New Dogs New Tricks: CEO Turnover, CEO-related Factors, and Innovation Performance*

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Abstract

This paper examines how CEO turnover and CEO-related factors influence innovation in the sample period 1993-2005. We find that CEO turnover is associated with significantly greater quantity and quality of future innovation, measured with the number of patents, citations, patents per research and development dollar, and citations per patent in the subsequent three-year and five-year periods. New internal CEOs are associated with more and better innovation than new external CEOs. We also find that innovation quantity and quality are positively associated with CEO overconfidence, option compensation, and information asymmetries. These empirical results remain robust to controlling for potential endogeneity issues and confirm the critical role of CEOs in innovation performance.

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1 Introduction

Technological innovation has been recognized as the main engine for economic growth since Solow (1957). At the firm level, innovation is often one of the most critical investment decisions made by top managers, since product development and process innovation are often significant determinants of future profitability and competitive advantage (Scherer, 1984; Ettlie, 1998). Moreover, much of the leadership for developing and championing innovation is driven by the CEO, whose compensation is frequently affected by the success of his/her firm's investment in research and development. However, despite the likely effect of CEOs on the quantity and quality of their firms' innovation, there are few studies that directly examine CEOs' effects on innovation performance.[1] This paper addresses this gap in the literature and examines how CEO turnover and characteristics affect firms' quantity and quality of innovation.

Although firm performance around the time of CEO turnover has received attention from previous studies (Murphy and Zimmerman, 1993), the effect of CEO turnover on innovation performance has not been previously studied. Additionally, although the literature has used research and development expenses to proxy for firms' innovation (Titman and Wessels, 1988; Lev and Sougiannis, 1996; Chan et al., 2001), our analysis focuses on the *output* of firms' research projects, rather than studying the associated accounting expenses (i.e., the research and development *input*). Consequently, we use patent data to examine firms' innovation performance. Moreover, we examine not just the number of patent-filings and patent-citations, but the productivity of research and development expenses and the influence of innovation, finding increased innovation productivity and influence following CEO turnover. Studying patent data has several advantages for measuring technological progress.[2] First, patents are realized innovation affecting future operating performance

[1] Some previous studies examine how CEOs influence research and development expenditures (Dechow and Sloan, 1991; Murphy and Zimmerman, 1993), which are of high uncertainty and could be inefficient or even irrational due to weak internal governance or irrational managerial optimism (Jensen, 1993; Hall, 1993). Similarly, Bertrand and Schoar (2003) note that manager fixed-effects can explain heterogeneity in firms' investment, financial, and organizational behavior, Graham et al. (2009) describe the association between CEO behavior and risk aversion, time performance, and optimism, and Kaplan et al. (2010) examine the individual characteristics of CEO candidates at companies that are involved in buyouts and venture-capital transactions.

[2] According to Griliches (1990), "In spite of all the difficulties, patents statistics remain a unique resource for

(Pandit et al., 2010). Second, patents are exclusive properties and have been actively traded in intellectual property markets (Lev, 2001). Third, firms have recognized the importance of patents since the establishment of the Court of Appeals for the Federal Circuit (CAFC) in 1982 and since several well-known patent lawsuits in the mid 1980s (Hall and Ziedonis, 2001; Hall, 2005).

There are a number of reasons that the effects of CEO turnover on innovation are particularly worthy of study. First, although previous studies such as Dechow and Sloan (1991) address the accounting incentives of departing and incoming CEOs, realized innovation measured with patents is much more closely tied to the real operations of a firm – as opposed to the accounting effects.[3] Second, the impact of CEO turnover on innovation could have implications for the effects of CEO departure on firm-value. This topic is related to research into how new CEOs increase firm value. More generally, it is related to how management affects firm performance (Bebchuk et al., 2002; Holmstrom and Kaplan, 2001; Bertrand and Schoar, 2003; Huson et al., 2004; Murphy and Zabojnik, 2007; Aivazian et al., 2010) and the association between governance and innovation (see Belloc (2010) for a discussion of previous research on the effects of corporate governance on innovation). Finally, Aghion et al. (2009) and Sapra et al. (2009) suggest that the replacement threat, from both institutional investors and the threat of takeover, incentivizes CEOs to innovate up to an optimal level. The implications of these studies can be tested empirically from an *ex post* perspective by examining if innovation increases after CEO turnover occurs.

We also examine the effects of other determinants of firms' innovation performance. For example, overconfident CEOs are more likely to invest in research and development, resulting in more innovation (Hirshleifer et al., 2010b; Galasso and Simcoe, 2010). Option compensation provides incentives to CEOs to take risks and engage in higher levels of innovation (Lerner and Wulf, 2007;

the analysis of the process of technical change. Nothing else even comes close in the quantity of available data, accessibility, and the potential industrial, organizational, and technological detail (p. 1702)."

[3]Moreover, in contrast to operating performance, our innovation values are not influenced by earnings-management, and arguably lead changes in operating performance. We also examine cumulative innovation performance – as well as innovation productivity and influence – along various time-dimensions, to provide a more complete interpretation of innovation associated with CEO turnover. Doing so provides a more thorough control for the effect associated with a new CEO compared to the previous CEO. Additionally, our findings relating to innovation indicate more than just changes in operating performance – they indicate improved operational efficiency (i.e., based on innovation productivity and influence) and the degree to which the relation is sensitive to firm- and CEO-specific characteristics.

Francis et al., 2009). In addition, we propose that forced turnover, the hiring of external as opposed to internal CEOs, and the degree of information asymmetries also affect firms' innovation performance. We also explore how these factors interact with CEO turnover in affecting innovation performance.

We begin our empirical analysis by constructing a panel of firm-year data that includes financial/accounting information of publicly listed firms from the CRSP/Compustat database, patents of these firms from the updated NBER patent database, and detailed CEO data from ExecuComp. We complement our data set with CEO overconfidence measures from Campbell et al. (2010) and forced CEO turnover data from Jenter and Kanaan (2008). We proxy for a firm's innovation performance with the number of patents filed by the firm ("patent counts") and the number of citations received by patents filed by the firm ("patent citations") over the subsequent three or five years.

Following from Murphy and Zimmerman (1993), we employ two-stage least-squares regressions to investigate if endogenous CEO turnover affects innovation performance;[4] we find that CEO turnover leads to significantly more patents and citations in the following five and three years. The occurrence of CEO turnover increases the number of patents over the following five-year and three-year periods by 106% and 99%, respectively, and increases five- and three-year patent citations by 273% and 258%, respectively. Forced turnover has a generally insignificant effect on innovation performance.

Moreover, new CEOs from inside the firm are associated with higher levels of innovation performance than new CEOs from outside the firm. Our results control for other determinants of innovation including previous years' research and development expenses, the market-to-book ratio, firm size, the market-adjusted stock return, the change in earnings, and industry dummies for Fama-French 30 industry-groups. Additional tests examine the effect of firm-specific characteristics and CEOs' expected tenure, to show the robustness of our findings to various controls.

We find that CEO overconfidence, stock-option compensation, and information asymmetries

[4]We follow from Murphy and Zimmerman (1993) and use all second-stage explanatory variables and two additional variables – CEO age and a dummy variable for whether the CEO is aged 64 or 65 – in our first-stage regression.

are associated with more patents and patent citations. These results provide evidence consistent with both earlier research and with the hypotheses that we test in this paper. We also examine the degree to which these factors affect the relation between CEO turnover and innovation. The interaction of CEO turnover and option compensation and of CEO turnover and information asymmetries carry negative coefficients. We interpret these findings as consistent with option compensation and information asymmetries having similar effects on innovation as CEO turnover – whereas the interaction terms are negative, the coefficients for each of CEO turnover, option compensation, and information asymmetries are positive. We do not find evidence that the effects of CEO overconfidence on innovation are significantly different in firm-years in which CEO turnover occurs.

Given that innovation quality is generally more important than innovation quantity, we construct empirical proxies to measure innovation productivity and innovation influence. We define innovation productivity as patent counts scaled by cumulative research and development expenses in the following three-year and five-year period, following from Lanjouw and Schankerman (2004). We define innovation influence as patent citations divided by patent counts in the following three and five years. We find that CEO departures are associated with more productive research projects and more influential patents. In particular, we document that CEO turnover is associated with a 360% increase in productivity using our five-year measure and a 418% increase in productivity using our three-year measure. Additionally, we note that CEO turnover is associated with a 76% increase in innovation influence using our five-year measure and a 78% increase in influence using our three-year measure.

We find that CEO overconfidence, option compensation, and information asymmetries lead to more productive research projects and more influential patents. The joint effect of CEO turnover and related factors suggests the following: (1) The innovation quality of overconfident new CEOs is statistically indistinguishable from that of all overconfident CEOs, and (2) option compensation and information asymmetries overlap with CEO turnover. Not only do these results confirm the

findings based on patent counts and citations, they also indicate that CEO turnover and related characteristics appear to affect innovation quality.

In addition to addressing endogeneity with our two-stage least-squares regressions, we subject our results to a number of additional robustness tests. First, we find that our results remain consistent when examining *changes* in innovation performance, productivity, and influence. Second, we demonstrate that our findings are robust to controlling for CEOs' expected tenure. These tests indicate that our results are not driven by potential endogeneity of firms that experience frequent CEO turnover also being more frequent, productive, and influential innovators. Given the difficulties in properly identifying the time required for CEOs to influence innovation, we show that our results are robust to several timing-related specifications. We also evaluate the robustness of our findings to industry-adjusted measures for patent counts and citations, as well as to using different specifications for industry-groups.

Our paper is related to a number of studies that examine the effects of CEO turnover and CEO-related determinants of innovation, and contributes to the literature in a number of ways. First, we find that CEO turnover leads to significantly more and better innovation, justifying the implications of Aghion et al. (2009) and Sapra et al. (2009) from an *ex post* perspective and confirming a real effect of CEO turnover on firms' investment behavior (as opposed to the accounting implications associated with CEO turnover). Consequently, we extend the works of Dechow and Sloan (1991) and Murphy and Zimmerman (1993). Moreover, by examining the effects of new CEOs on innovation, our research can contribute to ongoing studies related to the determinants of CEO turnover and the degree to which CEOs create value (Aivazian et al., 2010). Second, although some studies such as Xu (2009) and Xu (2010) have examined the effect of CEO turnover on research and development expenses, research and development suffers from uncertainty, inefficiency, and irrationality in measuring real innovation. This study serves as the first attempt to investigate and document how CEO turnover and related factors influence patent performance. Third, in measuring a firm's innovation performance, we consider not only the counts and citations of patents but also

quality-related measures, such as citations per patent and the number of patents granted per research and development dollar spent. The consistent results that we find across all innovation measures confirm the robustness of our results and strongly support an important role of CEO-related factors on innovation from the perspectives of both innovation quantity and innovation quality. Fourth, and motivated by recent research, we propose and empirically substantiate the effects of information asymmetries on innovation; this effect on innovation has not been previously studied. Finally, we confirm the effects of compensation structure and CEO overconfidence on innovation.

Our paper continues as follows. Section 2 provides a discussion of related literature and our paper's hypotheses. In Section 3, we discuss our data and empirically examine how CEO turnover, CEO overconfidence, CEO compensation, and information asymmetries affect firm-level patent counts and citations. We further inspect if the aforementioned factors explain innovation productivity and influence in Section 4, and examine the robustness of our findings in Section 5. We end with concluding remarks in Section 6.

2 Literature review and hypotheses development

We first focus on the relation between innovation and CEO turnover. The Quiet Life Hypothesis predicts that managers who prefer less work tend to under-invest in innovation, although performance-related compensation and the threat of replacement mitigate this behavior. This agency problem is particularly severe for managers with a stronger horizon problem and hence less powerful career concerns (Gibbons and Murphy, 1992) and larger firms (Holmstrom, 1989). Aghion et al. (2009) find that institutional investors provide managers with incentives that encourage innovation, and model a lazy-manager with career concerns hypothesis. Similarly, Sapra et al. (2009) propose that both large investors and external takeovers induce incumbent managers to continue innovating. These studies indicate an ex ante relation between innovation and CEO turnover since, assuming that innovation is value-increasing, CEOs who fail to innovate at an adequate level are

more likely to be replaced with new CEOs who engage in higher levels of innovation. Smith (1990) does not find a significant change in research and development expenses following a management buyout, although she does find increased research and development expenses prior to buyouts. To the degree that management is less likely to be replaced following a buyout, her results suggest that innovation behavior could be significantly associated with agency issues.

This relation is also consistent with Dechow and Sloan (1991). They argue that CEOs attempt to boost earnings and follow a suboptimal investment policy when they are close to departing their firms due to retirement ("horizon problem") or poor performance ("cover-up").[5] Additionally, Weisbach (1995) shows that CEO turnover leads to divestitures of poor-performing previously-completed acquisitions. Extending the relation to investment in innovation suggests that new CEOs would allocate resources to more promising investment opportunities, thus leading to more effective innovation.

As we note in our introduction, examining innovation has different implications than examining research and development expenditure or operating performance. Most importantly, innovation is tied to the output of firms' research and development activities, as opposed to the accounting *input*. Moreover, in contrast to operating performance, innovation is free of earnings-management issues – and its robustness to manipulation is particularly evident when we examine innovation productivity and influence. In essence, we are able to examine a clearer aspect of firms' operations and how it changes with CEO turnover. Our work also serves as an extension of Bertrand and Schoar (2003); although our results are consistent with how new individuals can affect firm-value (i.e., through innovation), we examine the degree to which innovation changes on average even with just the selection of a new CEO. This can add to our understanding of how managers influence firm-policies, as Bertrand and Schoar (2003) discuss.

We also focus on the *nature* of CEO turnover. Parrino (1997) presents evidence that firms in

[5]Cheng (2004) reports that compensation committees realize and effectively mitigate opportunistic reductions in research and development spending by increasing the association between CEO compensation and research and development expenses.

relatively homogeneous industries are more able to identify and replace low-quality CEOs. Other studies, such as Borokhovich et al. (1996) and Huson et al. (2004), examine whether the details associated with the CEO turnover can explain changes in operating performance or announcement effects around the time of CEO turnover. We hypothesize that the forced departure of a CEO and the selection of an individual from outside the firm should be associated with relatively lower levels of innovation, since the new CEO is more likely to be: (1) Unfamiliar with ongoing investment opportunities and slow in reevaluating a firm's ongoing investment activities since firms that experience forced departures are less likely to be as well-prepared for succession as firms that experience routine departures, and (2) more reluctant to pursue relatively risky innovation-related activities, due to less knowledge of the position and firm, as well as a greater fear of a forced departure. Motivated by the aforementioned studies, we form our first set of hypotheses:

Hypothesis 1a: Firms will create more innovation following CEO turnover

Hypothesis 1b: CEO turnover that follows a non-orderly succession is associated with less innovation

We extend Hypotheses 1a and 1b by examining the degree that the types of individuals and firms influence innovation. Indeed, our research examines not only the degree to which turnover influences innovation, but also the degree to which the influence is affected by individual-specific and firm-specific factors.

Previous research suggests that CEO confidence is an important determinant of many aspects of a firm's policies (Malmendier and Tate, 2005; Goel and Thakor, 2008; Malmendier and Tate, 2008; Campbell et al., 2010; Malmendier et al., 2010). Similarly, previous studies such as Rosen (1981) and Gabaix and Landier (2008) account for CEOs with different qualities in their models. Palia (2000) notes that managers with higher education-quality are more likely to join firms in

less-regulated industries, where the returns from their human capital are greater. Since investment in innovation depends on a CEO's assessment of future opportunities, it is reasonable to expect that CEO confidence affects innovation. Hirshleifer et al. (2010b) report that firms in innovative industries with overconfident CEOs invest more in innovation and obtain more patents and patent citations. Galasso and Simcoe (2010) develop a career concerns model where CEOs innovate to signal their abilities to the market and where excessively optimistic CEOs are more likely to innovate, especially in competitive industries. They find empirical results similar to Hirshleifer et al. (2010b). Moreover, Campbell et al. (2010) develop a model that suggests that overly optimistic CEOs tend to overinvest. This relation could be extended to overinvestment in research and development, which should result in more innovation.

We also examine whether the effect of CEO overconfidence on innovation is particularly prominent following CEO turnover. It is plausible that early in a CEO's tenure, CEO overconfidence has a relatively large effect on innovation. With the very selection of a new CEO, a firm often provides that individual with more flexibility for more significant adjustments to the firm's investment decisions. As a result, we evaluate the following hypotheses:

Hypothesis 2a: Overconfident CEOs are more likely to produce more innovation

Hypothesis 2b: The effect of CEO overconfidence on innovation is particularly severe immediately following CEO turnover

The structure of CEO compensation also affects innovation. Holmstrom (1989) argues that research activities are risky and uncertain, thus necessitating a compensation structure that provides incentives to encourage CEOs to innovate. Jensen and Murphy (1990) note that the use of stock and stock-option compensation is one approach for incentivizing the CEO to maximize shareholder wealth. Holthausen et al. (1995) examine the relation between the divisional CEO's compensation

structure and subsequent innovation within that division. The effects of stock and stock-option compensation receives support in recent studies: Lerner and Wulf (2007) find that the use of long-term incentives, such as stock options and restricted stock, leads to more productive research activities (measured by patent citations). Francis et al. (2009) examine how CEO compensation contracts – including vested and unvested options and golden parachutes – promote innovation, finding a significant effect of long-term incentives on innovation. Moreover, Manso (2010) suggests that the cost of designing short-term contracts for CEOs exceeds the cost of shirking from innovation. Compensation in stocks and stock options provides CEOs with upside potential for realizing value-increasing innovation. The argument is consistent with experiments in Ederer and Manso (2010), in which a compensation structure that tolerates early failure while rewarding long-term success promotes innovation.

However, we also note that the investment opportunity set is generally larger for firms that pursue compensation policies with a greater use of performance-based compensation (Smith and Watts, 1992). In particular, we expect the effects of option-compensation on innovation to be significantly diminished around the time of CEO turnover. Firms that replace their CEOs and use high levels of stock-option compensation should be particularly likely to reevaluate their investment opportunities. Consequently, the effects of CEO turnover and option compensation offset each other, and their interaction should be negatively associated with innovation. We study applications of the compensation-innovation relation to aspects relating to CEO turnover and characteristics, and examine the following hypotheses:

Hypothesis 3a: Managers with higher stock-option compensation will create more innovation

Hypothesis 3b: The positive effect of stock-option compensation on innovation is weakened during CEO turnover

Asymmetric information should also affect firms' innovation behavior. As suggested in Bhattacharya and Ritter (1983), managers can use patents as a credible signal to communicate with outside parties to mitigate asymmetric information. Using a data set consisting of 370 semiconductor start-up firms, Hsu and Ziedonis (2007) argue that firms' patent records work as effective quality-signals and explain the likelihood of an initial public offering. Since the importance of signaling increases with information asymmetries (Leland and Pyle, 1977; Amit et al., 1990), we propose innovation to be positively associated with information asymmetries.

Nevertheless, we expect innovation to be *negatively* associated with information asymmetries when a new CEO is selected. A firm with high information asymmetries should be particularly slow to provide a new CEO with the resources necessary for high levels of innovation, due to the difficulties and delays in assessing the new CEO's quality. In contrast, firms with lower levels of information asymmetries can more readily and effectively evaluate a new CEO's quality. Consequently, we state our final set of hypotheses:

Hypothesis 4a: Information asymmetries are generally positively associated with innovation

Hypothesis 4b: Information asymmetries are negatively associated with innovation for firm-years in which CEO turnover occurs

3 Empirical analysis

3.1 Data

To empirically test our hypotheses, we construct a panel of firm-year data on patents and CEO turnover from a variety of sources. We use patent data to examine firms' level of innovation since patents have been commonly used in the literature to measure technological progress. U.S. firms

have become more active in patenting their inventions and defending their intellectual property rights since the mid-1980s (Hall and Ziedonis, 2001; Hall, 2005; Bessen and Meurer, 2005). In contrast to research and development expenditures that usually involve uncertainty and could reflect agency issues (e.g., Jensen (1993)), Pandit et al. (2010) suggest that patents reflect realized innovation and often affect future operating performance. More importantly, unlike research and development expenditure, patents are assets owned by the firm; Lev (2001) notes that they have also been actively traded in intellectual property markets.

We obtain the financial and accounting information (including annual research and development expenditures) of U.S. public firms from the CRSP/Compustat merged database and link the data to the updated NBER patent data set.[6] The updated NBER patent data set contains detailed information on all U.S. patents granted by the U.S. Patent and Trademark Office (USPTO) to U.S. public firms between January 1976 and December 2006. We then expand our data by including the following: (i) CEO tenure, selection date, age, and compensation details from ExecuComp, (ii) measures of CEO overconfidence from Campbell et al. (2010), and (iii) forced CEO turnover data from Jenter and Kanaan (2008).[7] Due to data-availability issues, we study firm-years between 1993 and 2005.

In Table 1, we provide sample statistics for the variables that we use throughout our paper. We

[6]The NBER patent data set was first constructed by Hall et al. (2001) and the updated version is available at https://sites.google.com/site/patentdataproject/Home.

[7]Campbell et al. (2010) define high-optimism CEOs as those who hold options with moneyness greater than 100%. Jenter and Kanaan (2008) use Factiva to examine news articles around turnover and to identify the precise departure date. They follow from Parrino (1997) in their classification of forced and voluntary turnovers. They examine the age of the CEO, whether the departure is classified as forced or voluntary, reported policy differences/pressure, and whether "the press reports convincingly explain the departure as due to previously undisclosed personal or business reasons that are unrelated to the firm's activities." Their classification scheme takes into account the fact that few departures are openly classified as terminations.

propose the following four proxies for innovation performance of firm j in year t:

$$\begin{aligned}
CountsNext5yr_{j,t} &= Ln(1 + Counts_{j,t+1} + Counts_{j,t+2} + Counts_{j,t+3} + Counts_{j,t+4} \\
&\quad + Counts_{j,t+5}) \\
CountsNext3yr_{j,t} &= Ln(1 + Counts_{j,t+1} + Counts_{j,t+2} + Counts_{j,t+3}) \\
CitesNext5yr_{j,t} &= Ln(1 + Cites_{j,t+1} + Cites_{j,t+2} + Cites_{j,t+3} + Cites_{j,t+4} + Cites_{j,t+5}) \\
CitesNext3yr_{j,t} &= Ln(1 + Cites_{j,t+1} + Cites_{j,t+2} + Cites_{j,t+3}),
\end{aligned}$$

which are the log of one plus patent counts or citations over the following five-year or three-year periods.[8] $Counts_{j,t}$ is firm j's number of patents in year t, defined as the total number of patent applications filed by firm j in year t that were later approved by the USPTO (successful patent applications). $Cites_{j,t}$ is firm j's patent citations in year t, defined as the number of citations (including self-citations) received by all patents filed by firm j in year t; this measure reflects the importance of a patent by studying the patent's forward citations. It is noteworthy that we count patent counts and citations by their application-years, as suggested in Hall et al. (2001), "whenever possible, the application date should be used as the relevant time placer for patents." The prevalence of innovation performance vary significantly; for example, $CountsNext5yr$ has a mean value of 1.076, a median value of 0, and a value of 4.174 for the ninetieth percentile, while $CitesNext5yr$ has a mean value of 1.514, a median value of 0, and a value of 6.098 for the ninetieth percentile.

The main explanatory variable of interest, $CEOTurnover_{j,t}$, is an indicator variable equal to 1 for firm j in year t if CEO turnover happens in that firm-year and 0 otherwise. We define a CEO turnover event as occurring when a firm's ExecuComp record for the CEO is different from the previous year (we define the first year of a different CEO as the "transition year," since it is unclear at what point in that year the CEO departs). We also consider whether the new CEO

[8]The log-linearization follows from Lerner (1994), in which the log of patent counts plus one is used as the main explanatory variable for the firm value of biotech firms.

is from outside the firm – respectively, we use the terms "external" and "internal" for CEOs who are from outside the firm or are promoted from within the firm – following from Parrino (1997) and Murphy and Zabojnik (2007). A newly appointed CEO is defined as an external CEO if, when that individual is selected as CEO, he/she has been with that firm for less than one year. $ExtenalCEOTurnover_{j,t}$ is an indicator variable and equals 1 if the CEO has been at the firm for less than one year on appointment as CEO and 0 otherwise. Using data from Jenter and Kanaan (2008), we construct $ForcedTurnover_{j,t}$, an indicator variable representing forced turnover and equal to 1 if the CEO turnover of firm j in year t is classified as "forced" and 0 otherwise.

The summary statistics reported in Table 1 suggest that, of our sample firm-years, 8.6% are CEO turnover events and 6.3% can be defined as regular retirement event (the departing CEO is 64 or 65 years old). We also note that the average age for departing CEOs is approximately 57. In addition, new external CEO and forced CEO turnover occur in 1.4% and 0.6% of our sample firm-years, respectively.

Moreover, we consider several other control variables from the CRSP/Compustat merged files: The cumulative research and development expenditures are measured with $RD_{j,t-4,t}$ and $RD_{j,t-2,t}$, the log of the sum of the firm's annual research and development expenses for the most recent five years ($t-4$ to t) and the most recent three years ($t-2$ to t), respectively; the market-to-book ratio of the firm, $MtoB_{j,t}$ is the market value of firm j over its book value at the end of year t; the log of the firm's total assets, $LogAssets_{j,t}$; the market-adjusted stock return, $ExcessReturn_{j,t}$, as firm j's stock return in excess of the CRSP value-weight market return in year t; the lagged market-adjusted stock return, $ExcessReturn_{j,t-1}$; the difference in firm j's scaled earnings, $\Delta Earnings_{j,t} = \frac{Income_{j,t}}{Sales_{j,t-1}} - \frac{Income_{j,t-1}}{Sales_{j,t-2}}$; the lagged difference in firm j's scaled earnings, $\Delta Earnings_{j,t-1} = \frac{Income_{j,t-1}}{Sales_{j,t-2}} - \frac{Income_{j,t-2}}{Sales_{j,t-3}}$. The summary statistics for these control variables are largely consistent with the literature.

3.2 Innovation, CEO turnover, and other determinants

Our first hypothesis suggests that firms create more innovation following CEO turnover. Murphy and Zimmerman (1993), in evaluating the effect of CEO turnover on discretionary financial variables, provide two-stage least-squares estimates to control for the endogeneity of CEO turnover. In particular, they note that CEO turnover is a function of firm performance and CEO age. For firm-performance they consider both current and lagged changes in operating performance and current and lagged stock returns. For CEO age they consider both the CEO's age and an indicator variable for CEOs aged either 64 or 65. We follow their methodology and conduct two-stage least-squares regressions, hence evaluating the effects of CEO turnover on innovation performance while controlling for the effects of firm performance and CEO age on CEO turnover. In the first stage of our regressions, we regress $CEOTurnover_{j,t}$ on CEO age and an age dummy (equal to 1 for CEO's aged 64 or 65, and 0 otherwise), as well as the other control variables reflecting firm characteristics and performance used in our second-stage regression. Then, we regress the firm's innovation performance on the fitted value of $CEOTurnover_{j,t}$ and the other control variables in our second-stage regression:

$$\begin{aligned} Innovation_{j,t} = {} & Intercept + \beta_1\, Fitted\, CEOTurnover_{j,t} + \beta_2\, ForcedTurnover_{j,t} \\ & + \beta_3\, ExtenalCEOTurnover_{j,t} + \beta_4\, Cumulative\, RD_{j,t} + \beta_5\, MtoB_{j,t} \\ & + \beta_6\, LogAssets_{j,t} + \beta_7 ExcessReturn_{j,t} + \beta_8\, ExcessReturn_{j,t-1} \\ & + \beta_9\, \Delta Earnings_{j,t} + \beta_{10}\, \Delta Earnings_{j,t-1}, \end{aligned} \tag{1}$$

where $Innovation_{j,t}$ is measured with four innovation performance proxies: $CountsNext5yr_{j,t}$, $CountsNext3yr_{j,t}$, $CitesNext5yr_{j,t}$, and $CitesNext3yr_{j,t}$. The other control variables include the cumulative research and development expenditure ($RD_{j,t-4,t}$ or $RD_{j,t-2,t}$), the market-to-book ratio of the firm ($MtoB_{j,t}$), the log of the firm's total assets ($LogAssets_{j,t}$), the market-adjusted stock return ($ExcessReturn_{j,t}$), the lagged market-adjusted stock return ($ExcessReturn_{j,t-1}$), the difference in scaled earnings ($\Delta Earnings_{j,t}$), the lagged difference in scaled earnings ($\Delta Earnings_{j,t-1}$),

and industry dummies for the Fama-French 30 industry-groups.[9]

Table 2 reports the results of second-stage regressions that examine the effects of CEO turnover (as well as additional, relevant variables) on innovation performance using 14,982 firm-year observations. Statistical inferences can be made with the coefficients and heteroscedasticity-robust, industry-clustered standard errors (in parentheses). We find that the selection of a new CEO is associated with significantly more patents and citations in the following three and five years. The occurrence of CEO turnover increases $CountsNext5yr$ and $CountsNext3yr$ by 0.721 and 0.686, respectively, and increases $CitesNext5yr$ and $CitesNext3yr$ by 1.316 and 1.275, respectively. Moreover, in terms of economic magnitude, the coefficients suggest that five-year patent counts increases by 106% ($e^{0.721} - 1$) immediately after CEO turnover, and five-year patent citations increases by 273% ($e^{1.316} - 1$) immediately after CEO turnover.

Additionally, the other independent variables are of the expected signs. $ExtenalCEOTurnover$ is associated with consistently negative and significant coefficients.[10] The negative effect of a new external CEO on innovation is reasonable when considering the fact that an internal CEO is generally more familiar with a firm's technological competencies (Gupta, 1984; Datta and Guthrie, 1994) and is thus more capable of innovating more effectively and efficiently. Another possibility is that over-monitoring from shareholders or regulators may stifle innovation (e.g., Shadab (2008)). We would expect this to be the case if firms that select CEOs from outside are particularly likely to be focused on monitoring and internal controls; for example, Parrino (1997) notes the effects of industry homogeneity on the ease in which management can be replaced. Interestingly, we find that $ForcedTurnover$ is insignificantly negative, suggesting that the conditions of the previous CEO's exit are not significantly associated with subsequent innovation.

As expected, cumulative research and development expenditures, measured with $RD_{t-4,t}$ and

[9] We recognize that industry characteristics may affect firms' innovation decision. Consequently, we control for industry effects by including industry fixed-effects for the Fama-French 30 industry-groups. The definition of Fama-French 30 industry-groups is available at http://mba.tuck.dartmouth.edu/pages/faculty/ken.french.

[10] Combined with the coefficient associated with $CEOTurnover$, we find that the 16.3% of turnover events with an "external" CEO succession are not associated with significantly different levels of innovation.

$RD_{t-2,t}$, are associated with significantly higher levels of innovation. It is noteworthy that our finding related to innovation holds even when controlling for research and development expenditures (and hence the known relation of increased research input following CEO turnover). On a related note, we show in subsequent tables that research and development expenditures are more productive following CEO turnover. These tables are consistent with our argument that innovation increases following CEO turnover even when controlling for the level of research and development.

Firms with more growth options and larger firms – estimated with market-to-book ($MtoB$) and assets ($LogAssets$) respectively – are associated with higher levels of innovation. Current (though not lagged) market-adjusted stock returns have significantly negative effects on future innovation, consistent with the arguments discussed in Lev and Sougiannis (1996) and Chan et al. (2001) that investors are pessimistic about firms' research and development projects. Moreover, our finding that current and lagged changes in profitability are negatively associated with future innovation could be mechanical, to the degree that increased expenditures in research and development and other expenses that increase future innovation would reduce current profitability. Alternatively, the association between innovation and changes in profitability could reflect the cyclical nature of firms' innovation, if firms recognize the value of their innovation only further in the future. By the time that a firm's earnings are increasing, the firm could be focused on monetizing – rather than developing – innovation.

Table 2 presents evidence supporting Hypotheses 1a and 1b. In our subsequent tables, we evaluate the robustness of the relation between CEO turnover and innovation, and discuss other related implications.

Table 3 examines other hypotheses by including variables capturing CEO overconfidence, CEO compensation structure, and information asymmetries in the regression. To measure CEO overconfidence, we use a $HighOverconfidence_{j,t}$ indicator variable which is equal to one if firm j's CEO holds stock options that are more than 100% in the money in year t and zero otherwise. To measure compensation structure, we construct $OptionComp\%_{j,t}$, which is the percentage of the total

compensation paid in stock options to firm j's CEO in the subsequent year $(t+1)$. As reported in Table 1, 37.4% of CEOs are overconfident and average CEOs receive approximately one-third of compensation in stock options. Information asymmetries are measured with $\sigma_{CapmResidual_{j,t}}$, the standard deviation of firm j's daily return residuals from the capital asset pricing model (CAPM) in year t, following Blackwell et al. (1990) and Clarke et al. (2004). Due to limited data-availability for the aforementioned variables, the size of valid firm-year observations decreases to 9,374. In Table 3, our second-stage regression is the following:

$$\begin{aligned} Innovation_{j,t} = {} & Intercept + \beta_1\, Fitted\, CEOTurnover_{j,t} + \beta_2 HighOverconfidence_{j,t} \\ & + \beta_3 OptionComp\%_{j,t} + \beta_4 \sigma_{CapmResidual_{j,t}} + \beta_5 ForcedTurnover_{j,t} \\ & + \beta_6 ExternalCEOTurnover_{j,t} + \beta_7\, Cumulative\, RD_{j,t} + \beta_8\, MtoB_{j,t} \\ & + \beta_9\, LogAssets_{j,t} + \beta_{10} ExcessReturn_{j,t} + \beta_{11}\, ExcessReturn_{j,t-1} \\ & + \beta_{12}\, \Delta Earnings_{j,t} + \beta_{13}\, \Delta Earnings_{j,t-1}. \end{aligned} \tag{2}$$

We find that even after adding $HighOverconfidence$, $OptionComp\%$, and $\sigma_{CapmResidual}$ into our regressions, CEO turnover remains positively associated with future innovation. In addition, overconfident CEOs are more likely to engage in higher levels of innovation because they either believe in improved future investment opportunities or are overconfident of their research projects' potential, consistent with Hirshleifer et al. (2010b) and Galasso and Simcoe (2010). We also find evidence of the use of stock-option compensation being positively associated with higher levels of innovation, consistent with previous research (Francis et al., 2009). Finally, the coefficients associated with $\sigma_{CapmResidual}$ are positive but insignificant, which do not strongly support our proposition that, in an environment with relatively high levels of information asymmetries, firms seek to patent their innovations in order to signal their quality.

Our findings present in Table 3 thus indicate that firms' innovation performance depends on CEO turnover, CEO overconfidence, and the structure of CEO compensation, providing strong empirical support for Hypotheses 1a, 2a, and 3a, but not for Hypothesis 4a.

3.3 Sensitivity of turnover-innovation relation

To further examine how CEO turnover affects innovation, we introduce interaction variables and report the results in Table 4. The interaction variables are defined as the CEO turnover dummy multiplied by each of the following: $HighOverconfidence$, $OptionComp\%$, and $\sigma_{CapmResidual}$. The coefficients of these interaction variables reflect the marginal effects of these variables for firm-years in which CEO turnover occurs. We find that the interaction between $HighOverconfidence$ and $CEOTurnover$ is negative without statistical significance; we also find that the effect of $HighOverconfidence$ on innovation remains significantly positive. This finding suggests that overconfident CEOs create more innovation, regardless of whether CEO turnover occurs.

The interaction term $OptionComp\% \times CEOTurnover$ reveals significantly negative coefficients. This finding suggests that the effects of CEO turnover and option compensation overlap to a certain extent. This finding is reasonable when considering that new CEOs are more likely to reevaluate their firms' research projects and reallocate resources to more promising opportunities, particularly for firms with relatively high levels of incentive compensation (since for these firms, developing and monetizing growth options are likely to be of significant concern).

Finally, the negative coefficient associated with $\sigma_{CapmResidual} \times CEOTurnover$ suggests an overlapping effect of innovation. When a new CEO is selected, he/she has relatively strong incentives to signal his/her ability; these incentives are similar to the reasons that CEOs would wish to innovate in an environment with high information asymmetries. Notably, the coefficient associated with $\sigma_{CapmResidual}$ is significantly positive in this table, suggesting that the insignificance for $\sigma_{CapmResidual}$ in Table 3 might be attributed to the previous regression not controlling for the presence of information asymmetries with CEO turnover.

These findings, by examining the sensitivity of the relation between CEO turnover and innovation to other relevant variables, provide an improved level of empirical analysis. Future innovation remains positively associated with CEO turnover, CEO overconfidence, and option compensation. Controlling for the interaction terms also helps justify the positive relation between innovation and

information asymmetries. The interaction of CEO turnover with stock-option compensation and the interaction of CEO turnover with information asymmetries are both negative and significant, indicating potential overlapping effects of various factors. Our test results therefore support all of the hypotheses in Section 2 with the exception of Hypothesis 2b.

4 Innovation productivity and innovation influence

In this section, we propose two advanced proxies – innovation productivity and innovation influence – to measure innovation from a "quality" perspective. Innovation productivity is generally defined as the efficiency in which firms transform research and development expenditures into patents. Lanjouw and Schankerman (2004) note that innovation productivity is informative of firms' market values; it is a firm-specific characteristic and is generally sustainable and not tradable (Dierickx and Cool, 1989). Following Lanjouw and Schankerman (2004), we define the following measures for innovation productivity:

$$\begin{aligned} 5yrProductivity_{j,t} &= CountsNext5yr_{j,t} - ln(1 + RD_{j,t+1} + RD_{j,t+2} + RD_{j,t+3} + RD_{j,t+4} \\ &\quad + RD_{j,t+5}) \\ 3yrProductivity_{j,t} &= CountsNext3yr_{j,t} - ln(1 + RD_{j,t+1} + RD_{j,t+2} + RD_{j,t+3}), \end{aligned}$$

where $RD_{j,t+\tau}$ denotes firm j's research and development expenditures in year $t+\tau$. We omit firm-years with no cumulative research and development expenditures, and require $\sum_{\tau=1}^{5} RD_{j,t+\tau} > 0$ and $\sum_{\tau=1}^{3} RD_{j,t+\tau} > 0$ for valid $5yrProductivity_{j,t}$ and $3yrProductivity_{j,t}$, respectively. Table 5 shows that the occurrence of a CEO departure is associated with significantly higher levels of innovation productivity in the subsequent three and five years. The coefficients associated with $CEOTurnover$ suggests that $5yrProductivity$ increases by 360% ($e^{1.527} - 1$) and that $3yrProductivity$ increases by 418% ($e^{1.644} - 1$). Not only do our findings confirm previous results; they also provide new insights into the consequences of CEO replacement. New CEOs would

allocate resources to more promising research projects that will create more patents.

Similar to Table 3, $HighOverconfidence$ and $OptionComp\%$ are positively associated with innovation, $ExternalCEOTurnover$ is negatively associated with innovation, and both $\sigma_{CapmResidual}$ and $ForcedTurnover$ are insignificantly associated with innovation. The significantly negative coefficients associated with $RD_{t-4,t}$ and $RD_{t-2,t}$ could be attributed to the persistence of research and development investment. Higher cumulative research and development expenditures in the past imply higher future research and development investment, which is mechanically negatively associated with our proxies for innovation productivity.

We then construct the following two proxies for innovation influence:

$$5yrInfluence_{j,t} = CitesNext5yr_{j,t} - CountsNext5yr_{j,t}$$
$$3yrInfluence_{j,t} = CitesNext3yr_{j,t} - CountsNext3yr_{j,t},$$

which measure the (logarithmic) average number of citations received per patent for firm j in year t and reflect how influential firm j's patents are, on average. The final two columns of Table 5 show that CEO turnover is significantly associated with more influential patents in the following three and five years. The citations received per patent for the subsequent five-year and three-year periods increase by 76% and 78% respectively ($e^{0.566}-1$ and $e^{0.578}-1$). This finding indicates that the increased number of patents created by new CEOs are *valuable*, as patent citations may better reflect business value than patent counts (Trajtenberg, 1990). The other explanatory variables of interest are also consistent with our previous results. CEO overconfidence and the use of stock-option compensation are positively associated with innovation influence, information asymmetries and forced CEO turnover are insignificantly associated with innovation influence, and the hiring of a CEO from outside the firm is negatively associated with innovation influence. This table shows that our previous results are consistent to examining different dimensions of innovation – patent counts, citations, productivity, and influence.

In Table 6, we control for the interaction of CEO turnover with the other explanatory variables. Our results in this table are broadly similar to Table 4, although we find somewhat weaker statistical significance for productivity than we do for patent counts and citations. CEO overconfidence remains positive and significant, and its interaction with CEO turnover remains insignificant. Stock-option compensation remains positive and significant, with the interaction term of it with CEO turnover being significantly negative. Information asymmetries remain positive and significant; its interaction term with CEO turnover is significantly negative.

Interestingly, comparing this table with Table 4 shows how the effect of external CEOs varies depending on the dependent variable. $ExternalCEOTurnover$ has a significant effect on innovation performance (see Table 4), a somewhat less significant effect on innovation productivity, and an insignificant effect on innovation influence. The degree to which the significance declines with the tests in Table 6 highlights the benefits of examining several dimensions of innovation.

Our findings in this table are generally consistent with our earlier findings, suggesting that the effects of CEO turnover and other related variables on innovation applies to various regression specifications and various measures of firm-level innovation performance.

5 Robustness Tests

5.1 Additional firm-specific and turnover-specific controls

A potential endogeneity concern is the possibility that unobserved industry or firm characteristics could lead to an association between CEO turnover and innovation performance.[11] To address this issue, we follow from Murphy and Zimmerman (1993) and Huson et al. (2004) and examine *changes* in innovation performance following CEO turnover.[12]

[11] Although this explanation does not explain our more detailed results, such as why innovation productivity and influence are associated with CEO turnover or why the change in innovation performance following turnover might be associated with CEO characteristics.

[12] One of the problems with otherwise only testing innovation performance and not changes in innovation performance is that nonstationary disturbances in levels cause regression estimators to be inconsistent (Plosser and Schwert, 1978).

In Table 7, we show that our results are comparable when examining changes in levels of innovation performance. We define our dependent variables of interest as follows:

$$\begin{aligned}
\Delta CountsNext5yr_t &= CountsNext5yr_t - CountsNext5yr_{t-5} \\
\Delta CountsNext3yr_t &= CountsNext3yr_t - CountsNext3yr_{t-3} \\
\Delta CitesNext5yr_t &= CitesNext5yr_t - CitesNext5yr_{t-5} \\
\Delta CitesNext3yr_t &= CitesNext3yr_t - CitesNext3yr_{t-3}.
\end{aligned}$$

We find that $CEOTurnover$ remains positive and significant, as is the case with our other regressions. Our other explanatory variables of interest – $HighOverconfidence$, $OptionComp\%$, $ForcedTurnover$ and $ExternalCEOTurnover$ – are comparable with one exception: the coefficient of $\sigma_{CapmResidual}$ for the change in the number of patent citations over the subsequent three years appears to be negative. Overall, this table provides empirical evidence that our earlier findings cannot be simply attributed to unobserved industry or firm characteristics.

Additionally, in Table 8 we examine changes in innovation productivity and influence, defining our dependent variables of interest as:

$$\begin{aligned}
\Delta 5yrProductivity_t &= 5yrProductivity_t - 5yrProductivity_{t-5} \\
\Delta 3yrProductivity_t &= 3yrProductivity_t - 3yrProductivity_{t-3} \\
\Delta 5yrInfluence_t &= 5yrInfluence_t - 5yrInfluence_{t-5} \\
\Delta 3yrInfluence_t &= 3yrInfluence_t - 3yrInfluence_{t-3}.
\end{aligned}$$

We find that our primary explanatory variables of interest (i.e., $CEOTurnover$, $HighOverconfidence$, and $ExternalCEOTurnover$) are generally of comparable sign and significance.[13] This table confirms our results in Table 7 and demonstrates additional robustness of our earlier results.

We also address the nature of the new CEO's selection, and whether an incoming CEO believes that he/she is likely to remain at the firm for a relatively long-period of time. An alternative explanation for our results is that CEOs with low expected tenure (i.e., CEOs who are either

[13] One notable difference between these results and Table 7 is our finding that stock-option compensation *OptionComp%* is insignificant in this table. As our focus is on *changes* in innovation productivity and influence, we are not concerned by the lack of significance associated with *OptionComp%*.

hired at firms that frequently replace CEOs, or who are hired during a period of low expected tenure) might be provided with incentives that encourage higher levels of innovation and are not captured by existing control variables. Consequently, this alternative hypothesis would predict that the incoming CEO's expected tenure ought to influence their level of innovation, rather than the occurrence of CEO turnover.

In Panel A of Table 9 we modify the tests in Table 3 to include the interaction variable $DepCEOTenure$ – equal to the interaction of $CEOTurnover$ (an indicator variable equal to 1 in cases where a new CEO is put in place) and the natural log of the previous CEO's tenure. We believe that this interaction variable can reflect the effect of a new CEO's expected tenure on his/her innovation behavior. We find that our results remain robust to Table 3 for all variables of interest (including $CEOTurnover$). Interestingly, we find that $DepCEOTenure$ is negative and significant, consistent with the lazy-manager hypothesis that new CEOs with an expectation of relatively long tenure have relatively lower levels of innovation.

In Panel B of Table 9 we adopt an alternative approach to control for the CEO's expected tenure: excluding firm-years in which CEO turnover occurs and the new CEO departs within the following two years.[14] Our results remain comparable to earlier findings – in particular, $CEOTurnover$ remains significantly positive.

In Table 10 we examine the effect of the CEO's expected and ex post tenure (as in Table 9) on innovation productivity and influence. In Panel A, our results remain comparable to Table 9, with the exception that regressions with innovation productivity ($5yrProductivity$ and $3yrProductivity$) find significance for information asymmetries ($\sigma_{CapmResidual}$) and forced CEO turnover ($ForcedTurnover$). Panel B also remains comparable to earlier results, and the regressions with innovation productivity also find significance for the coefficient associated with information

[14] Our results are also robust to various time-periods, such as omitting firm-years in which the new CEO departs within the following one, three, four or five years. One reason that we do not use this as our primary test is that it suffers from look-ahead bias, to the degree that it is unclear whether new CEOs are aware of their likely tenure based on ex post analysis. We focus on turnover within the subsequent two years since we believe that this type of turnover is more likely to be expected (i.e., in the case of interim CEOs) than other types of turnovers that are expected to occur within a longer period in the future; however, we note that this test still suffers from using ex post data.

asymmetries. These results further confirm the effect of information asymmetries on innovation from a quality perspective. Tables 9 and 10 collectively demonstrate that our results are reasonably robust to endogeneity issues related to the CEO's expected tenure, for tests of innovation performance, productivity, and influence.

5.2 Timing of innovation decision

In this section, we present the robustness of our results to controlling for timing-related issues of innovation input and output, as it is difficult to identify the appropriate lag between research and development expenditures and patent applications.[15] First, in Panel A of Table 11 we replicate Table 3 with a one-year lag for the number of patents and patent citations in the subsequent three-year or five-year periods. The underlying assumption is that the result of a new CEO on innovation only begins to occur in the following year. Rather than occurring over the subsequent three-year or five-year periods, we present results in this regression that the effect occurs in the following three-year or five-year periods beginning one year in the future. Consequently, compared to equation (2), our equation for this table uses $t+1$ instead of t for the dependent variable:

$$\begin{aligned} Innovation_{j,t+1} = {} & Intercept + \beta_1\, Fitted\, CEOTurnover_{j,t} + \beta_2 HighOverconfidence_{j,t} \\ & + \beta_3 OptionComp\%_{j,t} + \beta_4 \sigma_{CapmResidual_{j,t}} + \beta_5 ForcedTurnover_{j,t} \\ & + \beta_6 ExternalCEOTurnover_{j,t} + \beta_7\, Cumulative\, RD_{j,t} + \beta_8\, MtoB_{j,t} \\ & + \beta_9\, LogAssets_{j,t} + \beta_{10} ExcessReturn_{j,t} + \beta_{11}\, ExcessReturn_{j,t-1} \\ & + \beta_{12}\, \Delta Earnings_{j,t} + \beta_{13}\, \Delta Earnings_{j,t-1}. \end{aligned} \tag{3}$$

We find that our results remain similar to earlier findings, even when we focus on subsequent innovation performance. In particular, the effect of CEO turnover remains positive and

[15] Some evidence suggests that the lag between research and development expenditures and patent applications is less than one year (Hausman et al., 1984; Hall et al., 1986; Griliches, 1990). Similarly, Hirshleifer et al. (2010a) examine the robustness of their results with various approaches to controlling for a lagged effect of research and development expenditures on patent filings – they find that their results are robust to different timing specifications. To the degree that a CEO can reallocate research resources, the delay in a CEO's effect on innovation performance ought to be closely related to the lag between research and development input and patent output.

significant (the coefficient has a fairly similar magnitude as well). Additionally, the effects of $HighOverconfidence$ and $OptionComp\%$ remain positive and significant, $\sigma_{CapmResidual}$ remains generally insignificant (although it is significant at the 10% level for regressions with patent citations as the dependent variable), $ForcedTurnover$ remains insignificant, and $ExternalCEOTurnover$ remains negative and significant. This panel thus shows that our results are robust to the effect of CEO turnover on innovation occurring with a one-year lag.

In Panel B, we replicate Table 3 using the contemporaneous level of innovation rather than the future three- or five-year cumulative level of innovation and find that $CEOTurnover$ remains positive and significant. The other explanatory variables of interest remain as expected – $HighOverconfidence$ and $OptionComp\%$ remain positive and significant, $ForcedTurnover$ remains insignificant (for patent counts it is negative and significant at the 10% level, due to a substantially lower standard error), and $ExternalCEOTurnover$ remains negative and significant. We also find that $\sigma_{CapmResidual}$ is significantly positive, as it is in some of our earlier tables.

Table 12 shows that our innovation productivity and influence findings are also reasonably robust to controlling for timing-related issues. Thus, Tables 11 and 12 collectively demonstrate a robust effect of new CEOs on innovation to various timing specifications, both by examining results with one-year lags and by examining contemporaneous relations.

5.3 Industry characteristics and specifications

Although we have controlled for fixed industry effects in earlier regressions, timing-varying industry effects may still be a concern. To address this issue, we first evaluate the degree to which our findings are robust to controlling for the corresponding industry's median level of innovation in the same year. We define the following industry-adjusted measures for the innovation performance of firm j in year t:

$$AdjCountsNext5yr_{j,t} = CountsNext5yr_{j,t} - Median(\{CountsNext5yr_{i,t}\}_{i=1,...,J})$$
$$AdjCountsNext3yr_{j,t} = CountsNext3yr_{j,t} - Median(\{CountsNext3yr_{i,t}\}_{i=1,...,J})$$
$$AdjCitesNext5yr_{j,t} = CitesNext5yr_{j,t} - Median(\{CitesNext5yr_{i,t}\}_{i=1,...,J})$$
$$AdjCitesNext3yr_{j,t} = CitesNext3yr_{j,t} - Median(\{CitesNext3yr_{i,t}\}_{i=1,...,J}),$$

where J denotes the number of firms in firm j's industry in year t. This approach controls for potential industry-year characteristics and reflects the relative innovation performance for each firm. We apply a similar adjustment procedure to the three-year and five-year cumulative research and development expenditures.

In unreported tests, we find that CEO turnover retains its significantly positive effect on the firm's relative innovation performance; this suggests that our results hold even when controlling for the industry's time-varying level of innovation.[16] Moreover, CEO overconfidence and option compensation remain positive and significant (and the effect of information asymmetries remains insignificant), as in Table 3. The only notable difference in this specification is that $ForcedTurnover$ becomes significantly negative.

We also recognize that our definition of industry groups has the potential to affect our findings and replicate earlier tests using Fama and French (1997) 48 industry-groups. In unreported results, the magnitude of the coefficients associated with $CEOTurnover$, $HighOverconfidence$, $OptionComp\%$, and $ExternalCEOTurnover$ are slightly lower than their counterparts in Table 3, but are of similar statistical significance. However, we find moderately higher statistical significance for the coefficient associated with $\sigma_{CapmResidual}$ compared to Table 3. Moreover, the estimates of the coefficients associated with other explanatory variables are consistent with the findings based on Fama-French 30 industry-groups.

Finally, we confirm that our findings relating to innovation productivity and influence are robust to adjusting for industry medians and for using Fama and French (1997) 48 industry-

[16]The results from the regressions that we discuss in this section are available upon request. We omit the tables from the current version for brevity.

groups. Consequently, we are reasonably convinced that the effects of CEO turnover and related characteristics on innovation cannot be attributed to time-varying industry effects or to industry classifications.

6 Conclusion

This paper examines the association between CEO turnover and innovation performance in the sample period 1993-2005. We find strong empirical support for the notion that CEO turnover increases the firm's output, efficiency, and influence in innovation. After controlling for the endogeneity of CEO turnover, we present evidence consistent with CEO turnover increasing a firm's patent counts, patent citations, patents per research and development dollar, and citations per patent in the subsequent three and five years. We also find that internal new CEOs create more innovation than external new CEOs. Moreover, we find that relatively overconfident CEOs, CEOs with higher option compensation, and an environment with relatively higher information asymmetries are associated with more innovation of higher quality. Finally, we find that stock-option compensation and information asymmetries are *negatively* associated with subsequent innovation around the time of CEO turnover.

Our study has a number of interesting implications. First, from an *ex post* perspective, the replacement of CEOs appears to be an effective mechanism for investors to modify a firm's under-innovating behavior. Second, we find that the replacement of a CEO with someone from outside the firm has a negative effect on the firm's innovation performance. This result provides new empirical evidence to research that examines the degree to which firm-performance varies depending on whether the new CEO is from inside or outside the firm. Third, we provide additional support to previous studies on the effects of option compensation and overconfidence on innovation. However, we offer novel results regarding these variables' effects around the time of CEO turnover. In particular, we document that the joint effect of CEO turnover and option compensation on innovation reduces the effects of the individual variables. Finally, we present evidence of the effects

of information asymmetries on innovation, finding a positive association in general and a negative association around the time of CEO turnover. These effects suggest that controlling for the effects of CEO turnover can provide helpful insights on the various determinants of a firm's innovation performance.

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Table 1: Sample statistics

This table provides sample statistics for variables that are used in this paper. Our variables are: The log of patent applications over the next five years that are subsequently approved ($CountsNext5yr$), the log of patent applications over the next three years that are subsequently approved ($CountsNext3yr$), the log of patent citations over the next five years ($CitesNext5yr$), and the log of patent citations over the next three years ($CitesNext3yr$). $CEOTurnover$ is an indicator variable equal to 1 for firm-years for which a new CEO is put in place in that firm year and 0 otherwise, $ForcedTurnover$ equals 1 if the CEO turnover is classified as "forced" and 0 otherwise, $ExternalCEOTurnover$ equals 1 if the CEO has been at the firm for less than one year on appointment as CEO and 0 otherwise, $RD_{t-4,t}$ equals the log of the sum of the firm's annual research and development expense for the previous five years, $RD_{t-2,t}$ equals the log of the sum of the firm's annual research and development expense for the previous three years, $MtoB$ is the market to book value of the firm, $LogAssets$ is the log of the firm's assets, $ExcessReturn_t$ is the market-adjusted stock return for that year, $ExcessReturn_{t-1}$ is the market-adjusted stock return for the previous year, $\Delta Earnings_t$ is equal to $\frac{Income_t}{Sales_{t-1}}$-$\frac{Income_{t-1}}{Sales_{t-2}}$, $\Delta Earnings_{t-1}$ is equal to $\frac{Income_{t-1}}{Sales_{t-2}}$-$\frac{Income_{t-2}}{Sales_{t-3}}$, $DepartingCEOAge$ is the age of the departing CEO, $DepartingCEOAgeDum6465$ equals 1 if the departing CEO is 64 or 65 years old upon departure, and 0 otherwise, $HighOverconfidence$ is a high-optimism overconfidence indicator using option holdings and exercises from Campbell et al. (2010), $OptionComp\%$ is the subsequent year's percentage of the CEO's total compensation paid in stock options, and $\sigma_{CapmResidual}$ is the standard deviation of the firm's beta-adjusted daily returns from the year.

Variable	N	Mean	Median	Standard Deviation	10th Percentile	90th Percentile
$CountsNext5yr$	14,982	1.076	0.000	1.870	0.000	4.174
$CountsNext3yr$	14,982	0.991	0.000	1.757	0.000	3.850
$CitesNext5yr$	14,982	1.514	0.000	2.696	0.000	6.098
$CitesNext3yr$	14,982	1.440	0.000	2.611	0.000	5.929
$CEOTurnover$	14,982	0.086	0.000	0.280	0.000	0.000
$ForcedTurnover$	14,982	0.006	0.000	0.076	0.000	0.000
$ExternalCEOTurnover$	14,982	0.014	0.000	0.119	0.000	0.000
$RD_{t-4,t}$	14,982	2.172	0.000	2.747	0.000	6.227
$RD_{t-2,t}$	14,982	2.033	0.000	2.599	0.000	5.895
$MtoB$	14,982	1.982	1.452	1.826	0.996	3.496
$LogAssets$	14,982	7.992	7.816	1.687	5.988	10.259
$ExcessReturn_t$	14,982	0.058	-0.011	0.572	-0.471	0.560
$ExcessReturn_{t-1}$	14,982	0.100	0.008	0.667	-0.448	0.630
$\Delta Earnings_t$	14,982	0.018	0.001	2.474	-0.092	0.080
$\Delta Earnings_{t-1}$	14,982	0.073	0.002	5.105	-0.090	0.084
$DepartingCEOAge$	14,982	56.6	57.0	7.6	47.0	66.0
$DepartingCEOAgeDum6465$	14,982	0.063	0.000	0.244	0.000	0.000
$HighOverconfidence$	9,470	0.374	0.000	0.484	0.000	1.000
$OptionComp\%$	14,808	0.330	0.295	0.299	0.000	0.749
$\sigma_{CapmResidual}$	14,982	2.435	2.096	1.339	1.142	4.136

Table 2: Determinants of innovation performance

This table provides the results of two-stage least squares regressions for the quantity of innovation. The dependent variables are the log of patent applications over the next five years that are subsequently approved ($CountsNext5yr$), the log of patent applications over the next three years that are subsequently approved ($CountsNext3yr$), the log of patent citations over the next five years ($CitesNext5yr$), and the log of patent citations over the next three years ($CitesNext3yr$). $CEOTurnover$ is an indicator variable equal to 1 for firm-years for which a new CEO is put in place in that firm year and 0 otherwise, $ForcedTurnover$ equals 1 if the CEO turnover is classified as "forced" and 0 otherwise, $ExternalCEOTurnover$ equals 1 if the CEO has been at the firm for less than one year on appointment as CEO and 0 otherwise, $RD_{t-4,t}$ equals the log of the sum of the firm's annual research and development expense for the previous five years, $RD_{t-2,t}$ equals the log of the sum of the firm's annual research and development expense for the previous three years, $MtoB$ is the market to book value of the firm, $LogAssets$ is the log of the firm's assets, $ExcessReturn_t$ is the market-adjusted stock return for that year, $ExcessReturn_{t-1}$ is the market-adjusted stock return for the previous year, $\Delta Earnings_t$ is equal to $\frac{Income_t}{Sales_{t-1}}$-$\frac{Income_{t-1}}{Sales_{t-2}}$, $\Delta Earnings_{t-1}$ is equal to $\frac{Income_{t-1}}{Sales_{t-2}}$-$\frac{Income_{t-2}}{Sales_{t-3}}$. The first stage of the regression models $CEOTurnover$ by regressing it against the independent variables provided in the second-stage regression as well as the CEO's age upon retirement and an indicator variable if the departing CEO is aged 64 or 65. Industry fixed-effects for the 30 Fama-French industry groups are included. Robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

	$CountsNext5yr$	$CountsNext3yr$	$CitesNext5yr$	$CitesNext3yr$
$CEOTurnover$	0.721*	0.686**	1.316**	1.275**
	(0.398)	(0.342)	(0.608)	(0.565)
$ForcedTurnover$	-0.362	-0.371	-0.577	-0.560
	(0.258)	(0.229)	(0.393)	(0.364)
$ExternalCEOTurnover$	-0.812**	-0.752***	-1.436***	-1.381***
	(0.324)	(0.275)	(0.513)	(0.466)
$RD_{t-4,t}$	0.313***		0.374***	
	(0.030)		(0.032)	
$RD_{t-2,t}$		0.339***		0.426***
		(0.033)		(0.037)
$MtoB$	0.063***	0.051***	0.120***	0.109***
	(0.012)	(0.010)	(0.019)	(0.019)
$LogAssets$	0.236***	0.214***	0.260***	0.232***
	(0.057)	(0.053)	(0.064)	(0.058)
$ExcessReturn_t$	-0.074**	-0.052	-0.166***	-0.143***
	(0.037)	(0.032)	(0.056)	(0.053)
$ExcessReturn_{t-1}$	-0.049	-0.036	-0.112	-0.100
	(0.044)	(0.040)	(0.068)	(0.066)
$\Delta Earnings_t$	-0.005**	-0.005**	-0.007**	-0.007**
	(0.002)	(0.002)	(0.004)	(0.003)
$\Delta Earnings_{t-1}$	-0.003***	-0.003***	-0.005***	-0.005***
	(0.000)	(0.000)	(0.000)	(0.000)
$Intercept$	-1.429***	-1.340***	-1.343***	-1.219**
	(0.451)	(0.427)	(0.519)	(0.491)
N	14,982	14,982	14,982	14,982
R^2	42.84%	45.03%	32.29%	34.14%

Table 3: Determinants of innovation performance – additional explanatory variables

This table provides the results of two-stage least squares regressions for the quantity of innovation. The dependent variables are as defined in Table 2. $CEOTurnover$ is an indicator variable equal to 1 for firm-years for which a new CEO is put in place in that firm year and 0 otherwise, $HighOverconfidence$ is a high-optimism overconfidence indicator using option holdings and exercises from Campbell et al. (2010), $OptionComp\%$ is the subsequent year's percentage of the CEO's total compensation paid in stock options, $\sigma_{CapmResidual}$ is the standard deviation of the firm's beta-adjusted daily returns from the year, $ForcedTurnover$ equals 1 if the CEO turnover is classified as "forced" and 0 otherwise, $ExternalCEOTurnover$ equals 1 if the CEO has been at the firm for less than one year on appointment as CEO and 0 otherwise, $RD_{t-4,t}$ equals the log of the sum of the firm's annual research and development expense for the previous five years, $RD_{t-2,t}$ equals the log of the sum of the firm's annual research and development expense for the previous three years, $MtoB$ is the market to book value of the firm, $LogAssets$ is the log of the firm's assets, $ExcessReturn_t$ is the market-adjusted stock return for that year, $ExcessReturn_{t-1}$ is the market-adjusted stock return for the previous year, $\Delta Earnings_t$ is equal to $\frac{Income_t}{Sales_{t-1}}$-$\frac{Income_{t-1}}{Sales_{t-2}}$. The first stage of the regression models $CEOTurnover$ by regressing it against the independent variables provided in the second-stage regression as well as the CEO's age upon retirement and an indicator variable if the departing CEO is aged 64 or 65. Industry fixed-effects for the 30 Fama-French industry groups are included. Robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

	$CountsNext5yr$	$CountsNext3yr$	$CitesNext5yr$	$CitesNext3yr$
$CEOTurnover$	0.977**	0.948**	1.543**	1.526**
	(0.489)	(0.444)	(0.646)	(0.611)
$HighOverconfidence$	0.213**	0.196**	0.337**	0.338**
	(0.100)	(0.095)	(0.138)	(0.136)
$OptionComp\%$	0.251**	0.229**	0.401***	0.377***
	(0.103)	(0.101)	(0.144)	(0.142)
$\sigma_{CapmResidual}$	0.038	0.048	0.026	0.037
	(0.034)	(0.033)	(0.052)	(0.050)
$ForcedTurnover$	-0.382	-0.407	-0.521	-0.522
	(0.349)	(0.313)	(0.588)	(0.557)
$ExternalCEOTurnover$	-0.905**	-0.867***	-1.339***	-1.298***
	(0.365)	(0.331)	(0.503)	(0.481)
$RD_{t-4,t}$	0.304***		0.357***	
	(0.037)		(0.042)	
$RD_{t-2,t}$		0.329***		0.407***
		(0.041)		(0.050)
$MtoB$	0.052***	0.040***	0.110***	0.099***
	(0.015)	(0.014)	(0.021)	(0.020)
$LogAssets$	0.233***	0.217***	0.237***	0.215***
	(0.063)	(0.059)	(0.072)	(0.066)
$ExcessReturn_t$	-0.099**	-0.073*	-0.219***	-0.194***
	(0.050)	(0.043)	(0.074)	(0.071)
$ExcessReturn_{t-1}$	-0.084**	-0.067*	-0.162**	-0.146**
	(0.040)	(0.035)	(0.068)	(0.064)
$\Delta Earnings_t$	-0.006**	-0.006**	-0.009**	-0.009**
	(0.002)	(0.002)	(0.004)	(0.004)
$\Delta Earnings_{t-1}$	-0.003***	-0.002***	-0.004***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
$Intercept$	-1.639***	-1.594***	-1.476**	-1.402**
	(0.620)	(0.594)	(0.750)	(0.714)
N	9,374	9,374	9,374	9,374
R^2	41.72%	43.86%	30.96%	32.65%

Table 4: Determinants of innovation performance – sensitivity of CEO turnover-innovation relation

This table provides the sensitivity of the relation between CEO turnover and innovation to variables used in Table 3. Additionally, this table is the result of the second-stage of two-stage least squares regressions as performed in Table 3. Industry fixed-effects for the 30 Fama-French industry groups are included. Robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

	$CountsNext5yr$	$CountsNext3yr$	$CitesNext5yr$	$CitesNext3yr$
$CEOTurnover$	3.688**	3.573**	3.688**	3.811**
	(1.811)	(1.673)	(1.811)	(1.800)
$HighOverconfidence$	0.186**	0.172**	0.186**	0.187**
	(0.087)	(0.084)	(0.087)	(0.088)
$HighOverconfidence$	-0.250	-0.306	-0.250	-0.263
$\times CEOTurnover$	(0.326)	(0.311)	(0.326)	(0.330)
$OptionComp\%$	0.420***	0.389***	0.420***	0.411***
	(0.155)	(0.150)	(0.155)	(0.154)
$OptionComp\%$	-1.940**	-1.848**	-1.940**	-1.999**
$\times CEOTurnover$	(0.892)	(0.830)	(0.892)	(0.879)
$\sigma_{CapmResidual}$	0.119**	0.126**	0.119**	0.117**
	(0.057)	(0.054)	(0.057)	(0.055)
$\sigma_{CapmResidual}$	-0.876**	-0.848**	-0.876**	-0.906**
$\times CEOTurnover$	(0.420)	(0.386)	(0.420)	(0.419)
$ForcedTurnover$	0.161	0.121	0.161	0.150
	(0.234)	(0.219)	(0.234)	(0.237)
$ExternalCEOTurnover$	-0.438**	-0.425**	-0.438**	-0.452**
	(0.192)	(0.178)	(0.192)	(0.194)
$RD_{t-4,t}$	0.307***		0.307***	
	(0.037)		(0.037)	
$RD_{t-2,t}$		0.331***		0.342***
		(0.042)		(0.043)
$MtoB$	0.050***	0.038**	0.050***	0.045***
	(0.017)	(0.016)	(0.017)	(0.017)
$LogAssets$	0.240***	0.224***	0.240***	0.228***
	(0.063)	(0.060)	(0.063)	(0.059)
$ExcessReturn_t$	-0.110**	-0.084**	-0.110**	-0.101**
	(0.047)	(0.040)	(0.047)	(0.047)
$ExcessReturn_{t-1}$	-0.079	-0.062	-0.079	-0.076
	(0.048)	(0.043)	(0.048)	(0.048)
$\Delta Earnings_t$	-0.005***	-0.004**	-0.005***	-0.004**
	(0.002)	(0.002)	(0.002)	(0.002)
$\Delta Earnings_{t-1}$	-0.002	-0.001	-0.002	-0.001
	(0.002)	(0.002)	(0.002)	(0.002)
$Intercept$	-1.973***	-1.918***	-1.973***	-1.903***
	(0.708)	(0.675)	(0.708)	(0.678)
N	9,374	9,374	9,374	9,374
R^2	37.76%	39.68%	37.76%	38.21%

Table 5: Determinants of innovation productivity and influence

This table provides the results of the second-stage of two-stage least squares regressions as performed in Table 3. All variables are as defined in Table 3 with the exception of the dependent variables, innovation productivity and innovation influence. Innovation productivity is defined as $5yrProductivity = CountsNext5yr - ln(RD_{t+1} + RD_{t+2} + RD_{t+3} + RD_{t+4} + RD_{t+5})$ and $3yrProductivity = CountsNext3yr - ln(RD_{t+1} + RD_{t+2} + RD_{t+3})$. Innovation influence is defined as $5yrInfluence = CitesNext5yr - CountsNext5yr$ and $3yrInfluence = CitesNext3yr - CountsNext3yr$. Innovation-productivity regressions only include observations with non-zero cumulative research and development expenditure. Industry fixed-effects for the 30 Fama-French industry groups are included. Robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

	$5yrProductivity$	$3yrProductivity$	$5yrInfluence$	$3yrInfluence$
$CEOTurnover$	1.527*	1.644**	0.566**	0.578***
	(0.915)	(0.826)	(0.222)	(0.219)
$HighOverconfidence$	0.132***	0.125***	-0.012	-0.011
	(0.039)	(0.036)	(0.020)	(0.019)
$OptionComp\%$	0.435**	0.438**	0.124***	0.142***
	(0.179)	(0.175)	(0.045)	(0.046)
$\sigma_{CapmResidual}$	0.442**	0.384**	0.150***	0.148***
	(0.179)	(0.170)	(0.051)	(0.052)
$ForcedTurnover$	-0.561	-0.676	-0.139	-0.115
	(0.502)	(0.437)	(0.285)	(0.290)
$ExternalCEOTurnover$	-1.245*	-1.334**	-0.434**	-0.431**
	(0.653)	(0.588)	(0.219)	(0.211)
$RD_{t-4,t}$	-0.741***		0.053***	
	(0.068)		(0.011)	
$RD_{t-2,t}$		-0.588***		0.078***
		(0.067)		(0.012)
$MtoB$	0.032	0.033	0.058***	0.058***
	(0.031)	(0.026)	(0.008)	(0.009)
$LogAssets$	0.419***	0.285***	0.004	-0.002
	(0.108)	(0.094)	(0.021)	(0.020)
$ExcessReturn_t$	-0.106	-0.057	-0.120***	-0.121***
	(0.065)	(0.056)	(0.027)	(0.030)
$ExcessReturn_{t-1}$	-0.092**	-0.056*	-0.078***	-0.079***
	(0.039)	(0.032)	(0.029)	(0.030)
$\Delta Earnings_t$	-0.004**	-0.003**	-0.003**	-0.003**
	(0.001)	(0.002)	(0.001)	(0.001)
$\Delta Earnings_{t-1}$	-0.002	-0.001	-0.002***	-0.002***
	(0.002)	(0.001)	(0.000)	(0.000)
$Intercept$	-3.295***	-2.907***	0.164	0.192
	(0.805)	(0.771)	(0.190)	(0.191)
N	4,405	4,363	9,374	9,374
R^2	20.94%	17.53%	8.13%	9.60%

Table 6: Determinants of innovation productivity and influence – sensitivity of CEO turnover-innovation relation

This table provides the results of the second-stage of two-stage least squares regressions as performed in Table 3. All variables are as defined in Table 5. Innovation-productivity regressions only include observations with non-zero cumulative research and development expenditure. Industry fixed-effects for the 30 Fama-French industry groups are included. Robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

	$5yrProductivity$	$3yrProductivity$	$5yrInfluence$	$3yrInfluence$
$CEOTurnover$	5.514	5.998*	2.206***	2.183***
	(3.435)	(3.174)	(0.796)	(0.803)
$HighOverconfidence$	0.376***	0.375***	0.096**	0.113***
	(0.136)	(0.135)	(0.039)	(0.040)
$HighOverconfidence$	-0.183	-0.311	-0.014	0.017
$\times CEOTurnover$	(0.436)	(0.457)	(0.199)	(0.203)
$OptionComp\%$	0.707***	0.676***	0.277***	0.273***
	(0.270)	(0.252)	(0.065)	(0.070)
$OptionComp\%$	-3.653	-4.036*	-1.436***	-1.404***
$\times CEOTurnover$	(2.300)	(2.089)	(0.392)	(0.406)
$\sigma_{CapmResidual}$	0.243***	0.246***	0.036*	0.036*
	(0.076)	(0.069)	(0.021)	(0.022)
$\sigma_{CapmResidual}$	-1.022	-1.108*	-0.518**	-0.513***
$\times CEOTurnover$	(0.633)	(0.582)	(0.202)	(0.198)
$ForcedTurnover$	-0.419	-0.535	0.197	0.222
	(0.503)	(0.494)	(0.202)	(0.210)
$ExternalCEOTurnover$	-0.648*	-0.655*	-0.097	-0.086
	(0.377)	(0.357)	(0.131)	(0.134)
$RD_{t-4,t}$	-0.736***		0.055***	
	(0.070)		(0.011)	
$RD_{t-2,t}$		-0.589***		0.079***
		(0.069)		(0.012)
$MtoB$	0.029	0.029	0.056***	0.057***
	(0.032)	(0.028)	(0.007)	(0.008)
$LogAssets$	0.434***	0.308***	0.008	0.003
	(0.105)	(0.090)	(0.019)	(0.019)
$ExcessReturn_t$	-0.123**	-0.076*	-0.127***	-0.128***
	(0.056)	(0.046)	(0.026)	(0.029)
$ExcessReturn_{t-1}$	-0.099**	-0.065	-0.075**	-0.076**
	(0.050)	(0.045)	(0.032)	(0.033)
$\Delta Earnings_t$	-0.003	-0.002	-0.002*	-0.002**
	(0.002)	(0.002)	(0.001)	(0.001)
$\Delta Earnings_{t-1}$	-0.001	-0.001	-0.001	-0.001
	(0.002)	(0.002)	(0.001)	(0.001)
$Intercept$	-3.884***	-3.570***	-0.038	-0.006
	(1.041)	(0.982)	(0.196)	(0.203)
N	4,405	4,363	9,374	9,374
R^2	14.48%	8.42%	4.17%	5.97%

Table 7: Determinants of changes in innovation performance

This table provides the results of two-stage least squares regressions for the quantity of innovation as in Table 3. The dependent variables are defined as *changes* in innovation performance $\Delta CountsNext5yr$ and $\Delta CitesNext5yr$ ($\Delta CountsNext3yr$ and $\Delta CitesNext3yr$) defined as the change in the value compared to the previous five (three) years: $\Delta CountsNext5yr_t = CountsNext5yr_t - CountsNext5yr_{t-5}$, $\Delta CountsNext3yr_t = CountsNext3yr_t - CountsNext3yr_{t-3}$, $\Delta CitesNext5yr_t = CitesNext5yr_t - CitesNext5yr_{t-5}$, $\Delta CitesNext3yr_t = CitesNext3yr_t - CitesNext3yr_{t-3}$. All other variables are as defined in Table 3. Industry fixed-effects for the 30 Fama-French industry groups are included and robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

	$\Delta CountsNext5yr$	$\Delta CountsNext3yr$	$\Delta CitesNext5yr$	$\Delta CitesNext3yr$
$CEOTurnover$	1.067***	0.852***	0.919**	1.477***
	(0.410)	(0.311)	(0.438)	(0.510)
$HighOverconfidence$	0.391***	0.275***	0.259**	0.347***
	(0.108)	(0.077)	(0.105)	(0.105)
$OptionComp\%$	0.180*	0.155**	0.036	0.107
	(0.108)	(0.068)	(0.084)	(0.084)
$\sigma_{CapmResidual}$	0.166***	0.039	0.063	-0.028
	(0.043)	(0.032)	(0.040)	(0.038)
$ForcedTurnover$	-0.134	-0.092	-0.239	-0.304
	(0.357)	(0.247)	(0.476)	(0.514)
$ExternalCEOTurnover$	-1.074***	-0.682***	-1.035**	-1.223***
	(0.363)	(0.234)	(0.425)	(0.388)
$RD_{t-4,t}$	-0.224***		-0.265***	
	(0.019)		(0.021)	
$RD_{t-2,t}$		-0.137***		-0.238***
		(0.013)		(0.019)
$MtoB$	0.093***	0.064***	0.076***	0.077***
	(0.022)	(0.014)	(0.029)	(0.024)
$LogAssets$	-0.057**	-0.059***	-0.127***	-0.119***
	(0.025)	(0.019)	(0.030)	(0.030)
$ExcessReturn_t$	-0.046	-0.051**	0.019	-0.093**
	(0.049)	(0.023)	(0.034)	(0.041)
$ExcessReturn_{t-1}$	-0.067**	-0.008	0.054	0.007
	(0.028)	(0.028)	(0.036)	(0.049)
$\Delta Earnings_t$	-0.000	0.000	0.003	-0.000
	(0.001)	(0.001)	(0.002)	(0.002)
$\Delta Earnings_{t-1}$	-0.003*	-0.002	-0.008***	-0.009**
	(0.002)	(0.002)	(0.003)	(0.004)
$Intercept$	-0.664**	-0.047	-0.136	0.153
	(0.327)	(0.209)	(0.289)	(0.273)
N	5,140	7,111	5,140	7,111
R^2	31.73%	13.71%	30.84%	14.54%

Table 8: Determinants of changes in innovation productivity and influence

This table provides the results of the second-stage of two-stage least squares regressions as performed in Table 3. The dependent variables are defined as *changes* in innovation productivity $\Delta 5yrProductivity$ and influence $\Delta 5yrInfluence$ ($\Delta 3yrProductivity$ and $\Delta 3yrInfluence$) defined as the change in the value compared to the previous five (three) years: $\Delta 5yrProductivity_t = 5yrProductivity_t - 5yrProductivity_{t-5}$, $\Delta 3yrProductivity_t = 3yrProductivity_t - 3yrProductivity_{t-3}$, $\Delta 5yrInfluence_t = 5yrInfluence_t - 5yrInfluence_{t-5}$, $\Delta 3yrInfluence_t = 3yrInfluence_t - 3yrInfluence_{t-3}$. As in Table 5, we define: $5yrProductivity = CountsNext5yr - ln(RD_{t+1} + RD_{t+2} + RD_{t+3} + RD_{t+4} + RD_{t+5})$, $3yrProductivity = CountsNext3yr - ln(RD_{t+1} + RD_{t+2} + RD_{t+3})$, $5yrInfluence = CitesNext5yr - CountsNext5yr$, and $3yrInfluence = CitesNext3yr - CountsNext3yr$. All other variables are as defined in Table 3. Innovation-productivity regressions only include observations with non-zero cumulative research and development expenditure. Industry fixed-effects for the 30 Fama-French industry groups are included and robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

	$\Delta 5yrProductivity$	$\Delta 3yrProductivity$	$\Delta 5yrInfluence$	$\Delta 3yrInfluence$
$CEOTurnover$	2.782***	2.267***	0.274	0.626**
	(0.852)	(0.596)	(0.274)	(0.286)
$HighOverconfidence$	0.662***	0.403***	0.005	0.072*
	(0.121)	(0.102)	(0.044)	(0.040)
$OptionComp\%$	-0.128	-0.008	-0.061	-0.048
	(0.185)	(0.148)	(0.055)	(0.039)
$\sigma_{CapmResidual}$	0.157***	0.014	-0.040**	-0.066***
	(0.053)	(0.052)	(0.018)	(0.014)
$ForcedTurnover$	-1.414**	-0.539	-0.073	-0.212
	(0.552)	(0.421)	(0.434)	(0.372)
$ExternalCEOTurnover$	-2.328***	-1.777***	-0.339	-0.541**
	(0.731)	(0.492)	(0.248)	(0.224)
$RD_{t-4,t}$	-0.327***		-0.095***	
	(0.055)		(0.011)	
$RD_{t-2,t}$		-0.185***		-0.101***
		(0.035)		(0.010)
$MtoB$	0.024	0.038	0.016	0.013
	(0.042)	(0.026)	(0.016)	(0.013)
$LogAssets$	0.049	-0.049	-0.058***	-0.060***
	(0.065)	(0.052)	(0.016)	(0.015)
$ExcessReturn_t$	0.084	0.073	0.004	-0.042*
	(0.062)	(0.051)	(0.023)	(0.024)
$ExcessReturn_{t-1}$	0.029	0.116***	0.035*	0.015
	(0.044)	(0.031)	(0.018)	(0.023)
$\Delta Earnings_t$	0.002	0.002	0.000	-0.001
	(0.004)	(0.003)	(0.001)	(0.001)
$\Delta Earnings_{t-1}$	-0.004	-0.001	-0.007***	-0.007***
	(0.004)	(0.002)	(0.002)	(0.002)
$Intercept$	-1.965***	-0.339	0.084	0.201*
	(0.467)	(0.434)	(0.135)	(0.108)
N	2,383	3,295	5,140	7,111
R^2	2.21%	-2.79%	14.75%	9.56%

Table 9: Determinants of innovation performance – robustness to new CEOs' expected tenure

This table provides the results of two-stage least squares regressions for the quantity of innovation as in Table 3. All variables are as defined in Table 3, with the exception of $DepCEOTenure$ in Panel A (defined as the natural log of the previous CEO's tenure, interacted with $CEOTurnover$). Panel B replicates our tests in Table 3 with a sample that excludes firm-years in which new CEOs depart within the subsequent two years. Industry fixed-effects for the 30 Fama-French industry groups are included and robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

Panel A: Including variable for prior CEO's tenure

	$CountsNext5yr$	$CountsNext3yr$	$CitesNext5yr$	$CitesNext3yr$
$CEOTurnover$	4.246**	4.100**	6.815**	6.698**
	(2.033)	(1.853)	(2.749)	(2.614)
$HighOverconfidence$	0.218**	0.201**	0.344**	0.344***
	(0.098)	(0.093)	(0.135)	(0.132)
$OptionComp\%$	0.269**	0.247**	0.431***	0.407***
	(0.109)	(0.106)	(0.151)	(0.150)
$\sigma_{CapmResidual}$	0.031	0.041	0.015	0.025
	(0.033)	(0.032)	(0.051)	(0.049)
$ForcedTurnover$	-1.362*	-1.352*	-2.096*	-2.065**
	(0.778)	(0.712)	(1.111)	(1.043)
$ExternalCEOTurnover$	-1.141***	-1.094***	-1.703***	-1.651***
	(0.438)	(0.400)	(0.623)	(0.597)
$DepCEOTenure$	-1.654**	-1.596**	-2.679**	-2.631***
	(0.793)	(0.723)	(1.069)	(1.017)
$RD_{t-4,t}$	0.301***		0.352***	
	(0.035)		(0.040)	
$RD_{t-2,t}$		0.326***		0.401***
		(0.040)		(0.048)
$MtoB$	0.058***	0.046***	0.119***	0.108***
	(0.014)	(0.014)	(0.022)	(0.021)
$LogAssets$	0.238***	0.222***	0.245***	0.224***
	(0.063)	(0.059)	(0.072)	(0.065)
$ExcessReturn_t$	-0.111**	-0.085*	-0.238***	-0.213***
	(0.050)	(0.043)	(0.076)	(0.072)
$ExcessReturn_{t-1}$	-0.084**	-0.067**	-0.163**	-0.146**
	(0.038)	(0.034)	(0.064)	(0.061)
$\Delta Earnings_t$	-0.007**	-0.006**	-0.010**	-0.009**
	(0.003)	(0.003)	(0.005)	(0.004)
$\Delta Earnings_{t-1}$	-0.003***	-0.003***	-0.006***	-0.005***
	(0.001)	(0.000)	(0.001)	(0.001)
$Intercept$	-1.755***	-1.705***	-1.661**	-1.583**
	(0.646)	(0.617)	(0.773)	(0.737)
N	9,374	9,374	9,374	9,374
R^2	35.11%	36.92%	22.60%	24.18%

Panel B: Omitting new CEOs who depart within the subsequent two years

	$CountsNext5yr$	$CountsNext3yr$	$CitesNext5yr$	$CitesNext3yr$
$CEOTurnover$	0.971*	0.937**	1.519**	1.493**
	(0.507)	(0.459)	(0.669)	(0.632)
$HighOverconfidence$	0.200**	0.183**	0.317**	0.317**
	(0.093)	(0.089)	(0.129)	(0.127)
$OptionComp\%$	0.247**	0.225**	0.396***	0.371**
	(0.107)	(0.104)	(0.148)	(0.146)
$\sigma_{CapmResidual}$	0.040	0.050	0.030	0.041
	(0.035)	(0.034)	(0.052)	(0.050)
$ForcedTurnover$	-0.573	-0.602*	-0.760	-0.762
	(0.389)	(0.357)	(0.628)	(0.597)
$ExternalCEOTurnover$	-0.857**	-0.817**	-1.253**	-1.206**
	(0.386)	(0.349)	(0.540)	(0.517)
$RD_{t-4,t}$	0.302***		0.355***	
	(0.036)		(0.042)	
$RD_{t-2,t}$		0.327***		0.404***
		(0.041)		(0.049)
$MtoB$	0.052***	0.040***	0.110***	0.099***
	(0.015)	(0.014)	(0.021)	(0.020)
$LogAssets$	0.235***	0.219***	0.240***	0.218***
	(0.064)	(0.060)	(0.074)	(0.067)
$ExcessReturn_t$	-0.100**	-0.074*	-0.221***	-0.196***
	(0.049)	(0.043)	(0.074)	(0.071)
$ExcessReturn_{t-1}$	-0.081*	-0.065	-0.160**	-0.145**
	(0.045)	(0.040)	(0.073)	(0.069)
$\Delta Earnings_t$	-0.006***	-0.006**	-0.009**	-0.009**
	(0.002)	(0.002)	(0.004)	(0.004)
$\Delta Earnings_{t-1}$	-0.003***	-0.003***	-0.005***	-0.004***
	(0.001)	(0.001)	(0.001)	(0.001)
$Intercept$	-1.664***	-1.617***	-1.501**	-1.426**
	(0.621)	(0.596)	(0.749)	(0.713)
N	9,285	9,285	9,285	9,285
R^2	41.69%	43.84%	30.96%	32.66%

Table 10: Determinants of innovation productivity and influence – robustness to new CEOs' expected tenure

This table provides the results of two-stage least squares regressions for the quantity of innovation as in Table 3. All variables are as defined in Table 5, with the exception of $DepCEOTenure$ in Panel A (defined as the natural log of the previous CEO's tenure, interacted with $CEOTurnover$). Panel B replicates our tests in Table 5 with a sample that excludes firm-years in which new CEOs depart within the subsequent two years. Innovation-productivity regressions only include observations with non-zero cumulative research and development expenditure. Industry fixed-effects for the 30 Fama-French industry groups are included and robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

Panel A: Including variable for prior CEO's tenure

	$5yrProductivity$	$3yrProductivity$	$5yrInfluence$	$3yrInfluence$
$CEOTurnover$	6.430*	7.270**	2.568***	2.599***
	(3.504)	(3.206)	(0.977)	(0.960)
$HighOverconfidence$	0.418**	0.420***	0.126***	0.143***
	(0.165)	(0.161)	(0.044)	(0.045)
$OptionComp\%$	0.431**	0.367*	0.162***	0.160***
	(0.201)	(0.196)	(0.052)	(0.054)
$\sigma_{CapmResidual}$	0.117***	0.109**	-0.016	-0.015
	(0.045)	(0.043)	(0.020)	(0.019)
$ForcedTurnover$	-2.321*	-2.747**	-0.733	-0.713
	(1.388)	(1.335)	(0.448)	(0.437)
$ExternalCEOTurnover$	-1.403**	-1.482***	-0.562**	-0.557**
	(0.638)	(0.575)	(0.275)	(0.262)
$DepCEOTenure$	-2.569*	-2.919**	-1.024***	-1.036***
	(1.412)	(1.289)	(0.379)	(0.373)
$RD_{t-4,t}$	-0.740***		0.051***	
	(0.073)		(0.010)	
$RD_{t-2,t}$		-0.601***		0.076***
		(0.067)		(0.012)
$MtoB$	0.041	0.041	0.061***	0.062***
	(0.030)	(0.027)	(0.009)	(0.009)
$LogAssets$	0.421***	0.300***	0.007	0.002
	(0.117)	(0.104)	(0.021)	(0.020)
$ExcessReturn_t$	-0.127*	-0.083	-0.127***	-0.128***
	(0.066)	(0.059)	(0.028)	(0.030)
$ExcessReturn_{t-1}$	-0.091**	-0.056*	-0.078***	-0.079***
	(0.039)	(0.032)	(0.028)	(0.029)
$\Delta Earnings_t$	-0.004***	-0.004**	-0.003*	-0.003**
	(0.002)	(0.002)	(0.002)	(0.002)
$\Delta Earnings_{t-1}$	-0.003***	-0.003***	-0.002***	-0.002***
	(0.001)	(0.000)	(0.000)	(0.000)
$Intercept$	-3.499***	-3.184***	0.094	0.122
	(0.887)	(0.845)	(0.186)	(0.189)
N	4,405	4,363	9,374	9,374
R^2	9.95%	0.10%	0.65%	2.51%

Panel B: Omitting new CEOs who depart within the subsequent two years

	$5yrProductivity$	$3yrProductivity$	$5yrInfluence$	$3yrInfluence$
$CEOTurnover$	1.475	1.620*	0.548**	0.556**
	(0.933)	(0.831)	(0.237)	(0.233)
$HighOverconfidence$	0.414**	0.418***	0.117***	0.134***
	(0.164)	(0.157)	(0.043)	(0.044)
$OptionComp\%$	0.446**	0.389**	0.149***	0.146***
	(0.183)	(0.174)	(0.052)	(0.053)
$\sigma_{CapmResidual}$	0.134***	0.128***	-0.010	-0.009
	(0.039)	(0.036)	(0.019)	(0.019)
$ForcedTurnover$	-0.673	-0.818*	-0.188	-0.159
	(0.546)	(0.485)	(0.305)	(0.315)
$ExternalCEOTurnover$	-1.208*	-1.317**	-0.396	-0.390*
	(0.694)	(0.615)	(0.242)	(0.233)
$RD_{t-4,t}$	-0.740***		0.052***	
	(0.067)		(0.011)	
$RD_{t-2,t}$		-0.588***		0.077***
		(0.066)		(0.012)
$MtoB$	0.031	0.033	0.058***	0.059***
	(0.031)	(0.027)	(0.008)	(0.009)
$LogAssets$	0.419***	0.286***	0.005	-0.001
	(0.107)	(0.094)	(0.021)	(0.020)
$ExcessReturn_t$	-0.108*	-0.060	-0.121***	-0.122***
	(0.063)	(0.053)	(0.026)	(0.030)
$ExcessReturn_{t-1}$	-0.086*	-0.050	-0.079***	-0.080**
	(0.044)	(0.037)	(0.030)	(0.032)
$\Delta Earnings_t$	-0.004***	-0.003**	-0.003**	-0.003**
	(0.001)	(0.002)	(0.001)	(0.001)
$\Delta Earnings_{t-1}$	-0.002	-0.001	-0.002***	-0.002***
	(0.002)	(0.001)	(0.000)	(0.000)
$Intercept$	-3.307***	-2.921***	0.163	0.191
	(0.796)	(0.762)	(0.189)	(0.190)
N	4,360	4,319	9,285	9,285
R^2	21.18%	17.80%	8.24%	9.69%

Table 11: Determinants of innovation performance – robustness to timing of innovation decisions

This table provides the results of two-stage least squares regressions for the quantity of innovation as in Table 3. In Panel A, the variables are as defined in Table 3, although the value in the following year is used, instead of the contemporaneous value. In Panel B, the variables are as defined in Table 3 with the exception of the dependent variables – the log of patent applications over the year that are subsequently approved over the next year (*Counts*) and the log of patent citations over the next year (*Cites*). Industry fixed-effects for the 30 Fama-French industry groups are included. Robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

Panel A: Using subsequent cumulative innovation performance

	$CountsNext5yr_{+1}$	$CountsNext3yr_{+1}$	$CitesNext5yr_{+1}$	$CitesNext3yr_{+1}$
$CEOTurnover$	0.939*	0.963**	1.267**	1.352**
	(0.482)	(0.439)	(0.633)	(0.591)
$HighOverconfidence$	0.256**	0.247**	0.339**	0.350**
	(0.111)	(0.106)	(0.146)	(0.142)
$OptionComp\%$	0.264***	0.251***	0.361***	0.343***
	(0.096)	(0.095)	(0.124)	(0.125)
$\sigma_{CapmResidual}$	-0.005	0.009	-0.067*	-0.058*
	(0.029)	(0.029)	(0.035)	(0.033)
$ForcedTurnover$	-0.387	-0.468	-0.544	-0.684
	(0.374)	(0.344)	(0.593)	(0.557)
$ExternalCEOTurnover$	-0.901**	-0.914***	-1.148**	-1.247***
	(0.359)	(0.329)	(0.494)	(0.458)
$RD_{t-4,t}$	0.270***		0.312***	
	(0.031)		(0.034)	
$RD_{t-2,t}$		0.297***		0.364***
		(0.036)		(0.041)
$MtoB$	0.060***	0.052***	0.113***	0.104***
	(0.017)	(0.016)	(0.023)	(0.022)
$LogAssets$	0.182***	0.168***	0.165***	0.143***
	(0.054)	(0.050)	(0.058)	(0.052)
$ExcessReturn_t$	-0.120**	-0.096*	-0.237***	-0.210**
	(0.058)	(0.054)	(0.091)	(0.089)
$ExcessReturn_{t-1}$	-0.099**	-0.090**	-0.156**	-0.145**
	(0.044)	(0.042)	(0.071)	(0.069)
$\Delta Earnings_t$	-0.004	-0.004	-0.005	-0.005
	(0.004)	(0.003)	(0.005)	(0.005)
$\Delta Earnings_{t-1}$	-0.003*	-0.003*	-0.004**	-0.004**
	(0.001)	(0.001)	(0.002)	(0.002)
$Intercept$	-1.284**	-1.268**	-0.916	-0.849
	(0.547)	(0.524)	(0.598)	(0.566)
N	8,516	8,516	8,516	8,516
R^2	35.95%	37.84%	26.87%	28.15%

Panel B: Contemporaneous values for innovation performance

	$Counts$	$Cites$
$CEOTurnover$	0.636**	1.125**
	(0.320)	(0.507)
$HighOverconfidence$	0.163**	0.324**
	(0.080)	(0.134)
$OptionComp\%$	0.175*	0.330***
	(0.091)	(0.122)
$\sigma_{CapmResidual}$	0.075**	0.112*
	(0.035)	(0.062)
$ForcedTurnover$	-0.342*	-0.558
	(0.189)	(0.357)
$ExternalCEOTurnover$	-0.604**	-0.925**
	(0.246)	(0.397)
RD_t	0.319***	0.413***
	(0.043)	(0.055)
$MtoB$	0.027**	0.086***
	(0.012)	(0.018)
$LogAssets$	0.181***	0.200***
	(0.053)	(0.066)
$ExcessReturn_t$	-0.083***	-0.213***
	(0.019)	(0.041)
$ExcessReturn_{t-1}$	-0.064***	-0.144***
	(0.018)	(0.042)
$\Delta Earnings_t$	-0.002	-0.003
	(0.002)	(0.003)
$\Delta Earnings_{t-1}$	-0.002**	-0.003***
	(0.001)	(0.001)
$Intercept$	-1.496***	-1.667**
	(0.541)	(0.748)
N	9,374	9,374
R^2	42.57%	31.78%

Table 12: Determinants of innovation productivity and influence – robustness to timing of innovation decisions

This table provides the results of the second-stage of two-stage least squares regressions as performed in Table 3. In Panel A, the variables are as defined in Table 5, although the value in the following year is used, instead of the contemporaneous value. In Panel B, the variables are as defined in Table 5 with the exception of the dependent variables – the log of patent applications over the year that are subsequently approved over the next year less that year's R&D expense ($Productivity$) and the log of patent citations over the next year less the log of patent applications over the year that are subsequently approved over the next year ($Influence$). Innovation-productivity regressions only include observations with non-zero cumulative research and development expenditure. Industry fixed-effects for the 30 Fama-French industry groups are included. Robust industry-clustered standard errors are provided in parentheses below the coefficient value. *, **, and *** denote significant differences from zero at the 10%, 5% and 1% levels respectively.

Panel A: Using subsequent cumulative innovation performance

	$5yrProductivity_{+1}$	$3yrProductivity_{+1}$	$5yrInfluence_{+1}$	$3yrInfluence_{+1}$
$CEOTurnover$	1.628*	1.764**	0.327	0.389*
	(0.870)	(0.795)	(0.225)	(0.222)
$HighOverconfidence$	0.475**	0.479**	0.083**	0.103**
	(0.192)	(0.188)	(0.042)	(0.043)
$OptionComp\%$	0.405**	0.361**	0.097**	0.091*
	(0.177)	(0.173)	(0.046)	(0.047)
$\sigma_{CapmResidual}$	0.065*	0.075**	-0.062***	-0.068***
	(0.037)	(0.036)	(0.010)	(0.010)
$ForcedTurnover$	-0.659	-0.821*	-0.157	-0.216
	(0.556)	(0.493)	(0.273)	(0.258)
$ExternalCEOTurnover$	-1.376**	-1.475***	-0.247	-0.333
	(0.621)	(0.565)	(0.225)	(0.231)
$RD_{t-4,t}$	-0.763***		0.042***	
	(0.055)		(0.009)	
$RD_{t-2,t}$		-0.617***		0.066***
		(0.052)		(0.010)
$MtoB$	0.031	0.034	0.053***	0.052***
	(0.031)	(0.028)	(0.008)	(0.008)
$LogAssets$	0.337***	0.207**	-0.017	-0.025
	(0.100)	(0.083)	(0.018)	(0.019)
$ExcessReturn_t$	-0.136*	-0.097	-0.117***	-0.114***
	(0.081)	(0.077)	(0.034)	(0.036)
$ExcessReturn_{t-1}$	-0.129***	-0.118***	-0.057**	-0.055**
	(0.045)	(0.045)	(0.027)	(0.028)
$\Delta Earnings_t$	-0.002	-0.001	-0.001	-0.001
	(0.003)	(0.002)	(0.002)	(0.002)
$\Delta Earnings_{t-1}$	-0.001	-0.001	-0.001***	-0.001***
	(0.002)	(0.002)	(0.001)	(0.001)
$Intercept$	-2.896***	-2.480***	0.367**	0.419***
	(0.787)	(0.752)	(0.148)	(0.161)
N	4,003	3,966	8,516	8,516
R^2	21.77%	17.95%	7.38%	8.22%

Panel B: Contemporaneous values for innovation performance

	$Productivity$	$Influence$
$CEOTurnover$	0.478	0.489**
	(0.299)	(0.206)
$HighOverconfidence$	0.058	0.162***
	(0.046)	(0.058)
$OptionComp\%$	0.070	0.155***
	(0.062)	(0.044)
$\sigma_{CapmResidual}$	-0.005	0.038
	(0.013)	(0.028)
$ForcedTurnover$	-0.222	-0.216
	(0.260)	(0.191)
$ExternalCEOTurnover$	-0.384	-0.321*
	(0.287)	(0.180)
RD_t		0.094***
		(0.015)
$MtoB$	0.042	0.059***
	(0.030)	(0.008)
$LogAssets$	0.092***	0.019
	(0.025)	(0.021)
$ExcessReturn_t$	-0.103***	-0.131***
	(0.032)	(0.024)
$ExcessReturn_{t-1}$	-0.096***	-0.081***
	(0.029)	(0.026)
$\Delta Earnings_t$	0.001	-0.001
	(0.040)	(0.002)
$\Delta Earnings_{t-1}$	0.040	-0.002***
	(0.059)	(0.000)
$Intercept$	-0.259	-0.171
	(0.244)	(0.243)
N	5,074	9,374
R^2	13.43%	10.90%