.7)	(3.6)	(3.6)	(2.5)	(2.8)
R&D/Assets	4.376***	6.973***	4.297***	2.710***	0.833***
	(4.7)	(4.4)	(4.5)	(3.6)	(3.1)
Ln(1+top five executive delta)	-0.076**	-0.129**	-0.068*	-0.059**	-0.018*
	(-2.2)	(-2.4)	(-1.9)	(-2.3)	(-1.8)
Ln(1+top five executive vega)	0.071*	0.095	0.042	0.041	0.008
	(1.9)	(1.6)	(1.1)	(1.4)	(0.8)
Ln(PPE/#employees)	-0.008	-0.007	-0.016	0.010	-0.001
	(-0.1)	(-0.1)	(-0.3)	(0.3)	(-0.1)
Leverage	-0.779***	-1.306***	-0.834***	-0.383**	-0.100
	(-3.4)	(-3.5)	(-3.3)	(-2.2)	(-1.4)
Cash/Assets	-0.002	-0.121	-0.069	-0.016	0.016
	(-0.0)	(-0.3)	(-0.3)	(-0.1)	(0.2)
Ln(Sales/#employees)	-0.134**	-0.148	-0.125*	-0.026	-0.017
	(-2.1)	(-1.5)	(-1.8)	(-0.6)	(-0.9)
Ln(Assets)	0.563***	0.826***	0.590***	0.227***	0.083***
	(13.6)	(13.0)	(13.5)	(8.5)	(8.2)
Sales growth	-0.305***	-0.513***	-0.337***	-0.179**	-0.057*
	(-3.5)	(-3.5)	(-3.4)	(-2.4)	(-1.9)
Tobin's q	0.050***	0.108***	0.069***	0.054***	0.021***
	(2.7)	(3.4)	(3.2)	(3.1)	(3.1)
Stock volatility	2.366	7.676*	4.511	4.657**	1.525*
	(0.9)	(1.8)	(1.5)	(2.3)	(1.9)
Stock return	0.086**	0.171***	0.106***	0.083***	0.020*
	(2.6)	(2.9)	(2.9)	(2.6)	(1.7)
ROA	1.237***	1.940***	1.176***	0.792***	0.230**
	(4.2)	(3.8)	(3.5)	(3.1)	(2.3)
Herfindahl index	-0.086	0.388	0.078	0.325	0.074
	(-0.1)	(0.4)	(0.1)	(0.8)	(0.5)
Herfindahl index^2	0.419	0.172	0.232	-0.042	0.020
	(0.6)	(0.2)	(0.3)	(-0.1)	(0.1)
Constant	-4.382***	-7.214***	-4.672***	-2.692***	-0.841***
	(-7.4)	(-7.4)	(-7.1)	(-6.0)	(-4.7)
Industry FE	Y	Y	N	Y	Y
Year FE	Y	Y	Y	Y	Y
N	3614	3614	3614	3614	3614
R-squared	0.56	0.53	0.51	0.41	0.30