Industry Tournament Incentives and Product Innovation

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Abstract

This paper examines how the tournament-like progression in CEO labor market influence product innovation. We exploit a text-based proxy for product innovation based on product descriptions from 10-Ks. We find a significant positive relation between industry tournament incentives and product innovation. Further, we show that product market competition strengthens this relation. Additionally, we explore that industry tournament incentives are more effective when the CEO labor market is more mobile and when CEO characteristics indicate a higher probability of winning the tournament prize. Overall, the evidence suggests that industry tournament incentives promote product innovation.

JEL classifications: G32, J31, J33, O31, O32
Keywords: tournament incentives, executive compensation, risk-taking, pay gap, product innovation

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1. Introduction

The 2015 CEO Success Study conducted by Strategy&, PwC's strategy consulting business, found that a growing number of top global companies are turning to potential outsider CEOs in their planned succession processes. This kind of talent race for CEOs and the possible mobility to the leading firms that operate in a similar product market can serve as strong motives to exert great efforts by CEOs. In addition, many firms adopt relative performance measures to compensate a CEO or reward a CEO based on how well her firm performs as compared to its peer group (Gong, Li, and Shin, 2011), so the CEO can earn a higher compensation without an actual move.

CEOs compete for the highest compensation within the industry. This can be considered as an external job market tournament setting outside the firm in which the winner of the tournament earns the difference between the highest compensation in the industry and her original compensation as a tournament prize. These kind of external tournament incentives in the labor market have been noticed by researchers. Notably, Coles, Li and Wang (2017) find that industry tournament incentives (ITI), measured as the pay differential between the firm's CEO and the highest paid CEO within the same industry, can increase firm performance, overall risk, and the riskiness of firm investment and financial policies. Researchers also have explored the effects of ITI on other corporate policies, including cash holdings (Huang, Jain, and Kini, 2017), debt contracting (Kubick, Lockhart, and Mauer, 2018), and tax reporting (Kubick and Lockhart, 2016).

This study aims to examine how ITI affect product innovation.[1] Product innovation is a major business activity for a firm. The competition from its rivals or potential new entrants and the discerning customers with rapid changing preferences force firms to modify and develop their products constantly for their survival and to earn more market shares and profits. Product innovations are performed through innovative activities which require substantial financial and human resources. It is crucial for the survival of a firm, since it builds entry barriers, maintains customer loyalty, protection against imitation and the firm's competitiveness and provides penetration to a market (Soete, 1981; Clark and Guy, 1998; Boehe and Cruz, 2010). New technologies, improvement of existing technologies or product/service quality can also lead to firm growth (Coad and Rao, 2008; Corsino and Gabriele, 2010). The ITI can affect product innovation through two channels. First, product innovation can differentiate a firm in its markets from its rivals and is likely to increase the performance and value of a firm. Firm performance is considered one of the major indicators of a CEO's capability by outsiders (Fee and Hadlocks, 2004). Therefore, CEOs are willing to engage in product innovation activities that have the potential to give profitable outcomes and signalize their own abilities. Both Kale, Reis, and Venkateswaran (2009), and Coles et al. (2017) find that the promotion-based tournament incentive can increase firm performance. Second, product innovation is highly uncertain. It requires extensive investment but may end up with failure. The ITI can provide convex payoffs because the winner of the job market tournament earns the pay gap between her original compensation and the compensation offered by the leading firm as the tournament prize, while others receive nothing. This "winner-takes-all" payoff structure is similar to stock options and has been shown to increase firm riskiness (Coles, Daniel, and Naveen, 2006; Kini and Williams, 2012). Therefore, the option-like payoff of

[1] Wikipedia defines product innovation as *"Product innovation is the creation and subsequent introduction of a good or service that is either new, or an improved version of previous goods or services."*

the tournament prize provided by the leading firm in the industry motivates CEOs to bear excessive risk and undertake product innovation activities.

Following Coles et al. (2017), we measure industry tournament as the pay gap between a firm's CEO and the second highest paid CEO in a firm operating in the same industry, where the industry is based on Fama-French 30 (FF-30) and Fama-French 48 (FF-48) industry classifications. We also use size-median based FF-30 and FF-48 industry classifications and various fixed and dynamic industry classifications suggested by Hoberg and Phillips (2010; 2016). We focus on ITI rather than firm level (internal) tournament incentives for other executives under a CEO because CEOs are supposed to be more influential than other executives in terms of setting up firm policies. Thus, CEOs are expected to play a more important role in making decisions on product innovation. Nevertheless, we include internal tournament incentives as a control variable in all empirical tests.

Measuring product innovation is challenging work. Most studies use R&D expenditures and patent-based variables to measure innovation (e.g. Tian and Wang, 2011; Hirshleifer, Hsu, and Li, 2013; Fang, Tian, and Tice, 2014). These variables are highly informative and represent firms' technological innovation environment. However, they do not necessarily represent each part of the product development process.[2] Firms need to transform these innovative concepts into real products. Our focus is the final output of the innovation, which is a useful product that the firm can sell. Therefore, the product innovation we define here can be either a newly invented good, or an existing good with significant improvements in technical specifications, constituents, materials, user-friendliness or functional aspects. Moreover, technological innovations through patents acts as long-term innovations to a firm as it takes a long time and managerial effort (Aghion and Tirole,

[2] Around 76% of the US public firms never file any patent during 1998-2010 period (Lonare, 2018).

1994; Manso, 2011), thus they require long-term managerial incentives in the form of stock options and restricted stocks (e.g. Lerner and Wulf, 2007; Francis, Hasan, and Sharma, 2011; Mao and Zhang, 2018). However, the focus of our paper is the annual product development, which generates profits in the short-run. ITI provide a short-term convex payoff for CEOs to increase firm performance and riskiness, thus it may not induce CEOs to carry long-term patenting activities based on the average CEO employment time span in the firm.[3] Moreover, Lerner and Wulf (2007) find that short-term incentives, such as bonuses, are not influential for long-term innovation. Therefore, ITI are more likely to be associated with product innovations than with patents.[4]

R&D and patent-based variables have some other shortcomings to measure product innovation such as missing data, trade secrets, and limited firm coverage (discussed in subsequent sections). Due to such limitations, researchers have tried to identify product innovation using textual analysis of 10-Ks (Hoberg and Philips, 2010; Lonare, 2018) or public news (Mukherjee, Singh, and Žaldokas, 2017). We follow Lonare (2018) to compute a text-based measure of product innovations using textual analysis of product descriptions reported in 10-K statements (discussed in section 3(C)). Specifically, we exploit the changes in product market vocabulary of a firm over time to gauge its product innovation outputs. We also test our findings using the product innovation measure introduced by Mukherjee et al. (2017).

We find a positive relation between ITI and product innovation, suggesting that the higher status, visibility, or larger compensation provided by earning the tournament prize encourages CEOs to engage in more product innovation activities. This relation is robust using various

[3] The average CEO tenure is 7.59 years in our sample.
[4] When we use patent or citation based variables to measure product innovation, the coefficients on ITI are either insignificant or even negative. The results are shown in Table 9.

industry classifications, including size-median Fama-French industries, and fixed and dynamic industry classifications proposed by Hoberg and Philips (2010; 2016).

We also examine how the effect of ITI on product innovation varies with product market competition. More competitive threats by rival firms imply more severe tournament among CEOs, which can induce more innovation. An increase in competition from rivals indicates more innovation activities performed by rivals. The firm has to engage in more innovation activities to catch up with its own rivals in terms of innovation for its survival. Also, increased competitive threats by rival firms can also intensify the labor market competition for CEO talent (Jung and Subramanian, 2017), which increases the CEO mobility. We use product market fluidity, proposed by Hoberg, Phillips, and Prabhala (2014) to measure firm-level competition. Product market fluidity captures how the rival firms' products differentiate relative to the firm's products. We find that the effect of tournament incentives on product innovation is more pronounced for CEOs in the firms exposed to high market competition when compared to CEOs of those exposed to low market competition.

Besides, if the CEO's labor market is less mobile, the effect of tournament incentive on product innovation could also be attenuated because it is more difficult for the CEO to move to the leading firm to win the tournament prize. We use two variables to measure CEO labor market mobility. One is the unconditional CEO turnover rate in each industry, the other is the adoption of Inevitable Disclosure Doctrine (IDD), which is a legal doctrine enabling a firm to inhibit its employees from working for industry competitors in order to bar them from divulging the firm's trade secrets (Lin, Wei, and Yang, 2018; Sanati, 2018; Klasa, Ortiz-Molina, Serfling, and Srinivasan, 2018). We find that labor market immobility reduces the incentive effect of industry tournament on product innovation.

Lastly, we examine how the relation between ITI and product innovation is affected by CEO characteristics, as they impact the probability of moving to the leading firm. We find that the impact of ITI on product innovation is larger when the CEO is not new, not the founder, and not of retirement age. We control for *CEO delta* (the sensitivity of CEO's wealth to stock price) and *CEO vega* (the sensitivity of CEO's wealth to stock volatility) in all the regressions. To account for endogeneity, we follow Coles et al. (2017) and use the sum of total compensation of all other CEOs in each industry except for the highest-paid CEO and the average compensation of geographically close CEOs as instrumental variables for ITI.

Our research contributes to the existing literature in two ways. This paper is the first to examine the effect of ITI on product innovation. Thus, it identifies a new channel through which tournament incentives can affect firm performance and firm riskiness. The most similar paper to this study is Shen and Zhang (2017), where they explore the effect of internal tournament incentives, measured as the pay difference between the CEO and the executives under the CEO, on firm's innovative efficiency. However, our paper examines the effect of tournament incentives arising from external CEO labor market on product innovation. Second, we identify a new compensation scheme to motivate product innovation, which can also be considered as a policy implication for corporate boards. Manso's (2011) theoretical work finds that to motivate innovations, shareholders should use long-term incentive plans that exhibit tolerance of failure and reward for long-term success, such as options with long vesting period and golden parachute. There are empirical studies examining the effects of managerial time horizon (Gonzalez-Uribe and Groen-Xu, 2015), stock options and restricted stocks (Lerner and Wulf, 2007), internal promotion-based tournament incentives (Shen and Zhang, 2017), and incentive compensation with longer vesting periods for unexercised options (Baranchuk, Kieschnick, and Moussawi, 2014) on innovation. Our findings suggest that ITI can also motivate product innovation, thus corporate boards should account for industry relative compensation level to induce CEOs for higher innovative activities when designing CEOs' compensation schemes.

The rest of this paper is organized as follows. In section 2, we discuss hypotheses. In section 3, we describe our sample and variable constructions. Section 4 summarizes our data. In section 5, we first examine the effect of ITI on product innovation for the whole sample, then we conduct sub-sample analysis based on firms exposed to high product market competition versus other firms, CEO labor market mobility, and various CEO characteristics. In section 6, we present the findings of a number of tests that relate to the robustness of our results. Section 7 concludes. The Appendix provides variable definitions.

2. Hypotheses development

Rank-order based tournament theory suggests that compensating workers on the basis of their relative position in an organization can be an optimal labor contract arrangement under certain circumstances. The large prize for the winner of the tournament motivates the contestants to exert more effort to win the contest. The theory is initiated by Lazear and Rosen (1981), who find that if it is costly to monitor workers' effort and it is hard to measure the output related to workers' effort, then compensation based on the workers' ordinal rank is an optimal scheme. This tournament prize can provide incentives for next level executives under a CEO position as well as the CEO herself. Although a CEO is in the highest hierarchy within a firm, the external labor market can induce the CEO to work harder to gain upward mobility. In the labor market, the pay gap between a CEO and the highest-paid CEO within her peers can be viewed as the size of the tournament prize. With a large prize size, a CEO has a strong incentive to work hard in order to have an upward leap in her career. In addition, many firms adopt relative performance measures or reward their CEOs based on how well the firms perform compared to their peer group when designing their executives' compensation (Gong et al. 2011). Therefore, the tournament prize can motivate a CEO to work harder even without her actual move.

Another outcome of tournament incentives is risk-taking. Hvide's (2002) theoretical model shows that, if a high reward in a group goes to the agent with the highest output, then the agents in the group may be provided with an incentive to take a higher risk. Goel and Thakor (2008) develop a two-period leadership selection model and find that, when managers are competing to be CEO, they choose riskier projects than when they have no promotion concerns and seek only to maximize the expected utility of compensation. Kini and Williams (2012) test a similar hypothesis regarding internal incentive and find that higher tournament incentives lead to an increase in a firm's overall risk as well as riskier firm policies, including higher R&D intensity, firm focus, leverage, and lower capital expenditures intensity. Coles et al. (2017) test the effect of ITI for CEOs within an industry and find that ITI can increase firm performance as well as the riskiness of firm investment and financial policies.

The objective of this paper is to examine whether ITI affect product innovation, which is a major business activity because firms are always faced with competition from their rivals or potential new entrants and customers' rapid changing preferences. A firm that is capable of differentiating its product from its rivals to a large extent is able to reach a profitable customer segment or has a higher markup, thus CEOs who are engaged in product innovation are more likely to be a strong candidate for the external tournament prize. Developing new products are also risky because it requires an injection of extensive capital and time. These investments are costly and may fail. However, in case these risky policies become successful, they will contribute to firm performance, which should enhance the CEO's statue in the industry and make her a stronger candidate for the external labor market.

Compared with outsider shareholders, managers are less diversified and thus are exposed to more firm-specific risk. Therefore, they may eschew risky projects although they have positive net present values if they are risk-averse (e.g., Smith and Stulz, 1985; Lambert, Larcker, and Verrecchia, 1991). Manso's (2011) theoretical work finds that to motivate innovations, shareholders should use long-term incentive plans that exhibit tolerance of failure and reward for long-term success, such as options with long vesting periods and golden parachutes. The ITI can provide a similar convex payoff to that of options because the winner of the job market tournament earns the tournament prize while others win nothing. This option-like feature has been proven to lead to excessive risk-taking behavior. Coles et al. (2017) find that the ITI lead to more risky firm policies and increase the overall riskiness of the firm. Therefore, the risk-taking motivation induced by tournament incentives also encourages CEOs to engage in developing innovative products. Shen and Zhang (2017) study how promotion-based tournament incentives for non-CEO senior executives affect corporate innovation. As CEOs have greater power on a firm's decision-making process than other executives, the external tournament incentives of CEOs are expected to have a stronger effect on product innovation.

Based on the above discussion, we posit Hypothesis 1:

H1: Firms exhibit higher product innovations when the size of the CEO tournament prize is larger.

An interesting question is to test whether the effect of tournament incentives on product innovation is shaped by product market competition faced by a firm. It is probable that the effect of tournament incentives on product innovation is more pronounced when firms are faced with more competitive threats by rival firms. A CEO has numerous rivals in a competitive industry, where firms have homogenous products. The CEO may need a product differentiation to gain a competitive advantage in the market, which can boost her probability to win the tournament. Also, the competitiveness of the industry implies a fiercer tournament among CEOs of firms in the industry. Further, the firms in competitive industries may have a larger demand for talented CEOs who can bring in different skills and pioneering ideas to change the firm (Jung and Subramanian, 2017), making the labor market for CEO talent more competitive and thus increasing the mobility of CEOs. Jung and Subramanian (2017) link CEO talents with product market competition theoretically. In their model setting, firms offer partially substitutable products, and productivity contributes to profits more disproportionately as the product substitutability increases. A firm's quality and its CEO's talent jointly determine the firm productivity. Their model concludes that industries with greater product substitutability have larger dispersions of CEO pay and firm size, cateris paribus, which suggest that manager talent matters more in the more competitive product market. Therefore, the effect of tournament incentives on product innovation is expected to be stronger in firms that operate in the more competitive environment.

Further, Hoberg et al. (2014) find a negative relation between firm-level product market competition and the propensity to make payouts through dividends or share repurchases and a positive relation between the product market competition and cash holdings. Therefore, firms with a high degree of market competition can use the accumulated cash to obtain product market benefits. Consistent with this view, Huang et al. (2017) find that product market competition strengthens the relation between ITI and market share gains. Accordingly, as firms can use the increased cash holding for product innovation, product market competition can also potentially strengthen the relation between ITI and product innovations.

Based on the above discussion, we posit the hypothesis below:

H2: The positive effect of ITI on product innovation is more pronounced for firms facing higher product market competition.

The industry tournament incentives are supposed to have no effect on CEOs if they cannot win the tournament prize. Therefore, any factor that affects the likelihood of winning the tournament prize, including the CEO's labor market mobility and various CEO characteristics that affect the probability of moving to other firms, can impact the effects of ITI. First, if there is a friction in the labor market, the CEO cannot move up through the industry hierarchy easily to win the tournament prize. Moreover, if the firm and CEO characteristics indicate a low probability of job switching, then the CEOs are more inclined to stay in the current firm instead of moving, thus the outsider job market opportunities are not attractive to such CEOs. Hence, the hindered probability of winning the tournament prize could curtail the risk and performance motivation rooted by ITI and so could cut down the effects of ITI on product innovation. Accordingly, we propose the following testable hypothesis:

H3: The positive effect of industry tournament incentive on product innovation is less pronounced when the probability of winning the tournament prize is lower.

3. Data sources, variable construction, and sample description

A. Data sources

The SEC filings started in 1994 but the full coverage of public firms took three more years. Thus, we consider the sample period from 1998 to 2016. We obtain CEO compensation data from the Standard and Poor's (S&P) ExecuComp database providing data on salary, bonus, stock awards, option grants, and total compensation for executives of public firms. We obtain stock return data from the Center for Research in Security Prices (CRSP) and firm characteristics from the Compustat files. The sample excludes financial (SIC codes 6000-6999) and utility firms (SIC codes 4900-4999). We obtain 10-K statements from SEC Edgar to compute product innovation.

B. Measures of industry tournament incentives

Following Coles et al. (2017), we measure ITI as the pay gap between the CEO under consideration and the second highest paid CEO in the same industry to eliminate outlier effect, which is defined as *Ind Pay Gap*. Our main analysis applies the Fama-French 30 industry classification (FF-30) and Fama-French 48 industry classifications (FF-48). Specifically, our main independent variable of interest, *Ind Pay Gap*, is calculated as follows;

log (Ind Pay Gap) = log (Total compensation of the second highest paid CEO in the same industry - Total compensation of the CEO)

We also test the effect of ITI on product innovation using FF-30 (FF-48) size-median industry classification, 10-K based fixed and dynamic industry classifications proposed by Hoberg and Phillips (2010; 2016).

C. Dependent variables: Product innovation

We use textual analysis of 10-K's product descriptions filed on the SEC Edgar website to form our product innovation measure. The text-based product innovation is based on the product differentiation computed using the cosine similarity method.[5] For each firm, product differentiation is defined as the change in the use of unique words in the firm's product description from time t to time $t+i$.

There are several reasons to use this proxy of product innovation, instead of R&D and patent-based innovation variables. He and Tian (2018) report that over 50% of the US firms voluntarily

[5] We follow Hoberg and Phillips (2010) to calculate product differentiation.

prefer not to report R&D expenses in their financial statements. Koh and Reeb (2015) explore that 10.5% of non-reporting R&D firms display patent activities and report that missing or blank R&D does not mean a lack of innovative activities. Approximately, 76% of the US public firms never file any patent in the 1998-2010 period and 54% of the firms that file patents have no patent in its firm-year observations (Lonare, 2018). Saidi and Zaldokas (2016) argue that firms facing a trade-off between patenting and secrecy induce innovating firms to patent less. Hall, Jaffe, and Trajtenberg (2001) call attention to the fact that not all innovation outcomes are patented since some innovations do not meet the criteria of patentability set by USPTO.[6]

On the other hand, firms constantly modify or introduce new products and services, irrespective of patent grants, based on the market demand every year. Item 101 of Regulation S-K by the SEC requires the US public firms to report the significant products and services they offer to the market in their 10-K's business descriptions every year.[7] Also, product descriptions in 10-Ks are legally required to be accurate and current (Hoberg et al., 2014). They are usually stated in Item 1A or Item 1. Hoberg and Phillips (2010; 2016) use the logarithmic growth in the number of words in the product description section of a firm's 10-K in subsequent years to capture new product introductions. This measure can only capture product introductions when the product description size is larger in the subsequent year. We use the improved version of this measure developed by Lonare (2018) that uses change in product market space rather than just increase in size of product descriptions and call it as a product innovation as it also accounts for product composition. He shows that this text-based product innovation measure is influenced by CEO characteristics, CEO incentives, and corporate governance. The product descriptions in 10-Ks are

[6] USPTO stands for the United States Patent and Trademark Office. USPTO issues patents and trademarks to inventors and businesses.
[7] Documented on Electronic Code of Federal Regulations website: www.ecfr.gov.

supposed to have sufficient information on all the significant products and services, and the difference between two years' product descriptions is likely due to new product development. This text-based measure also serves as a continuous measure of product innovation due to the availability of continuous product and services changes from 10-Ks. In robustness tests, we also follow Mukherjee et al.'s (2017) methodology to obtain new product introduction information for our sample period and test our main hypothesis using this measure of product innovation.

The reasons why we study ITI and product innovation instead of patent-based technological innovation are as follows. Innovation through patents arises from long-term CEO incentives in the form of equity option compensation (Lerner and Wulf, 2007; Francis et al., 2011; Mao and Zhang, 2018). Thus, patent-based innovation is considered as long-term innovation to a firm as it takes a long period and significant managerial effort (Aghion and Tirole, 1994; Manso, 2011). Also, Lerner and Wulf (2007) find that short-term incentives, such as bonuses, are not influential for long-term innovation. Industry tournament incentives provide a short-term convex payoff for CEOs to increase firm performance and riskiness, and thus it may not induce CEOs to carry long-term patenting activities. Additionally, managers seek short-term aims and prefer to invest in which they have faster paybacks to intensify their reputation (Narayanan, 1985, Holmstrom and Costa, 1986; Hirshleifer and Thakor, 1992). Product innovation does not necessarily require patents, instead needs a relatively shorter period and lesser resources than a patent requires, generating profit in short-run that indicates the ability of a CEO and increases her reputation.

To compute text-based product innovation proxy, first 10-Ks are downloaded from the US EDGAR for sample firms using Central Index Key (CIK) number. Product description (also known as business description) section is reported in Item 1 or Item 1A of 10-Ks and is extracted from all 10-Ks. Firm-specific updates in products are captured using the help of trademark text characters.

For example, Apple Inc. has “iPhone” as a trademark text character registered on USPTO, but “iPhone 5”, “iPhone 6”, and “iPhone 7” are the new products associated to the trademark “iPhone”. In product description text, “iPhone5”, “iPhone6”, and “iPhone7” are considered as different words by eliminating space between the product and its version. This procedure helps in retaining new product names in word lists. Also, revisions in trademark text characters are tracked in the product description text. For example, Apple Inc. has “OS X” and “OS X YOSEMITE” as two registered trademark characters in USPTO’s trademark database. These two trademarks are also documented in the product descriptions of Apple Inc. An automated script identifies these revisions in the trademark and considers “OSX” and “OSXYOSEMITE” as two separate words in the product description text. This step is important because textual analysis scripts separate words delimited by spaces. Lastly, product description texts are cleaned using standard procedure followed in textual analysis literature.[8]

Next, cleaned product description texts are converted into lists of unique words for each description text. Two unique word lists generated for a firm at time t and $t+i$ are used for computing product innovation measure. The two-word lists are combined to form a main dictionary which consists of unique words from both of the lists. Then, a binary *N-vector* is formed separately for these two-word lists where each element of the *N-vector* is set to 1 if a given word in the word list is present in the main dictionary. These two binary N-vectors are associated with period t and $t+i$. For each time period t, the binary *N-vector* is denoted by P_t and normalized to have a unit length:

[8] First, common words are deleted from product descriptions that are used by more than 25 percent of all the firms in the same year. Then, stop words and geographical words, country names, city names, common people names, and surnames are removed (numbers are also deleted). Further, words are stemmed using Porter stemming algorithm. We omit product descriptions that have fewer than 20 unique words. Finally, only nouns and proper nouns (defined by wiktionary.org) along with the trademark characters and the revisions in product names are considered in cleaned version of product description texts.

$$V_t = \frac{P_t}{\sqrt{P_t \times P_t}} \quad (1)$$

The product similarity for a firm from period *t* to *t+i* is calculated as

$$Prod\ Simi_{t,t+i} = V_t \times V_{t+i}, \quad (2)$$

and the product innovation is calculated as:

$$Prod\ Innov_{t,t+i} = 1 - (Prod\ Simi_{t,t+i}) \quad (3)$$

Prod Innov is bounded between zero and one. It is equal to zero for firms that experience no change in their product market space. Higher values of *Prod Innov* denote a larger change in the firm's product space, which is equivalent to higher product innovations.

To illustrate the intuition behind what *Prod Innov* measures, suppose a firm uses five words to describe its products in year *t* and eight words in year *t+1*. Based on the information in the table below, we compute $Prod\ Simi_{t,t+1}$ as 0.79 and $Prod\ Innov_{t,t+1}$ as 0.209, as defined in equations (2) and (3), respectively. We see that the firm has three new words in period *t+1*, which potentially represents new products or services, or developments to the existing ones, and thereby suggests product innovation.

Word	*Year (t)*	*Year (t+1)*	*P(t)*	*P(t +1)*	*V(t)*	*V(t+1)*
computer	Yes	Yes	1	1	0.447	0.354
mouse	Yes	Yes	1	1	0.447	0.354
motherboard	Yes	Yes	1	1	0.447	0.354
chip	Yes	Yes	1	1	0.447	0.354
signal	Yes	Yes	1	1	0.447	0.354
bluetooth	No	Yes	0	1	0.000	0.354
sensor	No	Yes	0	1	0.000	0.354
wireless	No	Yes	0	1	0.000	0.354

D. Control variables

For all the regressions, we control for internal tournament incentives (*Firm gap*). Following Kale et al. (2009), Kini and Williams (2012), and Coles et al. (2017), we calculate *Firm gap* as the difference between CEO total compensation and median of vice presidents' (VP) total compensation. We also include *CEO delta* and *CEO vega* in the regression, where CEO delta is defined as the change in executive wealth per $1,000 change in stock price and CEO vega is the change in the value of the CEO's wealth for a 0.01 change in the annualized standard deviation of stock returns. Following Coles, Daniel, and Naveen (2006; 2013), we use the Black-Scholes option valuation model modified by Merton (1973) to account for dividends, and use the estimates in Bettis, Bizjak, and Lemmon (2005) to model how the holding period of stock options varies with volatility. We use the SAS code provided by Coles et al. (2013) to compute CEO delta and CEO vega.[9] Following Coles et al. (2017), we also control the number of CEOs in the industry. We follow the innovation literature to control for firm characteristics that could be related to a firm's product innovation abilities. The firm characteristics include firm size (the logarithm of total assets), investment in innovation (R&D expenditures scaled by total assets), profitability (ROA), asset tangibility (net property, plant, and equipment scaled by total assets), leverage (book leverage scaled by total assets), investment in fixed assets (capital expenditures scaled by total assets), cash holding (cash scaled by total assets), growth opportunities (Tobin's Q), product market competition (the logarithm of product market fluidity measure), and firm age. See Appendix A for detailed definitions of all the variables. In all our regression models, we include year fixed effects and industry fixed effects.

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[9] We find some minute error in this code and fix it to get CEO Delta and Vega.

E. Measurement for product competition and CEO labor market mobility

We also study whether the effect of ITI on product innovation differs in firms with various levels of competition and labor mobility. We use product market fluidity measure developed by Hoberg et al. (2014) as a proxy for product market competition. The product market fluidity is a measure of firm-level competitive competition based on the description of a firm's product space and rivals move in their 10-Ks. A higher magnitude of product market fluidity denotes a firm is facing more competitive threats from its rivals, in other words, rivals are creating more innovative products.

Besides, the effect of tournament incentives on product innovation could differ in the labor market mobility for a CEO, because it affects the probability of being promoted to the leading firm within the industry. We use two variables to measure CEO mobility. The first variable is the unconditional probability of CEO turnover in each industry (industry mobility) in the given year. The turnover is defined as when a CEO in the next year is not the same person as the CEO in the current year. More CEO turnover represents less friction in the labor market, indicating a higher probability of moving to the leading firm. Thus, we expect to observe a higher effect of ITI on product innovation with the increase in industry mobility.

Another proxy for CEO labor mobility is whether the firm's headquarter is located in the states that have adopted the Inevitable Disclosure Doctrine (IDD), which is a legal doctrine empowering a firm to constrict its employees to work for industry competitors in order to hamper employee from revealing the firm's trade secrets. The doctrine is adopted by many states and is independent of non-compete or non-disclosure agreements, and applicable even if these agreements are not signed by a manager. The court can prohibit the employee from working for a rival or constraint her responsibilities undertaken in the rival firm. Thus, IDD can weaken the managers' mobility within the industry (Klasa et al., 2018).

F. CEO characteristics

We also examine whether various CEO characteristics can affect the relation between ITI and product innovation. Following Coles et al. (2017), we consider whether the CEO is new, a founder, or of retirement age. The CEO is defined as newly hired if she is in the first year of service as CEO (*New CEO* = 1, 0 otherwise). The CEO is identified as a founder if the most recent title in ExecuComp indicates that the CEO is a founder of the firm (*Founder* = 1, 0 otherwise). We consider CEO as near retirement if the CEO is older than 65 (*Retire CEO* = 1, 0 otherwise). A new CEO or a CEO nearing retirement has a smaller probability of mobility, and thus the effect of ITI should be less pronounced for these CEOs.

If CEO is also the founder of the firm, she might use her power to engage in more product innovation to win the tournament prize. Alternatively, she might enjoy the high status and large control power in the firm, thus winning the tournament or moving to the leading company in the industry is less attractive for her. Therefore, it is not conclusive if a founder CEO can aggravate or attenuate the relation between ITI and product innovation.

G. Instrumental variables

There might be reverse causality between ITI and product innovation. It is possible that innovative firms set their CEOs' compensations to motivate them to invest in riskier projects. Therefore, we follow Coles et al. (2017) and use the sum of total compensation of all other CEOs in each industry except for the highest-paid CEO, *Ind CEO comp*, and the average compensation of geographically close CEOs, *Geo CEO mean*, as instrumental variables for ITI. We measure the average compensation of geographically close CEOs as the average total compensation in each year received by all other CEOs who work at firms which are headquartered within a 250-km radius of the firm except its industry peers. The average pay level of an industry and compensation level of geographically close firms are expected to be highly correlated with ITI. However, these industry-wide variables are unlikely to relate to firm level product innovation directly.

4. Summary statistics

Table 1 shows summary statistics for our main variables. Panel A presents details of product innovation, incentive variables, and other variables. Panel B shows the correlation matrix for the main variables.

As shown in Panel A of Table 1, the mean value of text-based product innovation measure, *Prod innov,* is 0.13 (standard deviation of 0.09) with the 90th percentile of 0.25. The mean (median) of our first measure of industry pay gap, *Ind Pay Gap*, using second-highest CEO pay within FF-30 industry classifications as the benchmark is $25 million ($18.7 million). The magnitude of ITI is much larger than the internal pay gap, which has a mean (median) value $3.1 million ($2 million). These values are similar to those reported in Coles et al. (2017). We also report summary statistics of *Ind Pay Gap* variable measured on the basis of FF-30 size-median, FF-48, FF-48 size-median, FIC-100, FIC-200, FIC-300, TNIC-2 and TNIC-3 industry classifications in the Panel A of Table 1. The medians of CEO delta and CEO vega are $755.51 per thousand dollars and $103.76 per thousand dollars, respectively[10], and the magnitudes are very similar to that in Cole, Daniel, and Naveen (2006).

[10] We use the variable SHROWN_EXCL_OPTIONS in ExecuComp to measure the number of stock grants, which includes both restricted and unrestricted shares. For stock options, we use the Black-Scholes model to compute their values. Following Core and Guay (1999) and Coles et al. (2006; 2013), we separately compute the option deltas and vegas for the existing options and new option grants. For the existing unvested options, we use the exercise date and the fiscal year to compute the maturity. The maturity of vested options is assumed to be three years less than that of unvested options. We assume that the newly granted options have the same maturity as the unvested options. If the

Panel B shows the correlation matrix for the main variables. The correlation between *Prod innov* and the two industry pay gap variables is positive, which is consistent with our null hypothesis that product innovation is positively related to the external tournament prize size. CEO Vega is also positively correlated to *Prod innov*, which is consistent with the view that larger sensitivity of CEO's wealth to stock volatility induces risk-taking behavior (Coles et al., 2006). The correlation between *Prod innov* and R&D is 0.13, which is consistent with the fact that R&D investment contributes to product innovations.

5. Results

5.1. ITI and product innovation

In this section, we analyze the effects of ITI (*Ind Pay Gap*) on product innovation using ordinary least squares (OLS) regression as well as two-stage least squares (2SLS) approach. In all regressions performed in this section and other sections, we cluster standard errors by firm to address serial correlation and heterogeneity in the idiosyncratic error of the regressions and include year and industry fixed effects to eliminate heterogeneity by year and industry.

First, we use OLS regression to test whether the ITI influence product innovation. The estimated OLS model is:

$$\begin{aligned} Prod\ Innov_{i,(t,t+1)} = {} & \alpha_i + \beta_1 Ln(Ind\ Pay\ Gap)_{i,t} + \beta_2 Ln\left(Firm\,gap\right)_{i,t} \\ & + \beta_3 Ln\left(CEO\ delta\right)_{i,t} + \beta_4 Ln\left(CEO\ vega\right)_{i,t} \\ & + \beta_5 Firm\_Characteristics_{i,t} + \gamma Other\_ControlVariables_{i,t} + \varepsilon_{i,t} \end{aligned} \tag{4}$$

maturity is longer than 10 years, we assume that it is equal to 10 years. The risk-free rate is the yield for Treasury constant maturities and is from the U.S. Federal Reserve Bank website. The estimated dividend yields and volatilities are given in ExecuComp. The vega for stock grants is zero, so we only use the option portfolios to calculate vega. Finally, CEO delta is the dollar change in CEO wealth associated with a 1% change in the firm's stock price, CEO vega is the change in CEO wealth associated with a 0.01 change in the standard deviation of the firm's returns.

where *i* indexes firms and *t* indexes years. The dependent variable is *Prod Innov*, which is defined as the product differentiation in firms' product descriptions (from 10-Ks) from year *t* to year *t+1*. See Appendix A for detailed information on all the other variables.

We next consider the scenario in which the relation between ITI and product innovation may be endogenous. We use two-stage least square (2SLS) estimation to test whether the ITI influence product innovation. The first-stage regression used to compute predicted values for ITI is

$$\begin{aligned} Ln(Ind\ Pay\ Gap)_{i,t} = \alpha_i + \delta_1 Ln(Ind\ CEO\ comp)_{i,t} + \delta_2 Ln(Geo\ CEO\ mean)_{i,t} \\ + \delta_3 Ln\left(Firm\, gap\right)_{i,t} + \delta_4 Ln\left(CEO\ delta\right)_{i,t} + \delta_5 Ln\left(CEO\ vega\right)_{i,t} \\ + \delta_6 Firm\_Characteristics_{i,t} + \lambda Other\_ControlVariables_{i,t} + \eta_{i,t} \end{aligned} \quad (5)$$

The instruments used for the endogenous variable in our analyses are *Ln(Ind CEO comp)*, which is the sum of total compensation of all other CEOs in each industry except the highest-paid CEO and *Ln(Geo CEO mean)*, which is in each year average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm.

We report our main findings regarding OLS and 2SLS regressions in Table 2. The first three columns present results using the Fama-French 30 (FF-30) industry classifications, and the last three columns present results using the Fama-French 48 (FF-48) industry classification. Models 1 and 4 show the results regarding OLS regressions. Models 2, 3, 5, and 6 illustrate the results regarding 2SLS regressions. The Hausman exogeneity tests in both the industry classifications reject the null hypothesis of exogeneity, which confirms endogeneity of the variable *Ln(Ind Pay Gap)*. The significant coefficient on *Ln(Ind CEO comp)* and the large F-statistics (3708.7 in FF-30 and 2450.22 in FF-48) in the first stages of 2SLS regressions imply that the instrument variables satisfy relevance criterion. As a validity test, overidentification test statistics (Hansen's *J* test) are

0.15 and 0.17, respectively when the industry is based on FF-30 and FF-48. Therefore, the instruments used are unlikely to affect firm-level product innovation directly.

The coefficients on *Ln(Ind Pay Gap)* are positive and statistically significant for both the OLS regressions (models 1 and 4) and the second stage of 2SLS regressions (models 3 and 6) when we use FF-30 and FF-48 industry classifications. In terms of economic significance, the second stage of 2SLS indicates that a one standard deviation increase in industry pay gap around its mean results in 14.14% (15.70%) standard deviation increase in the next year's product innovation in FF-30 (FF-48).[11] These results are consistent with our Hypothesis 1 that the level of product innovation increases in the size of the industry tournament prize. The coefficients on *Ln(CEO vega)* are all significantly positive when we use OLS or 2SLS model. CEO vega (sensitivity of managerial wealth to firm risk) is documented to provide convexity to CEOs' payoffs and motivates them to carry riskier investment and financing policies (e.g. Rajgopal and Shevlin, 2002; Coles et al., 2006; Mao and Zhang, 2018). Consistent with risk-enhancing behavior of CEO vega, we find positive and statistically significant coefficients on ITI in all the models. The sign of the coefficient on *Ln(CEO delta)* is not clear ex-ante. On one hand, as the sensitivity of CEO's wealth with respect to the firms' stock price becomes larger, CEOs are more aligned with shareholders who have an affinity for risk, thus the CEOs might innovate their products more aggressively. On the other hand, larger delta exposes the CEOs to more risk, and risk-aversion might induce CEOs to be more conservative and thus engage in less product innovation activities. The negative coefficients on *Ln(CEO delta)* in both the OLS regressions and the 2SLS regressions show that the latter effect dominates. This argument is consistent with Smith and Stulz (1985) and Guay (1999), who assert

[11] We use the following method to compute economic significance:

$$\frac{\left[\text{Ln(mean of } \textit{Ind Pay Gap} \text{+0.5std) - Ln(mean of } \textit{Ind Pay Gap} \text{-0.5std)}\right] \times \text{coef on Ln(}\textit{Ind Pay Gap}\text{)}}{\text{std(}\textit{Prod Innov}\text{)}}$$

that risk-aversion can discourage executives from risky investment when their wealth depends highly on firm performance.

Among other control variables in the second stage of 2SLS regressions, the coefficients on *Ln(Firm gap)* are positive, but the magnitudes are much smaller than those on industry tournament incentive variables (*Ln(Ind Pay Gap)*). This confirms our conjecture that CEOs play a more important role than other executives in setting product innovation policies. We also find a positive relation between R&D expenditures and product innovation, which means that more R&D expenditures lead to more product development. We find a positive relation between firm cash holdings and product innovation, indicating that cash can be deployed in risk-involving innovative activities. Additionally, larger firms, firms with more growth opportunities, higher intangible assets, higher leverage, and firms investing less in tangible assets tend to produce higher product innovations. Product innovations are also positively associated with product market competition, which is represented by *Prodmkt Fluid.*

Overall, the findings are consistent with our null hypothesis that when the industry tournament prize is high, CEOs have larger incentives to undertake more innovative product activities that have the potential to increase firm performance. This is also consistent with the risk-taking behaviors caused by tournament incentives because product innovation is associated with uncertainty and riskiness.

5.2. ITI effect and product market competition

In this section, we test how the effect of tournament incentives on product innovation is impacted by product market competition faced by a firm. Increased competitive threats by rival firms may induce CEOs for more innovation activities because other CEOs as their tournament rivals threaten the CEOs more and competition among all CEOs can become more severe. Hoberg et al. (2014) find a negative relation between product market competition and the propensity to make payout through dividends or share repurchases and a positive relation between the market competition and cash holdings. The increase in cash holdings in case of higher product market competition can induce CEOs to spend more on innovative activities to win the tournament prize.

We obtain product market fluidity data from Hoberg and Phillips personal website. The data is between 1997 and 2015. Product market fluidity captures how rival firms' products differentiate relative to a firm's products.[12] Then, we separate our sample into two subsamples based on the median values of product market fluidity and run separate 2SLS regressions for the two subsamples.

Table 3 reports our findings on these regressions. Columns (1) and (2) use FF-30 classification to calculate industry tournament, and (3) and (4) uses FF-48 industry classification. In both the industry classifications, we have significant Hausman statistics in columns (2) and (4), confirming the endogeneity of *Ln(Ind Pay Gap)* for the firms of high fluidity. We cannot reject the null hypothesis of exogeneity in columns (1) and (3), which are regressions for the firms with low fluidity, based on Hausman exogeneity test. Nevertheless, we use 2SLS regression for both the industry classifications because OLS regression usually gives a much smaller magnitude of coefficients and the magnitudes of OLS and 2SLS are not comparable.[13]

As shown in Table 3, the coefficients on *Predicted Ln(Ind Pay Gap)* in columns (2) and (4) are much larger than those in columns (1) and (3), the significance levels are also much larger in columns (2) and (4) than their counterparts, indicating that the effect of ITI on product innovation

[12] For detail information about fluidity data, please see Hoberg et al. (2014).
[13] We have unreported OLS regression results for all the four subsamples. The magnitude of the coefficient on *Ln(Ind Pay Gap)* is reliably larger in subsamples with larger product fluidity. The tables are available upon request.

is stronger in competitive product market, which is consistent with our Hypothesis 2. This result suggests that the positive effect of ITI on product innovation is more pronounced for firms facing higher product market competition. Hence, the firms facing high product market competition appear to be the main driver of the positive relation between industry tournament incentives and product innovation in the full sample. Our results are also consistent with Huang et al. (2017). They find that ITI reinforce the relation between excess cash and market share gains, and this relation is more pronounced in firms facing more competitive threats, indicating that the product market benefits of ITI are concentrated in more competitive product markets.

5.3. ITI and CEO labor market mobility

In this section, we test how the effect of ITI on product innovation is impacted by CEO mobility. We use two variables to measure CEO mobility: one is the adoption of Inevitable Disclosure Doctrine (IDD) by states, as it hinders job mobility of CEOs, and the other is the industry mobility (unconditional CEO turnover rate within the industry).

There are many factors affecting labor market mechanism, and among them, regulations or agreements restraining labor mobility are pervasive. Among the factors influencing labor mobility, IDD, which is a legal doctrine empowering a firm to constrict its employees to work for industry competitors in order to hamper its employees from revealing the firm's trade secrets, has a crucial place in labor market (Lin et al., 2018; Sanati, 2018; Klasa et al., 2018). In order for a case to be under this doctrine, the employee must be in a position that she had the authorization to enter into the firm's trade secrets, she will work under a position in a rival firm that she will inevitably use the trade secrets she obtained from the previous firm, and the usage of the trade secret will originate irreparable damage to the firm. The doctrine is adopted by many states and is independent of non-compete or non-disclosure agreements, and applicable even if these agreements are not signed by the employee (manager). The court can prohibit the employee from working for the rival or constraint her responsibilities undertaken in the rival firm. Thus, IDD can weaken employee mobility. In fact, Klasa et al. (2018) illustrate that the acceptance of IDD significantly narrows the managers' mobility within their industries. We follow Klasa et al. (2018)[14] to set an indicator variable of IDD, where it is set equal to one when IDD is effective in the state that the firm locates in a given year, and zero otherwise. Next, we divide the whole sample into two subsamples based on the IDD indicator. Last, we run 2SLS regression in each subsample separately.

Industry mobility is the unconditional probability of CEO turnover in each industry. We separate our sample into two subsamples based on the median of unconditional CEO turnover rate. Table 4 and Table 5 report the analyses on CEO labor mobility. Table 4 reports the results using industry mobility, and Table 5 shows the results using IDD. We only report the second stage of the 2SLS regressions for brevity. In both the tables, columns (1) and (2) use FF-30 industry classification to calculate industry tournament pay gap, and columns (3) and (4) use FF-48 industry classification. As we can see in Table 4, the coefficients on the predicted pay gap are only significant in the subsample with higher mobility (Industry Mobility > median). Table 5 presents subsample analyses on IDD indicator. Although the coefficients on the predicted pay gap are significant no matter whether the firm is located in the states with the adoption of IDD or not, the magnitudes and the significance levels of the coefficients are larger in the subsamples of firms located at states without IDD. Therefore, we explore that product innovation is less sensitive to ITI in the firms located at states which recognize IDD. However, we can say even though the adoption of IDD weakens the importance of ITI on product innovation activities, it does not totally

[14] For the table illustrating the states' adoption and rejection dates of IDD, please see Klasa et al. (2018). Also, there are similar tables in Lin et al. (2018) and Sanati (2018).

eliminate their impact on product innovation, which indicates the persistence of the effect of ITI on product innovation in spite of the existence of IDD. These results are consistent with Hypothesis 3, suggesting that CEO labor market mobility plays an import role on the effectiveness of ITI.

5.4. CEO characteristics and the effect of ITI on product innovation

Table 6 shows the results of the effect of ITI on product innovation conditional on various CEO characteristics, including whether CEO is new (the first year of service in the firm as a CEO), the founder, and of retirement age (above 65). Panels A and B show the results based on FF-30 and FF-48 industry classifications, respectively. We only report the second stage of 2SLS regressions. For the new CEO subsample (column (1)), the coefficient on the *Predicted Ln(Ind Pay Gap)* is only significant at 10% level in Panel A and becomes insignificant in Panel B. The reason might be that a newly assigned CEO may not be motivated to transfer to another firm immediately. In contrast, the coefficient on the pay gap for a continuing CEO is positive and statistically significant, indicating that ITI are more effective to motivate her for product innovation. Also, in both FF-30 and FF-48 industry classifications when a CEO is the founder of the firm (column (3)), the coefficient on pay gap is insignificant, which indicates that external tournament incentives are not effective for the founder CEO. The possible reasons can be that the founder CEO is likely to be powerful, has a high status and more commitments to that firm. Also, the human capital of a founder CEO is more bounded than that of a non-founder CEO to the firm. Therefore, the outside opportunities are not expected to be attractive to a founder CEO. Consistently, the coefficient on ITI is significantly positive when a CEO is not the founder. As expected, in both industry classifications, the coefficient on ITI is larger when a CEO is not of the retirement age (column (6)), indicating that the outside labor market may not be attractive to a retiring CEO who might want to enjoy a quiet life near retirement.

6. Robustness tests

We use several alternative industry classifications to repeat all the previous analyses. Specifically, we use FF-30 and FF-48 size-median industry classifications and various 10-K based industry classifications developed by Hoberg and Phillips (2010; 2016). 10-K based industry classifications include three fixed-industry classifications (fixed 100 industries [FIC-100], fixed 200 industries [FIC-200], fixed 300 industries [FIC-300]) and two dynamic network industry classifications (TNIC-2 and TNIC-3)[15]. Hoberg and Philips (2016) state that these industry classifications capture horizontal relatedness between firms and contain information additional to the traditional SIC or NAIC industry classifications. Further, 10-K based industry classifications use information that firms provide to determine who they compete against based on their product descriptions instead of predefined industry groups.

Correspondingly, *Ind Pay Gap* is defined as the pay gap between the second-highest-paid CEO's total compensation within the same 10-K text-based industry classifications and the total compensation of CEO under consideration. We include year fixed effects in all specifications and *t*-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. We do not include industry fixed effects in dynamic industry classification (TNIC 2 and TNIC 3), as the industry definition using similarity scores allow firms to change their groups each year based on these scores. Table 7 reports our findings. Similar to the results illustrated in Table 2, we find positive and significant coefficients on *Predicted Ln(Ind Pay Gap)* for all the ITI models computed using several other industry classifications, including FF-30 and FF-48 size-median industry classifications and 10-K based industry classifications. These

[15] TNIC-2 classification is calibrated to be as granular as two-digit SIC codes and TNIC-3 as three-digit SIC codes. For detailed explanations for these 10-K based industry classifications, see Hoberg and Philips' data library web page http://hobergphillips.usc.edu/industryclass.htm.

results suggest that the positive effect of ITI on product innovation is robust to using different measures of industry classifications.

We also use an alternative method to measure product innovation. We follow Mukherjee et al.'s (2017) methodology to obtain new product introduction information for our sample period. First, we search LexisNexis database for corporate news that is labeled under the subject "New Products" and contain new product keywords such as "Launch", "Product", "Introduce", "Begin", and "Unveil" in their headlines. We download the news based on company ticker names and then use the one-factor model to do event studies to obtain abnormal returns.[16] Following Mukherjee et al. (2017), we only keep the product announcements in a fiscal year which the stock return exceeds its 75th percentile. This method provides count on major new products introduced by the firm. Then, we use the natural logarithm of one plus total number of product announcements by a firm in a fiscal year which the stock return exceeds its 75th percentile as a measure of product innovations. As shown in Table 8, the coefficients on industry tournament prize size are statistically significant in both OLS and 2SLS specifications. Thus, our result regarding the effect of ITI on product innovation is robust to using the number of product announcements as a proxy for product innovation.

Next, we analyze the effect of ITI on patenting activities. We first obtain patent and citation count variables for a period 1998-2010 from Kogan, Papanikolaou, Seru, and Stoffman (2017).[17] We then extend these patent-based variables up to period 2016 using bulk patent data provided by USPTO. Following innovation literature, we use patent count, citation count, and number of

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[16] Following Mukherjee et al. (2017), we first fit a market model over the window (−246,−30) around the announcement date to obtain the beta for the firm's stock, then we calculate cumulative abnormal returns over a 3-day period (−1,1).

[17] We thank Noah Stoffman for making patent variables readily available on his personal website.

citations per patent as proxies for patent-based technological innovation and run 2SLS regressions. The results are shown in Table 9. The coefficients on the industry tournament prize are either negative or insignificant. These results are probably because the patent-based innovations are motivated by CEOs long-term incentives. Although promotion-based tournament incentives have an option-like convex payoff, they are more likely to induce short-run product innovation activities for CEOs.

Product innovations are also a function of patenting activities as firms can use their patents to produce new goods and services or improving existing ones. Product innovations in the current year could be the results of patenting activities by the firm in previous years. We test our baseline hypothesis using product innovations that are not created through patents. First, we run an OLS regression with our text-based product innovation measure as a dependent variable and the number of applied patents in the last three years as independent variables. We use the following OLS specification:

$$Prod\ Innov_{i,(t,t+1)} = \alpha_i + \beta_1 Ln\left(1 + \#Patents_{i,t+1} + \#Patents_{i,t} + \#Patents_{i,t-1}\right) + \varepsilon_{i,t+1} \tag{6}$$

We then obtain error terms from the regression and call the residuals as non-patenting product innovation since this variable excludes patent effect. Then, we use this non-patenting product innovation variable as a dependent variable in our baseline 2SLS model. The results are documented in Table 10. We still have positive and significant coefficients on industry pay gap in the models of FF-30 and FF-48 industry classifications. This result suggests that ITI also affect product innovation that does not stem from patents.

7. Conclusion

CEOs have been evaluated on the basis of their firms' relative performance compared to their peer groups (Gong et al., 2011) and *The 2015 CEO Success Study* conducted by Strategy& shows that top global firms tend to recruit outside CEOs in their succession plans. Also, several preceding studies argue the existence of contest among CEOs in moving to the leading firms due to the gap between their own compensation and the compensation of the CEO assuming the office in the leading firm, which is considered as the prize of the contest (Nguyen and Phan, 2015; Kubick and Lockhart, 2016; Coles et al., 2017; Huang et al., 2017; Kubick et al., 2018). Previous studies (e.g., Kale et al., 2009; Kini and Williams, 2012; Coles et al., 2017) find a positive effect of tournament incentives on firm performance, firm risk, and the riskiness of policy choices. This tournament characteristic of compensational difference motivates executives to undertake product innovation activities because product innovation has a potentially profitable outcome and is also highly uncertain and risky. This study examines how industry tournament incentives (ITI) influence product innovation. Our argument rests on the premise that the motivation to transfer to a leading firm in the industry will induce CEOs to exert greater effort for product innovation because taking a position as a CEO in a leading firm in the industry will provide them with higher status, visibility, and more comprehensive compensation packages.

Motived by Hoberg and Philips (2010; 2016) and Lonare (2018), we use textual analysis of product descriptions reported in 10-K statements to measure product innovation. Specifically, we exploit the changes in product market vocabulary of a firm over time to gauge its innovation outputs. First, we allocate a product location space based on the firm's product description text. Then, using the cosine similarity method, we measure the difference in two product location spaces for a firm and denote this difference as product innovation. The changes in a firm's product location space represent product variations and quality changes over time. We take advantage of the rich and continuous information on the product descriptions in 10-Ks, because they are required by the SEC to be disclosed. This also provides us with an objective measure of the firm's product innovation and overcomes the concerns related to using patent-based measures as a proxy for product innovation.

We find that ITI affect product innovation positively. The positive relation between ITI and product innovation remains robust to the different alternative measures of industry classification. Also, we investigate whether product market competition affects the relation between ITI and product innovation. We show that ITI are more effective on product innovation in the firms exposed to high market competition. Further, we examine how CEO labor market mobility affects the relation between ITI and product innovation. We use two variables to measure mobility: the unconditional CEO turnover rate within the industry (industry mobility) and the adoption of IDD. We find that in both cases, the effect of tournament incentives on product innovation is attenuated in the relatively immobile CEO labor market.

Further, our findings indicate that the effects of ITI on product innovation are more pronounced when a CEO's characteristics indicate a higher probability of moving to the leading firm within the industry, including when the CEO is not new, not the founder, and is not of the retirement age. Overall, our analyses indicate that ITI are important incentive mechanisms to motivate CEOs for product innovations.

Appendix A
Data sources and definitions

Variable	Definition
Text-based product innovation variable	
Prod Innov$_{t,t+1}$	For each firm, this is a change in the product spaces from period *t* to *t+1*. It is computed using "cosine" similarity method based on the use of unique words in the firm's product descriptions in the two different periods. The details of formation of the text-based product innovation is discussed in section 2.1. (US SEC filings)
Incentives variables	
Ind Pay Gap ($000)	The pay gap between the second-highest-paid CEO's total compensation within the same industry and the CEO's total compensation. We use Fama-French 30-industry (size-median industry), Fama-French 48-industry (size-median industry), FIC (100, 200, and 300), and TNIC (2 and 3) classifications.
Firm gap ($000)	The pay gap between CEO's total compensation and the median VP total compensation
CEO Delta (per $1)	Dollar change in CEO wealth associated with a 1% change in the firm's stock price
CEO Vega ($000)	Dollar change in CEO wealth associated with a 0.01 change in the standard deviation of the firm's returns
Patent-based variables and product announcement variable	
LN_Prod_Announce	The natural logarithm of one plus total number of product announcements by a firm in a fiscal year which the stock return exceeded the 75th percentile.
LN_PAT	The natural logarithm of one plus total number of patents applications filed (and eventually granted) by a firm in a fiscal year. Set to zero if missing for patenting firms.
LN_CITE	The natural logarithm of one plus total number of citations received to patents applied (and eventually granted) by a firm in a fiscal year. Set to zero if missing for patenting firms.
LN_CITEPP	The natural logarithm of one plus the number of citations per patent (based on applications filed) by a firm in a fiscal year.
Firm characteristics	
Total assets ($000,000)	Book value of total assets in millions of constant dollars, CPI-adjusted (Compustat)
R&D	R&D expenditures divided by total assets, set to 0 if missing (Compustat)
Cash	Cash scaled by total assets (Compustat)
ROA	Operating income before interest divided by total assets (Compustat)
Capital Invest	Investment in property, plant, and equipment divided by total assets (Compustat)
Leverage	Book leverage scaled by market value of total assets (Compustat)
Capital Expend	Capital expenditures scaled by total assets (Compustat)
Q	market value of equity plus book value of assets minus book value of equity minus balance sheet deferred taxes) divided by book value of assets (Compustat)
Prodmkt Fluid	Measure of firm-level competitive threats based on the description of a firm's product space and rivals move in their 10-Ks developed by Hoberg et al. (2014). A higher product market fluidity for the firm indicates a greater market threat from the competitors. (Hoberg-Phillips Data Library)
Firm Age (years)	Firm age is computed as one plus the difference between the year under investigation and the first year the firm appears on the CRSP tapes. (CRSP)
CEO characteristics	
CEO New	A dummy variable assigned to 1 in the CEO's first year of service as CEO, and set to 0 otherwise (ExecuComp)
CEO Founder	A dummy variable assigned to 1 if a CEO is also the founder of the firm, and set to 0 otherwise (ExecuComp)

CEO Retire	A dummy variable assigned to 1 if the CEO's age is more than 65 years, and set to 0 otherwise (ExecuComp)
Industry characteristics	
Ind # CEOs	The number of CEOs (or firms) within the same industry in the sample year (ExecuComp)
Industry Mobility	The unconditional probability of CEO departure in each industry in the given year (ExecuComp)
Instruments and other variables	
Ind CEO comp ($000,000)	The sum of total compensation of all other CEOs in each industry (or size-based half industry), except the highest-paid CEO (ExecuComp)
Geo CEO mean ($000)	The average total compensation received by all other CEOs who work at firms in a different industry which are headquartered within a 250-km radius of the firm (ExecuComp)

References

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

Baranchuk, N., Kieschnick, R. and Moussawi, R., 2014. Motivating innovation in newly public firms. *Journal of Financial Economics,* 111, pp. 578-588.

Bettis, J. C., Bizjak, J. M. and Lemmon, M. L., 2005. Exercise behavior, valuation, and the incentive effects of employee stock options. *Journal of Financial Economics,* 76, pp. 445-470.

Boehe, D. M. and Cruz, L. B., 2010. Corporate social responsibility, product differentiation strategy and export performance. *Journal of Business ethics*, 91, pp. 325-346.

Clark, J. and Guy, K., 1998. Innovation and competitiveness: a review: Practitioners' forum. *Technology Analysis and Strategic Management,* 10, pp. 363-395.

Coad, A. and Rao, R., 2008. Innovation and firm growth in high-tech sectors: A quantile regression approach. *Research policy*, 37, pp. 633-648.

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

Coles, J. L., Daniel, N. D. and Naveen, L., 2013. Calculation of compensation incentives and firm-related wealth using Execucomp: Data, program, and explanation. *SSRN Online.*

Coles, J. L., Li, Z. and Wang, A. Y., 2017. Industry tournament incentives. *The Review of Financial Studies*, 31, pp. 1418-1459.

Core, J. and Guay, W., 1999. The use of equity grants to manage optimal equity incentive levels. *Journal of accounting and economics*, 28, pp. 151-184.

Corsino, M. and Gabriele, R., 2010. Product innovation and firm growth: evidence from the integrated circuit industry. *Industrial and corporate change*, 20, pp. 29-56.

Fang, V. W., Tian, X. and Tice, S., 2014. Does stock liquidity enhance or impede firm innovation?. *The Journal of Finance*, 69, pp. 2085-2125.

Fee, C. E. and Hadlock, C. J., 2004. Management turnover across the corporate hierarchy. *Journal of Accounting and Economics*, 37, pp. 3-38.

Francis, B. B., Hasan, I. and Sharma, Z., 2011. Incentives and innovation: Evidence from CEO compensation contracts. *Working paper.*

Goel, A. M. and Thakor, A. V., 2008. Overconfidence, CEO selection, and corporate governance. *The Journal of Finance*, 63, pp. 2737-2784.

Gong, G., Li, L. Y. and Shin, J. Y., 2011. Relative performance evaluation and related peer groups in executive compensation contracts. *The Accounting Review,* 86, pp. 1007-1043.

González-Uribe, J. and Groen-Xu, M., 2017. CEO contract horizon and innovation. *Working paper.*

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

Hall, B. H., Jaffe, A. B. and Trajtenberg, M., 2001. The NBER patent citation data file: Lessons, insights and methodological tools.

He, J. and Tian, X., 2018. Finance and Corporate Innovation: A Survey. *Asia-Pacific Journal of Financial Studies,* 47, pp. 165-212.

Hirshleifer, D., Hsu, P.-H. and Li, D., 2013. Innovative efficiency and stock returns. *Journal of Financial Economics,* 107, pp. 632-654.

Hirshleifer, D. and Thakor, A. V., 1992. Managerial conservatism, project choice, and debt. *The Review of Financial Studies,* 5, pp. 437-470.

Hoberg, G. and Phillips, G., 2010. Product market synergies and competition in mergers and acquisitions: A text-based analysis. *The Review of Financial Studies,* 23, pp. 3773-3811.

Hoberg, G. and Phillips, G., 2016. Text-based network industries and endogenous product differentiation. *Journal of Political Economy,* 124, pp. 1423-1465.

Hoberg, G., Phillips, G. and Prabhala, N., 2014. Product market threats, payouts, and financial flexibility. *The Journal of Finance,* 69, pp. 293-324.

Holmstrom, B. and Costa, J. R. I., 1986. Managerial incentives and capital management. *The Quarterly Journal of Economics,* 101, pp. 835-860.

Huang, J., Jain, B. and Kini, O., 2017. Industry Tournament Incentvies and the Product Market Benefits of Corporate Liquidity. *Forthcoming in Journal of Financial and Quantitative Analysis.*

Hvide, H. K., 2002. Tournament rewards and risk taking. *Journal of Labor Economics,* 20, pp. 877-898.

Jung, H. W. H. and Subramanian, A., 2017. CEO talent, CEO compensation, and product market competition. *Journal of Financial Economics,* 125, pp. 48-71.

Kale, J. R., Reis, E. and Venkateswaran, A., 2009. Rank-order tournaments and incentive alignment: The effect on firm performance. *The Journal of Finance,* 64, pp. 1479-1512.

Kini, O. and Williams, R., 2012. Tournament incentives, firm risk, and corporate policies. *Journal of Financial Economics,* 103, pp. 350-376.

Klasa, S., Ortiz-Molina, H., Serfling, M. and Srinivasan, S., 2018. Protection of trade secrets and capital structure decisions. *Journal of Financial Economics,* 128, pp. 266-286.

Kogan, L., Papanikolaou, D., Seru, A. and Stoffman, N., 2017. Technological innovation, resource allocation, and growth. *The Quarterly Journal of Economics,* 132, pp. 665-712.

Koh, P.-S. and Reeb, D. M., 2015. Missing randd. *Journal of Accounting and Economics,* 60, pp. 73-94.

Kubick, T. R. and Lockhart, G. B., 2016. Do external labor market incentives motivate CEOs to adopt more aggressive corporate tax reporting preferences?. *Journal of Corporate Finance*, 36, pp. 255-277.

Kubick, T. R., Lockhart, G. B. and Mauer, D. C., 2018. Industry tournament incentives and debt contracting. *Working paper*.

Lambert, R. A., Larcker, D. F. and Verrecchia, R. E., 1991. Portfolio considerations in valuing executive compensation. *Journal of Accounting Research*, pp. 129-149.

Lazear, E. P. and Rosen, S., 1981. Rank-order tournaments as optimum labor contracts. *Journal of political Economy*, 89, pp. 841-864.

Lerner, J. and Wulf, J., 2007. Innovation and incentives: Evidence from corporate RandD. *the Review of Economics and Statistics*, 89, pp. 634-644.

Lin, C., Wei, L. and Yang, N., 2018. Labor Market Immobility and Incentive Contract Design. *Working paper*.

Lonare, G., 2018. Corporate Innovation in Product Space, Beyond Patents and Trademarks: A Textual Analysis. *Working paper*.

Manso, G., 2011. Motivating innovation. *The Journal of Finance*, 66, pp. 1823-1860.

Mao, C. X. and Zhang, C., 2018. Managerial Risk-Taking Incentive and Firm Innovation: Evidence from FAS 123R. *Journal of Financial and Quantitative Analysis*, 53, pp. 867-898.

Merton, R. C., 1973. Theory of rational option pricing. *The Bell Journal of economics and management science*, pp. 141-183.

Mukherjee, A., Singh, M. and Žaldokas, A., 2017. Do corporate taxes hinder innovation?. *Journal of Financial Economics*, 124, pp. 195-221.

Narayanan, M., 1985. Managerial incentives for short-term results. *The Journal of Finance*, 40, pp. 1469-1484.

Nguyen, H. and Phan, H. V., 2015. Industry pay gap and mergers and acquisitions. *Working paper*.

Rajgopal, S. and Shevlin, T., 2002. Empirical evidence on the relation between stock option compensation and risk taking. *Journal of Accounting and Economics*, 33, pp. 145-171.

Saidi, F. and Zaldokas, A., 2016. Patents as substitutes for relationships. *Working paper*.

Sanati, A., 2018. How Does Labor Mobility Affect Corporate Leverage and Investment?. *Working paper*.

Shen, C. H.-h. and Zhang, H., 2017. Tournament Incentives and Firm Innovation. *Review of Finance*, p. rfw064.

Smith, C. W. and Stulz, R. M., 1985. The determinants of firms' hedging policies. *Journal of financial and quantitative analysis*, 20, pp. 391-405.

Soete, L. L. G., 1981. A general test of technological gap trade theory. *Weltwirtschaftliches Archiv*, 117, pp. 638-660.

Tian, X. and Wang, T. Y., 2011. Tolerance for failure and corporate innovation. *The Review of Financial Studies*, 27, pp. 211-255.

Table 1

Descriptive Statistics and correlations

This table presents summary statistics (Panel A) and correlation table (Panel B) for ExecuComp firms, excluding financials and utility firms, from the period 1998 to 2015. The product innovation variable *Prod innov* measure the difference in the product descriptions of a firm from year *t* to *t+1*. The details for computing *Prod innov* measure is discussed in the section 3.C. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same industry and the CEO's total compensation. We use industry classifications based on Fama-French 30 (48), fixed industry classifications (FIC 100, 200, and 300), and dynamic industry classifications (TNIC-2 and 3). FIC and TNIC industry classifications are based on 10-Ks' product descriptions developed by Hoberg and Philips (2016). Appendix A defines all the variables. All the continuous variables are winsorized at 1% and 99%.

Panel A: Summary statistics

Variable	N	Mean	Median	SD	10^{th} pctl	90^{th} pctl
Prod innov$_{t,t+1}$	19,842	0.13	0.11	0.09	0.04	0.25
Incentives variables ($000)						
Ind Pay Gap (FF 30)	19,842	24,998.02	18,687.18	24,324.42	6,239.23	46,305.70
Ind Pay Gap (FF 30-size median)	19,789	14,587.52	8,407.23	19,498.10	1,623.03	30,996.80
Ind Pay Gap (FF 48)	19,413	20,451.25	14,524.46	21,682.39	4,637.01	39,123.51
Ind Pay Gap (FF 48-size median)	19,236	11,690.18	6,698.71	16,343.06	829.19	25,755.86
Ind Pay Gap (FIC-100)	18,316	14,880.53	11,237.97	17,806.35	2,949.77	25,316.94
Ind Pay Gap (FIC-200)	16,404	11,334.20	8,897.18	11,420.10	1,848.58	21,130.46
Ind Pay Gap (FIC-300)	15,183	10,562.15	8,075.50	10,205.77	1,660.39	21,130.05
Ind Pay Gap (TNIC-2)	19,739	20,798.82	16,164.64	19,868.21	5,855.51	36,130.27
Ind Pay Gap (TNIC-3)	14,872	12,967.88	9,722.62	13,690.35	2,564.73	24,198.80
Firm gap ($000)	19,842	3,114.57	1,990.68	3,365.17	349.40	7,294.19
CEO Delta ($000)	19,842	755.51	191.70	7,291.86	27.46	1,237.47
CEO Vega ($000)	19,842	103.76	41.84	199.68	0.20	265.88
Patent-based variables and product announcement variable						
LN_Prod_Announce	6,385	0.34	0	0.54	0	1.10
LN_PAT	15,280	1.68	1.10	1.76	0.00	4.29
LN_CITE	15,280	2.69	2.20	2.74	0.00	6.68
LN_CITEPP	15,280	1.26	0.98	1.30	0.00	3.11
Firm characteristics						
Total assets ($000,000)	19,842	5,339.07	1,226.61	19,715.91	210.28	10,294.00
R&D	19,842	0.03	0.00	0.06	0.00	0.11
Cash	19,842	0.17	0.10	0.18	0.01	0.43
ROA	19,842	0.13	0.13	0.13	0.04	0.25
Capital Invest	19,842	0.26	0.20	0.22	0.05	0.60
Leverage	19,842	0.22	0.20	0.19	0.00	0.47
Capital Expend	19,842	0.05	0.04	0.05	0.01	0.11
Q	19,842	2.01	1.59	1.33	0.97	3.52
Prodmkt Fluid	19,842	6.06	5.47	3.08	2.65	10.37
Firm Age (years)	19,842	23.38	18.00	18.19	6.00	45.00
CEO characteristics						
CEO New (dummy)	19,572	0.10				

CEO Founder (dummy)	19,842	0.03				
CEO Retire (dummy)	19,369	0.07				
Industry characteristics						
Ind # CEOs	19,842	111.47	79.00	76.46	29.00	218.00
Industry Mobility	19,842	0.12	0.11	0.05	0.07	0.18
Instruments and other variables						
Ind CEO comp ($000,000)	19,842	527.80	480.59	381.09	107.05	1,027.13
Geo CEO mean ($000)	19,842	5,249.74	5,113.63	1,738.41	3,364.43	7,159.19

Panel B: Correlation Table

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	*Prod innov*$_{t,t+1}$	1.00																		
2	*Ind Pay Gap* (FF 30)	0.16	1.00																	
3	*Ind Pay Gap* (FF 30-size median)	0.13	0.73	1.00																
4	*Firm gap*	0.05	-0.08	0.07	1.00															
5	*CEO Delta*	0.01	0.02	0.05	0.05	1.00														
6	*CEO Vega*	0.06	-0.07	0.06	0.45	0.11	1.00													
7	*Total assets*	0.04	-0.06	0.03	0.34	0.05	0.32	1.00												
8	*R&D*	0.13	0.19	0.07	-0.02	0.00	0.02	-0.06	1.00											
9	*Cash*	0.07	0.23	0.05	-0.05	0.02	-0.03	-0.10	0.56	1.00										
10	*ROA*	-0.09	-0.05	0.04	0.09	0.04	0.09	0.02	-0.35	-0.18	1.00									
11	*Capital Invest*	-0.03	-0.15	-0.11	-0.02	0.00	-0.03	0.06	-0.32	-0.40	0.11	1.00								
12	*Leverage*	0.00	-0.15	-0.04	0.10	-0.01	0.03	0.08	-0.22	-0.38	-0.05	0.24	1.00							
13	*Capital Expend*	0.01	0.04	0.00	-0.02	0.01	-0.04	0.01	-0.16	-0.20	0.15	0.70	0.03	1.00						
14	*Q*	0.01	0.17	0.10	0.10	0.10	0.10	-0.06	0.31	0.39	0.21	-0.18	-0.20	0.04	1.00					
15	*Prodmkt Fluid*	0.11	0.21	0.12	0.11	0.04	0.08	0.07	0.31	0.27	-0.17	0.02	0.01	0.11	0.15	1.00				
16	*Firm Age*	0.00	-0.20	-0.05	0.21	0.00	0.20	0.25	-0.12	-0.20	0.04	0.07	0.09	-0.05	-0.13	-0.24	1.00			
17	*Ind # CEOs*	0.07	0.49	0.40	0.02	0.01	0.02	-0.05	0.44	0.45	-0.09	-0.39	-0.27	-0.17	0.22	0.27	-0.19	1.00		
18	*Ind CEO comp*	0.07	0.67	0.54	0.10	0.01	0.04	-0.01	0.39	0.41	-0.08	-0.34	-0.23	-0.12	0.24	0.30	-0.18	0.92	1.00	
19	*Geo CEO mean*	0.01	0.20	0.17	0.16	0.00	0.06	0.04	0.13	0.14	-0.05	-0.11	-0.03	-0.05	0.12	0.09	0.01	0.11	0.24	1.00

Table 2

Industry tournament incentives and product innovation

The dependent variable *Prod innov*$_{t,t+1}$ measures product innovation based on the difference in product descriptions of a firm from year *t* to *t+1*. The details for computing *Prod innov* measure is discussed in the section 3.C. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects in all specifications and T-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

ITI measure	***ITI based on FF-30 industry classification***			***ITI based on FF-48 industry classification***		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS		OLS	2SLS	
		1st stage	2nd stage		1st stage	2nd stage
Dependent variable	*Prod innov*$_{t,t+1}$	*Ln(Ind Pay Gap)*$_t$	*Prod innov*$_{t,t+1}$	*Prod innov*$_{t,t+1}$	*Ln(Ind Pay Gap)*$_t$	*Prod innov*$_{t,t+1}$
Predicted *Ln(Ind Pay Gap)*$_t$			0.012***			0.011***
			(4.77)			(4.27)
Ln(Ind Pay Gap)$_t$	0.004***			0.003**		
	(3.30)			(2.11)		
Ln(Firm gap)$_t$	0.003***	-0.146***	0.004***	0.003***	-0.180***	0.004***
	(3.52)	(-28.95)	(4.34)	(3.36)	(-31.14)	(4.39)
Ln(CEO delta)$_t$	-0.006***	-0.009**	-0.006***	-0.006***	-0.011***	-0.006***
	(-7.53)	(-2.51)	(-7.58)	(-7.44)	(-2.85)	(-7.47)
Ln(CEO vega)$_t$	0.002***	0.005	0.002***	0.002***	0.001	0.002***
	(3.51)	(1.46)	(3.65)	(3.33)	(0.40)	(3.49)
Ln(Total assets)$_t$	0.006***	-0.079***	0.007***	0.006***	-0.089***	0.007***
	(6.15)	(-16.89)	(6.67)	(5.88)	(-16.69)	(6.52)
R&D$_t$	0.139***	-0.321***	0.142***	0.114***	-0.152	0.117***
	(5.71)	(-3.85)	(5.84)	(4.72)	(-1.53)	(4.82)
Cash$_t$	0.023***	-0.017	0.023***	0.022***	-0.053*	0.022***
	(2.83)	(-0.66)	(2.87)	(2.78)	(-1.84)	(2.85)
ROA$_t$	-0.029***	0.083***	-0.029***	-0.027***	0.122***	-0.027***

	(-3.75)	(3.12)	(-3.76)	(-3.50)	(4.01)	(-3.51)
Capital Invest$_t$	-0.019**	0.075**	-0.018**	-0.015*	0.066*	-0.015*
	(-2.36)	(2.21)	(-2.34)	(-1.88)	(1.71)	(-1.87)
Leverage$_t$	0.004	0.123***	0.003	0.005	0.110***	0.005
	(0.66)	(5.27)	(0.60)	(0.89)	(4.35)	(0.86)
Capital Expend$_t$	0.049*	-0.259**	0.047*	0.056**	-0.275**	0.054**
	(1.93)	(-2.48)	(1.85)	(2.20)	(-2.43)	(2.15)
Q$_t$	-0.001	-0.013***	-0.001	-0.001	-0.017***	-0.001
	(-1.19)	(-3.74)	(-1.21)	(-1.59)	(-4.35)	(-1.58)
Ln(Prodmkt Fluid)$_t$	0.013***	-0.028**	0.013***	0.014***	-0.039***	0.014***
	(4.57)	(-2.29)	(4.58)	(4.81)	(-2.86)	(4.85)
Ln(Firm Age)$_t$	0.004***	-0.006	0.004***	0.003***	0.001	0.003***
	(3.00)	(-1.17)	(3.06)	(2.84)	(0.22)	(2.82)
Ln(Ind # CEOs)$_t$	-0.029***	-0.881***	-0.031***	-0.018***	-0.909***	-0.022***
	(-3.67)	(-14.05)	(-3.91)	(-2.62)	(-17.84)	(-3.17)
Ln(Ind CEO comp)$_t$ (IV)		1.910***			1.694***	
		(85.57)			(69.93)	
Ln(Geo CEO mean)$_t$ (IV)		0.005			-0.008	
		(0.41)			(-0.55)	
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	19,842	19,842	19,842	19,413	19,413	19,413
R-squared	0.131	0.793	0.129	0.136	0.763	0.134
Endogeneity, relevance, and Overidentification tests						
Hausman test: *p*-value			0.00***			0.00***
First-stage *F*-statistics			3708.7***			2450.22***
Hansen's *J*-statistic			0.15			0.17

Table 3

Industry tournament incentives and product innovation (differing in product market competitions)

The table reports the second-stage of IV regression models of product innovation on lagged predicted values of CEO industry pay gap. The dependent variable *Prod innov*$_{t,t+1}$ measures product innovation based on the difference in product descriptions of a firm from year *t* to *t+1*. The details for computing *Prod innov* measure is discussed in the section 3.C. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. Product Market Fluidity measures firm-level competitive threats based on changes in rivals' products relative to the firm's products. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects in all specifications and T-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

ITI measure	***ITI based on FF-30 industry classification***		***ITI based on FF-48 industry classification***	
	Prodmkt Fluid < median	*Prodmkt Fluid* > median	*Prodmkt Fluid* < median	*Prodmkt Fluid* > median
	(1)	(2)	(3)	(4)
Predicted *Ln(Ind Pay Gap)*$_t$	0.007*	0.017***	0.005	0.016***
	(1.71)	(5.68)	(1.18)	(5.56)
Ln(Firm gap)$_t$	0.004***	0.004***	0.003**	0.005***
	(2.85)	(3.79)	(2.31)	(4.40)
Ln(CEO delta)$_t$	-0.006***	-0.005***	-0.006***	-0.005***
	(-6.35)	(-5.01)	(-6.15)	(-4.90)
Ln(CEO vega)$_t$	0.002***	0.002**	0.002***	0.002**
	(3.09)	(2.36)	(2.84)	(2.37)
Ln(Total assets)$_t$	0.004***	0.009***	0.004***	0.009***
	(2.61)	(7.03)	(2.71)	(6.74)
R&D$_t$	0.090**	0.161***	0.093**	0.127***
	(2.06)	(6.22)	(2.15)	(4.84)
Cash$_t$	0.028**	0.024**	0.031**	0.020**
	(2.13)	(2.50)	(2.37)	(2.26)
ROA$_t$	-0.052***	-0.022**	-0.049***	-0.018**
	(-2.88)	(-2.50)	(-2.89)	(-2.12)
Capital Invest$_t$	-0.001	-0.032***	0.002	-0.027***
	(-0.08)	(-3.43)	(0.21)	(-2.78)
Leverage$_t$	0.024***	-0.010	0.024***	-0.007
	(2.95)	(-1.35)	(3.03)	(-1.03)
Capital Expend$_t$	0.030	0.067**	0.037	0.074***
	(0.72)	(2.38)	(0.88)	(2.66)
Q$_t$	0.002	-0.002**	0.001	-0.003***
	(1.10)	(-2.55)	(0.85)	(-3.03)
Ln(Prodmkt Fluid)$_t$	0.011**	0.008	0.011**	0.008
	(2.25)	(1.52)	(2.35)	(1.42)
Ln(Firm Age)$_t$	0.003*	0.004***	0.003	0.004**

	(1.65)	(2.84)	(1.64)	(2.53)
Ln(Ind # CEOs)$_t$	-0.023**	-0.040***	-0.020**	-0.020**
	(-2.02)	(-3.57)	(-1.97)	(-2.04)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	9,921	9,921	9,703	9,710
R-squared	0.096	0.152	0.101	0.158
Endogeneity, relevance, and Overidentification tests				
Hausman test: *p*-value	0.15	0.00***	0.11	0.00***
First-stage *F*-statistics	1525.38***	2309.99***	1154.28***	1403.72***
Hansen's *J*-statistic	0.64	0.29	0.74	0.29

Table 4

Industry tournament incentives and product innovation (differing in CEO industry mobility)

The table reports the second-stage of IV regression models of product innovation on lagged predicted values of CEO industry pay gap. The dependent variable *Prod innov*$_{t,t+1}$ measures product innovation based on the difference in product descriptions of a firm from year *t* to *t+1*. The details for computing *Prod innov* measure is discussed in the section 3.C. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. *Industry mobility* is the unconditional probability of CEO departure in each industry in the given year. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects in all specifications and T-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

ITI measure	***ITI based on FF-30 industry classification***		***ITI based on FF-48 industry classification***	
	Industry Mobility < median	Industry Mobility > median	Industry Mobility < median	Industry Mobility > median
	(1)	(2)	(3)	(4)
Predicted *Ln(Ind Pay Gap)*$_t$	0.005	0.013***	0.005	0.011***
	(1.20)	(3.99)	(1.25)	(3.42)
Ln(Firm gap)$_t$	0.002	0.005***	0.002*	0.005***
	(1.52)	(4.32)	(1.75)	(4.13)
Ln(CEO delta)$_t$	-0.006***	-0.006***	-0.006***	-0.006***
	(-6.08)	(-6.38)	(-5.78)	(-6.32)
Ln(CEO vega)$_t$	0.002**	0.003***	0.002**	0.003***
	(2.33)	(3.56)	(2.13)	(3.56)
Ln(Total assets)$_t$	0.007***	0.006***	0.006***	0.006***
	(5.55)	(5.42)	(5.02)	(5.26)
R&D$_t$	0.112***	0.164***	0.104***	0.132***
	(3.98)	(5.76)	(3.81)	(4.21)
Cash$_t$	0.023**	0.024***	0.021**	0.023***
	(2.33)	(2.60)	(2.17)	(2.61)
ROA$_t$	-0.021**	-0.033***	-0.015	-0.033***
	(-2.06)	(-3.44)	(-1.52)	(-3.49)
Capital Invest$_t$	-0.011	-0.026***	-0.011	-0.020*
	(-1.08)	(-2.85)	(-1.22)	(-1.89)
Leverage$_t$	0.010	-0.001	0.010	0.001
	(1.30)	(-0.12)	(1.45)	(0.11)
Capital Expend$_t$	0.014	0.073**	0.029	0.074**
	(0.41)	(2.40)	(0.95)	(2.31)
Q$_t$	-0.000	-0.002**	-0.002	-0.002*
	(-0.12)	(-2.04)	(-1.43)	(-1.65)
Ln(Prodmkt Fluid)$_t$	0.016***	0.010***	0.016***	0.012***
	(4.51)	(3.05)	(4.48)	(3.42)
Ln(Firm Age)$_t$	0.003*	0.004***	0.002	0.005***

	(1.93)	(3.10)	(1.39)	(3.24)
Ln(Ind # CEOs)$_t$	-0.021*	-0.041***	-0.010	-0.028***
	(-1.89)	(-3.95)	(-0.99)	(-3.14)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
Observations	9,116	10,726	9,363	10,050
R-squared	0.115	0.140	0.117	0.146
Endogeneity, relevance, and Overidentification tests				
Hausman test: *p*-value	0.00***	0.00***	0.00***	0.00***
First-stage *F*-statistics	1,111.11***	2,576.52***	996.36***	1,619.93***
Hansen's *J*-statistic	0.31	0.67	0.98	0.29

Table 5

Industry tournament incentives and product innovation (impact of Inevitable Disclosure Doctrine)

The table reports the second-stage of IV regression models of product innovation on lagged predicted values of CEO industry pay gap. The dependent variable *Prod innov*$_{t,t+1}$ measures product innovation based on the difference in product descriptions of a firm from year *t* to *t+1*. The details for computing *Prod innov* measure is discussed in the section 3.C. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. IDD is a dummy variable set to 1 if a firm, for a given year, is located in the state which has adopted Inevitable Disclosure Doctrine, otherwise set to zero. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects, industry fixed effects, and state fixed effects in all specifications and *T*-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

ITI measure	***ITI based on FF-30 industry classification***		***ITI based on FF-48 industry classification***	
	IDD = 1	*IDD = 0*	*IDD = 1*	*IDD = 0*
	(1)	(2)	(3)	(4)
Predicted *Ln(Ind Pay Gap)*$_t$	0.009**	0.011***	0.007**	0.011***
	(2.39)	(3.20)	(2.16)	(3.01)
Ln(Firm gap)$_t$	0.005***	0.002*	0.005***	0.003**
	(3.63)	(1.87)	(3.58)	(2.19)
Ln(CEO delta)$_t$	-0.005***	-0.007***	-0.005***	-0.007***
	(-4.44)	(-6.41)	(-4.33)	(-6.44)
Ln(CEO vega)$_t$	0.001*	0.003***	0.001	0.003***
	(1.65)	(3.83)	(1.63)	(3.71)
Ln(Total assets)$_t$	0.006***	0.008***	0.005***	0.008***
	(3.94)	(5.41)	(3.68)	(5.44)
R&D$_t$	0.152***	0.148***	0.114***	0.123***
	(3.81)	(5.14)	(2.92)	(4.15)
Cash$_t$	0.019	0.027**	0.021*	0.023**
	(1.54)	(2.51)	(1.88)	(2.18)
ROA$_t$	-0.042***	-0.016*	-0.041***	-0.012
	(-3.32)	(-1.85)	(-3.24)	(-1.38)
Capital Invest$_t$	-0.017	-0.023**	-0.014	-0.018*
	(-1.43)	(-2.24)	(-1.17)	(-1.73)
Leverage$_t$	-0.004	0.009	0.001	0.007
	(-0.47)	(1.12)	(0.18)	(0.92)
Capital Expend$_t$	0.049	0.041	0.056	0.046
	(1.26)	(1.32)	(1.50)	(1.43)
Q$_t$	-0.002	-0.000	-0.002*	-0.000
	(-1.53)	(-0.10)	(-1.87)	(-0.23)
Ln(Prodmkt Fluid)$_t$	0.011***	0.015***	0.014***	0.014***
	(2.89)	(3.51)	(3.55)	(3.36)
Ln(Firm Age)$_t$	0.004**	0.004**	0.004**	0.003*

	(2.17)	(2.13)	(2.53)	(1.65)
Ln(Ind # CEOs)$_t$	-0.019*	-0.052***	-0.020**	-0.029***
	(-1.79)	(-4.33)	(-2.15)	(-2.66)
Year fixed effects	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes
State fixed effects	Yes	Yes	Yes	Yes
Observations	10,249	9,588	10,059	9,349
R-squared	0.119	0.157	0.129	0.159
Endogeneity, relevance, and Overidentification tests				
Hausman test: *p*-value	0.05*	0.02**	0.02**	0.00***
First-stage *F*-statistics	1700.23***	1668.81***	1283.54***	1154.74***
Hansen's *J*-statistic	0.43	0.56	0.74	0.27

Table 6

Industry tournament incentives and product innovation (the probability of winning as measured by CEO characteristics)

The table reports the second-stage of IV regression models of product innovation on lagged predicted values of CEO industry pay gap. The dependent variable *Prod innov*$_{t,t+1}$ measures product innovation based on the difference in product descriptions of a firm from year *t* to *t+1*. The details for computing *Prod innov* measure is discussed in the section 3.C. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. A *CEO New* is set to one if a CEO is in the first year of service as CEO, and zero otherwise. *CEO Founder* is set to one if a given CEO is also a founder of the firm, and zero otherwise. *CEO Retire* is set to one if the CEO's age is more than 65 years, and zero otherwise. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects, and in all specifications and *T*-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: **ITI based on FF-30 industry classification**

	(1)	(2)	(3)	(4)	(5)	(6)
	CEO New = 1	CEO New = 0	CEO Founder = 1	CEO Founder = 0	CEO Retire = 1	CEO Retire = 0
Predicted *Ln(Ind Pay Gap)*$_t$	0.011*	0.011***	-0.016	0.012***	0.014*	0.011***
	(1.85)	(4.38)	(-0.88)	(4.82)	(1.74)	(4.37)
Controls$_t$	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,995	17,577	636	19,206	1,419	17,950
R-squared	0.131	0.129	0.143	0.128	0.116	0.127
Endogeneity, relevance, and Overidentification tests						
Hausman test: *p*-value	0.05*	0.00***	0.38	0.00***	0.20	0.00***
First-stage *F*-statistics	672.46***	3064.92***	30.13***	3652.39***	309.39***	3227.83***
Hansen's *J*-statistic	0.63	0.24	0.88	0.14	0.44	0.21

Panel B: ITI based on FF-48 industry classification

	(1)	(2)	(3)	(4)	(5)	(6)
	CEO New = 1	CEO New = 0	CEO Founder = 1	CEO Founder = 0	CEO Retire = 1	CEO Retire = 0
Predicted *Ln(Ind Pay Gap)*$_t$	0.007	0.011***	0.007	0.011***	0.009	0.011***
	(1.23)	(4.08)	(0.45)	(4.22)	(0.91)	(4.33)
Controls$_t$	Yes	Yes	Yes	Yes	Yes	Yes
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	1,940	17,212	631	18,782	1,382	17,569
R-squared	0.133	0.133	0.153	0.133	0.121	0.130
Endogeneity, relevance, and Overidentification tests						
Hausman test: *p*-value	0.07*	0.00***	0.87	0.00***	0.47	0.00***
First-stage *F*-statistics	364.27***	2144.32***	32.13***	2427.10***	220.25***	2223.40***
Hansen's *J*-statistic	0.86	0.24	0.23	0.15	0.35	0.24

Table 7

Industry tournament incentives and product innovation (observed in different industry specifications)

The table reports the second-stage of IV regression models of product innovation on lagged predicted values of CEO industry pay gap. The dependent variable *Prod innov*$_{t,t+1}$ measures product innovation based on the difference in product descriptions of a firm from year *t* to *t+1*. The details for computing *Prod innov* measure is discussed in the section 3.C. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same industry classification and the CEO's total compensation. In Panel A, we compute industry pay gap using Fama-French 30 size-median (48 size-median) industry classifications or product based fixed industry classifications (FIC 100, 200, and 300). In Panel B, we compute industry pay gap using product based network industry classifications (TNIC 2 and 3). We use FIC and TNIC from Hoberg and Phillips (2010, 2016). The TNIC-2 classification is calibrated to be as granular as two-digit SIC codes and TNIC-3 as three-digit SIC codes. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same industry classification, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects, and in all specifications and *T*-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

Panel A: Other fixed industry classifications

ITI measure	FF-30 size-median industry	FF-48 size-median industry	FIC-100 industry	FIC-200 industry	FIC-300 industry
Dependent variable	*Prod innov*$_{t,t+1}$				
	(1)	(2)	(3)	(4)	(5)
Predicted *Ln(Ind Pay Gap)*$_t$	0.013***	0.011***	0.009***	0.008***	0.007***
	(4.64)	(3.81)	(4.03)	(4.00)	(3.34)
Ln(Firm gap)$_t$	0.005***	0.005***	0.004***	0.004***	0.003***
	(4.44)	(4.28)	(3.71)	(4.08)	(3.20)
Ln(CEO delta)$_t$	-0.006***	-0.006***	-0.006***	-0.006***	-0.006***
	(-7.27)	(-6.87)	(-7.07)	(-8.05)	(-6.97)
Ln(CEO vega)$_t$	0.002***	0.002***	0.002***	0.003***	0.002***
	(3.36)	(3.52)	(3.82)	(4.04)	(3.66)
Ln(Total assets)$_t$	0.003**	0.003*	0.006***	0.006***	0.006***
	(2.01)	(1.89)	(6.24)	(5.75)	(5.15)
R&D$_t$	0.150***	0.122***	0.102***	0.077***	0.043
	(5.99)	(4.88)	(4.06)	(3.06)	(1.59)
Cash$_t$	0.027***	0.027***	0.022***	0.015*	0.020**
	(3.19)	(3.29)	(2.79)	(1.84)	(2.45)
ROA$_t$	-0.029***	-0.027***	-0.027***	-0.026***	-0.027***
	(-3.54)	(-3.45)	(-3.28)	(-3.10)	(-3.04)
Capital Invest$_t$	-0.016**	-0.012	-0.015*	-0.014*	-0.012
	(-2.07)	(-1.43)	(-1.92)	(-1.75)	(-1.37)
Leverage$_t$	0.003	0.005	0.010*	0.005	0.001
	(0.58)	(0.86)	(1.67)	(0.77)	(0.20)
Capital Expend$_t$	0.051**	0.059**	0.051**	0.047*	0.039
	(1.98)	(2.25)	(2.09)	(1.90)	(1.53)
Q$_t$	-0.002*	-0.002***	-0.002*	-0.002*	-0.002*
	(-1.71)	(-2.58)	(-1.95)	(-1.91)	(-1.91)
Ln(Prodmkt Fluid)$_t$	0.014***	0.015***	0.012***	0.011***	0.008**

	(4.76)	(4.86)	(3.87)	(3.48)	(2.26)
Ln(Firm Age)$_t$	0.004***	0.004***	0.004***	0.004***	0.005***
	(3.26)	(2.80)	(3.36)	(3.14)	(3.67)
Ln(Ind # CEOs)$_t$	-0.033***	-0.026***	-0.013***	-0.007	-0.004
	(-3.84)	(-3.31)	(-2.68)	(-1.52)	(-0.79)
Year fixed effects	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes
Observations	19,007	18,132	18,316	16,404	15,183
R-squared	0.120	0.127	0.141	0.150	0.151
Endogeneity, relevance, and Overidentification tests					
Hausman test: *p*-value	0.00***	0.00***	0.00***	0.00***	0.00***
First-stage *F*-statistics	570.04***	368.16***	2635.55***	2439.83***	2488.30***
Hansen's *J*-statistic	0.33	0.16	0.63	0.59	0.72

Panel B: Dynamic network industry classifications

ITI measure	TNIC-2 industry classification	TNIC-3 industry classification
Dependent variable	*Prod innov$_{t,t+1}$*	
	(1)	(2)
Predicted *Ln(Ind Pay Gap)$_t$*	0.022***	0.011***
	(8.32)	(5.17)
Ln(Firm gap)$_t$	0.005***	0.005***
	(5.20)	(4.36)
Ln(CEO delta)$_t$	-0.006***	-0.005***
	(-7.81)	(-6.13)
Ln(CEO vega)$_t$	0.002***	0.002***
	(4.01)	(2.94)
Ln(Total assets)$_t$	0.007***	0.007***
	(7.66)	(6.68)
R&D$_t$	0.152***	0.162***
	(6.98)	(7.39)
Cash$_t$	0.030***	0.031***
	(3.81)	(3.61)
ROA$_t$	-0.025***	-0.020**
	(-3.35)	(-2.25)
Capital Invest$_t$	-0.014**	-0.018**
	(-2.09)	(-2.52)
Leverage$_t$	-0.000	-0.005
	(-0.00)	(-0.76)
Capital Expend$_t$	0.073***	0.097***
	(3.09)	(3.99)
Q$_t$	-0.002*	-0.003***
	(-1.76)	(-3.16)
Ln(Prodmkt Fluid)$_t$	0.013***	0.018***

	(5.20)	(6.09)
Ln(Firm Age)$_t$	0.003**	0.002*
	(2.42)	(1.81)
Ln(Ind # CEOs)$_t$	-0.017***	-0.013***
	(-7.99)	(-5.95)
Year fixed effects	Yes	Yes
Industry fixed effects	No	No
Observations	19,739	14,872
R-squared	0.119	0.124
Endogeneity, relevance, and Overidentification tests		
Hausman test: *p*-value	0.00***	0.10
First-stage *F*-statistics	1,821.00***	1699.07***
Hansen's *J*-statistic	0.35	0.03

Table 8
Industry tournament incentives and product announcements

The dependent variable *LN_Prod_Announce* is the natural logarithm of one plus total number of product announcements by a firm in a fiscal year which the stock return exceeded the 75th percentile. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects in all specifications and T-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

ITI measure	*ITI based on FF-30 industry classification*			*ITI based on FF-48 industry classification*		
	(1)	(2)	(3)	(4)	(5)	(6)
	OLS	2SLS		OLS	2SLS	
		1st stage	2nd stage		1st stage	2nd stage
Dependent variable	$LN\_Prod\_Announce_{t+1}$	$Ln(Ind\ Pay\ Gap)_t$	$LN\_Prod\_Announce_{t+1}$	$LN\_Prod\_Announce_{t+1}$	$Ln(Ind\ Pay\ Gap)_t$	$LN\_Prod\_Announce_{t+1}$
Predicted $Ln(Ind\ Pay\ Gap)_t$			0.073***			0.090***
			(3.09)			(3.72)
$Ln(Ind\ Pay\ Gap)_t$	0.031**			0.024*		
	(2.02)			(1.87)		
$Ln(Firm\ gap)_t$	-0.005	-0.162***	0.000	-0.005	-0.212***	0.006
	(-0.38)	(-16.20)	(0.03)	(-0.42)	(-17.72)	(0.44)
$Ln(CEO\ delta)_t$	0.004	-0.013	0.004	0.006	-0.018*	0.007
	(0.42)	(-1.58)	(0.40)	(0.58)	(-1.86)	(0.61)
$Ln(CEO\ vega)_t$	0.002	0.003	0.002	0.002	-0.001	0.002
	(0.20)	(0.47)	(0.26)	(0.21)	(-0.10)	(0.29)
$Ln(Total\ assets)_t$	0.113***	-0.089***	0.117***	0.106***	-0.102***	0.114***
	(7.12)	(-11.16)	(7.42)	(6.86)	(-10.46)	(7.32)
$R\&D_t$	1.112***	-0.502***	1.151***	1.022***	-0.211	1.066***
	(3.52)	(-3.22)	(3.66)	(3.23)	(-1.10)	(3.40)
$Cash_t$	0.166*	-0.013	0.165*	0.155*	-0.074	0.159*
	(1.85)	(-0.28)	(1.85)	(1.74)	(-1.44)	(1.80)
ROA_t	0.070	0.132*	0.074	0.078	0.132	0.088
	(0.54)	(1.66)	(0.58)	(0.61)	(1.34)	(0.69)

Capital Invest$_t$	-0.028	0.159*	-0.028	-0.004	0.154*	-0.008
	(-0.30)	(1.90)	(-0.30)	(-0.05)	(1.66)	(-0.08)
Leverage$_t$	-0.161**	0.170***	-0.164**	-0.135*	0.162***	-0.140**
	(-2.26)	(3.50)	(-2.33)	(-1.93)	(2.88)	(-2.00)
Capital Expend$_t$	0.894*	-0.812***	0.878*	0.939**	-1.032***	0.940**
	(1.85)	(-2.73)	(1.83)	(2.07)	(-3.16)	(2.09)
Q_t	0.021*	-0.021***	0.021*	0.021*	-0.020***	0.021*
	(1.79)	(-2.91)	(1.79)	(1.82)	(-2.61)	(1.81)
Ln(Prodmkt Fluid)$_t$	0.073**	0.010	0.072**	0.065*	-0.019	0.065*
	(2.10)	(0.40)	(2.08)	(1.90)	(-0.64)	(1.94)
Ln(Firm Age)$_t$	-0.005	-0.019	-0.005	-0.006	0.000	-0.006
	(-0.28)	(-1.63)	(-0.26)	(-0.32)	(0.02)	(-0.35)
Ln(Ind # CEOs)$_t$	-0.289***	-0.790***	-0.303***	-0.212***	-0.855***	-0.256***
	(-2.89)	(-6.13)	(-3.02)	(-2.64)	(-7.37)	(-3.15)
Ln(Ind CEO comp)$_t$ (IV)		1.968***			1.782***	
		(46.33)			(38.35)	
Ln(Geo CEO mean)$_t$ (IV)		-0.009			-0.021	
		(-0.34)			(-0.66)	
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	6,383	6,383	6,385	6,185	6,185	6,186
R-squared	0.172	0.767	0.170	0.168	0.707	0.162
Endogeneity, relevance, and Overidentification tests						
Hausman test: *p*-value			0.03***			0.00***
First-stage *F*-statistics			1092.13***			735.37***
Hansen's *J*-statistic			0.35			0.31

Table 9

Industry tournament incentives and Patent-based innovation

The table reports the second-stage of IV regression models of patent-based innovation variables on lagged predicted values of CEO industry pay gap. *LN_PAT* is the natural logarithm of one plus total number of patents applications filed (and eventually granted) by a firm in a fiscal year; *LN_CITE* is the natural logarithm of one plus total number of citations received to these applied patents; and *LN_CITEPP* is the natural logarithm of one plus the number of citations per patent. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects in all specifications and T-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

ITI measure	***ITI based on FF-30 industry classification***			***ITI based on FF-48 industry classification***		
Dependent variable	LN_PAT_{t+1}	LN_CITE_{t+1}	LN_CITEPP_{t+1}	LN_PAT_{t+1}	LN_CITE_{t+1}	LN_CITEPP_{t+1}
	(1)	(2)		(3)	(4)	
Predicted $Ln(Ind\ Pay\ Gap)_t$	-0.090**	-0.073	0.024	-0.104**	-0.109	0.014
	(-2.07)	(-1.08)	(0.73)	(-2.20)	(-1.47)	(0.39)
$Ln(Firm\ gap)_t$	-0.009	0.036	0.042***	-0.005	0.040	0.046***
	(-0.40)	(1.06)	(2.72)	(-0.22)	(1.20)	(2.86)
$Ln(CEO\ delta)_t$	-0.061***	-0.074**	-0.013	-0.060***	-0.077**	-0.017
	(-2.70)	(-2.20)	(-0.87)	(-2.70)	(-2.35)	(-1.17)
$Ln(CEO\ vega)_t$	0.070***	0.097***	0.037***	0.058***	0.078***	0.028**
	(3.43)	(3.36)	(3.20)	(2.84)	(2.69)	(2.42)
$Ln(Total\ assets)_t$	0.593***	0.716***	0.130***	0.602***	0.737***	0.146***
	(18.31)	(16.34)	(7.60)	(18.69)	(17.19)	(8.80)
$R\&D_t$	6.682***	8.984***	2.674***	6.734***	9.230***	2.867***
	(11.28)	(10.88)	(7.97)	(11.20)	(11.23)	(8.87)
$Cash_t$	0.300*	0.353	0.133	0.429**	0.594**	0.255**
	(1.73)	(1.37)	(1.18)	(2.52)	(2.34)	(2.28)
ROA_t	0.654***	0.994***	0.383***	0.565***	0.828***	0.304**
	(3.56)	(3.64)	(3.14)	(3.12)	(3.10)	(2.57)
$Capital\ Invest_t$	-1.004***	-1.427***	-0.457***	-0.886***	-1.199***	-0.362**
	(-3.93)	(-3.76)	(-2.86)	(-3.38)	(-3.11)	(-2.24)

Leverage$_t$	-0.828***	-1.016***	-0.225**	-0.746***	-0.882***	-0.172*
	(-5.45)	(-4.47)	(-2.23)	(-5.07)	(-4.02)	(-1.75)
Capital Expend$_t$	2.840***	4.526***	1.529***	2.896***	4.484***	1.489***
	(3.80)	(4.05)	(2.98)	(3.95)	(4.05)	(2.90)
Q$_t$	0.097***	0.152***	0.050***	0.101***	0.167***	0.060***
	(5.44)	(5.44)	(3.71)	(5.81)	(6.14)	(4.55)
Ln(Prodmkt Fluid)$_t$	-0.031	0.037	0.054	0.033	0.158	0.118**
	(-0.39)	(0.32)	(1.09)	(0.43)	(1.40)	(2.48)
Ln(Firm Age)$_t$	0.081**	0.046	-0.044*	0.090**	0.062	-0.038*
	(2.07)	(0.83)	(-1.92)	(2.36)	(1.12)	(-1.67)
Ln(Ind # CEOs)$_t$	0.115	-0.058	-0.220*	0.077	0.001	-0.107
	(0.57)	(-0.20)	(-1.72)	(0.44)	(0.00)	(-0.89)
Year fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Industry fixed effects	Yes	Yes	Yes	Yes	Yes	Yes
Observations	15,280	15,280	15,280	14,910	14,910	14,910
R-squared	0.424	0.405	0.330	0.437	0.421	0.346
Endogeneity, relevance, and Overidentification tests						
Hausman test: *p*-value	0.11	0.23	0.95	0.45	0.49	0.91
First-stage *F*-statistics	3,124.93***	3,124.93***	3,124.93***	1,872.18***	1,872.18***	1872.18***
Hansen's *J*-statistic	0.06	0.00	0.00	0.06	0.00	0.00

Table 10

Industry tournament incentives and product innovation (excluding patenting technology)

The table reports the second-stage of IV regression models of product innovation (excluding patenting technology) on lagged predicted values of CEO industry pay gap. The dependent variable, *Non-patent Prod innov*, is the residual error term obtained by estimating the following OLS regression specification:

$$Prod\ Innov_{i,(t,t+1)} = \alpha_i + \beta_1 Ln\left(1 + \#Patents_{i,t+1} + \#Patents_{i,t} + \#Patents_{i,t-1}\right) + \varepsilon_{i,t+1}$$

Prod innov$_{t,t+1}$ measures product innovation based on the difference in product descriptions of a firm from year t to $t+1$. The details for computing *Prod innov* measure is discussed in the section 3.C. *LN_PAT* is the natural logarithm of one plus total number of patents applications filed (and eventually granted) by a firm in a fiscal year. *Ind Pay Gap* is the pay gap between the second-highest-paid CEO's total compensation within the same Fama-French 30-industry (48-industry) classification and the CEO's total compensation. The data includes ExecuComp firms, excluding financials and utility firms, from 1998 to 2015. In the first stage, we regress CEO *Ind Pay Gap* incentive variable on contemporaneous control variables and instruments. The instruments are the natural logarithms of the sum of total compensation of all other CEOs in the same Fama-French 30 (48) industry, *Ind CEO comp* and the average total compensation received by all other CEOs working in the firms that are headquartered within a 250-km radius of the firm, *Geo CEO mean*. Appendix A defines all the other variables. We include year fixed effects and industry fixed effects in all specifications and T-statistics (in parentheses) are computed using robust standard errors corrected for clustering of observations at the firm level. Signs ***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

ITI measure	***ITI based on FF-30 industry classification***	***ITI based on FF-48 industry classification***
Dependent variable	*Non-patent Prod innov*$_{t,t+1}$	*Non-patent Prod innov*$_{t,t+1}$
	(1)	(2)
Predicted *Ln(Ind Pay Gap)*$_t$	0.011***	0.011***
	(3.82)	(3.53)
Ln(Firm gap)$_t$	0.004***	0.004***
	(3.41)	(3.33)
Ln(CEO delta)$_t$	-0.006***	-0.006***
	(-5.44)	(-5.65)
Ln(CEO vega)$_t$	0.001*	0.001*
	(1.70)	(1.70)
Ln(Total assets)$_t$	0.004***	0.004***
	(3.65)	(3.60)
R&D$_t$	0.072***	0.062**
	(2.81)	(2.56)
Cash$_t$	0.016*	0.015*
	(1.74)	(1.69)
ROA$_t$	-0.024**	-0.020**
	(-2.43)	(-2.11)
Capital Invest$_t$	-0.014	-0.011
	(-1.23)	(-0.93)
Leverage$_t$	0.012	0.011
	(1.61)	(1.61)
Capital Expend$_t$	0.033	0.046
	(0.84)	(1.19)
Q$_t$	-0.002	-0.002
	(-1.63)	(-1.58)

Ln(Prodmkt Fluid)$_t$	0.017***	0.017***
	(5.07)	(4.97)
Ln(Firm Age)$_t$	0.003**	0.004**
	(2.20)	(2.41)
Ln(Ind # CEOs)$_t$	-0.039***	-0.027***
	(-4.15)	(-3.28)
Year fixed effects	Yes	Yes
Industry fixed effects	Yes	Yes
Observations	13,732	13,397
R-squared	0.123	0.128
Endogeneity, relevance, and Overidentification tests		
Hausman test: *p*-value	0.00***	0.00***
First-stage *F*-statistics	2,713.40***	1,609.59***
Hansen's *J*-statistic	0.05	0.02