BJM BRITISH JOURNAL OF MANAGEMENT
British Academy of Management

*British Journal of Management, Vol. 00, 1–22 (2018)*
DOI: 10.1111/1467-8551.12330

# CEO Incentives, Takeover Protection and Corporate Innovation

Khelifa Mazouz and Yang Zhao[1]

Cardiff Business School, Aberconway Building, Colum Drive, Cardiff, CF10 3EU, UK, and [1]Newcastle University Business School, 5 Barrack Rd, Newcastle-upon-Tyne NE1 4SE, UK
Corresponding author email: mazouzk@cardiff.ac.uk

**This study examines the effects of CEO equity-based compensation and anti-takeover provisions on corporate innovation. Using a large sample of US firms over the period 1996–2014, we find that long-term incentives have a stronger influence on innovation when combined with takeover threats. We also show that equity-based compensation is more likely to spur innovation for small firms and firms in industries with high product market competition and innovation pressure. However, this effect is somewhat weaker in the presence of anti-takeover provisions, suggesting that takeover protection encourages managerial shirking even when external competition is high. Finally, in addition to the existing evidence on the valuation effect of CEO equity-based compensation, we identify innovation as an important channel through which managerial incentives can enhance firm value. Our results have potential implications for shareholders, managers and policymakers.**

Innovation demands risk-taking – which, in turn, entails redefining failure, stripping away its power of inhibit (Lynne Doughtie)

## Introduction

Corporate innovation is the process of developing new technology, practice and strategy that increase firm value. It is the key to a firm's long-term competitiveness and sustainability (Romer, 1987, 1990), especially in highly competitive industries (Adams, 1990). However, investment in innovation is risky and time-consuming, as it involves exploring new and untested approaches that are likely to fail (Manso, 2011). For this reason, risk-averse managers often opt for routine operations rather than innovation (March, 1991). Identifying new ways to motivate these managers to invest more in innovation is of critical importance not only to firm survival, but also to the competition between nations (Solow, 1957). In this study, we aim to investigate whether takeover protection affects the ability of long-term managerial incentives to spur innovation and whether managerial incentives affect firm value through innovation.

Several studies argue that managerial compensation schemes, such as executive stock options, will promote innovation because the value of equity-based compensation depends largely on the long-term performance of the firm (Kim, Patro and Pereira, 2017; Lerner and Wulf, 2007). However, such incentives alone may not be sufficient to guarantee engagement in innovation, as equity-based compensation can increase the sensitivity of a manager's portfolio to their firm's stock price movements (Low, 2009; Ross, 2004). Risk-averse managers also would not invest in innovation when a takeover threat is imminent, as the expected payoff from such investment is long-term and highly uncertain (Shleifer and Summers, 1988) and the market is often myopic (Ali, Ciftci and Cready, 2012; Martin, 2012).

Thus, while equity-based incentives can protect managers from market myopia (Thanassoulis, 2013), they cannot provide safeguards against opportunistic takeovers, which target underpriced firms (Humphery-Jenner, 2014). Furthermore, Stein (1988) argues that, due to the unforeseeable

nature of innovation, the market may undervalue R&D-intensive firms. Thus, without appropriate protection, equity-based compensation may not provide managers with sufficient incentives to engage in innovation. Manso (2011) formalizes this view and develops a theoretical model in which motivating managers to engage in innovation requires compensation schemes that reward long-term success and offer protection from early failure. However, the principal–agent model views takeover threats as a market-monitoring device that deters managerial shirking (Jensen and Meckling, 1976). Thus, any attempt to protect managers from market discipline may undermine their incentive to act in the interests of shareholders (Jensen and Murphy, 1990). In the context of innovation, a reduction in takeover threats would allow managers to receive high compensation without investing in risky projects. Thus, in the presence of anti-takeover provisions, equity-based compensation may have a weak or even a negative effect on innovation.

In addition to the literature on the link between incentives and innovation, several studies show that equity-based compensation can increase firm value (Conyon and Freeman, 2004; Sun, Cahan and Emanuel, 2009). However, the channels through which incentives affect firm value are not yet well understood. In this study, we are interested in whether equity-based compensation can create value through its effect on innovation. Prior research on the impact of innovation on firm value is also muddled. Some studies argue that innovation yields better performance (Bayus, Erickson and Jacobson, 2003; Pauwels *et al.*, 2004), while others suggest that innovation does not add value (Foster and Kaplan, 2011). In an attempt to clarify the apparent contradictions between these studies, Sorescu and Spanjol (2008) classify innovations into breakthrough and incremental and argue that the former is more likely to generate economic rents and enhance firm value. Risk-averse managers may avoid innovations that increase risk, even when such innovations generate economic rents. This is because the increased risk may endanger the firm's survival and have negative consequences on managers. Thus, equity-based compensation can enhance firm value by motivating managers to act in the shareholders' interests and prioritize investments in innovation with potential economic rents.

In summary, this study attempts to enhance our understanding of the role of managerial incentives and takeover protection in the value-creation process and contributes to the literature by answering the following questions: Does the effect of managerial incentives on innovation depend upon the extent to which managers are protected from the takeover pressure? And do managerial compensation schemes affect firm value through innovation? We investigate these questions empirically using a large sample of US firms. We find that carefully designed incentives can simulate innovation better when used in conjunction with market discipline. We also find overwhelming evidence that takeover protection has a positive direct effect and a negative moderating effect on innovation, with the effects being generally more pronounced for small firms and firms in highly competitive industries. Finally, we show that innovation outcome partially mediates the positive effect of equity-based compensation on firm value. This evidence suggests that managers who are compensated by share-based plans can increase their wealth by investing in innovative projects with the potential to generate economic rents.

Our contribution to the literature is threefold. First, unlike the extant literature that tends to treat incentives and takeover protection as independent determinants of innovation (Atanassov, 2013; Lerner and Wulf, 2007), we argue, and provide evidence, that these two determinants are interrelated and the ultimate effect of incentives on innovation depends on the presence of anti-takeover provisions. Second, prior studies present two conflicting views on the relationship between takeover protection and innovation. On the one hand, takeover protection can mitigate managerial myopia and encourage managers to invest in long-term projects, such as innovation (Manso, 2011). On the other hand, insulating a firm from takeover threats can lead to managerial entrenchment and underinvestment in risky activities, including R&D (Jensen and Meckling, 1976; Jensen and Murphy, 1990). We contribute to this debate by showing that these two effects coexist and the overall impact of takeover protection on innovation reflects the relative strength of each effect, which, in turn, depends on the nature of the managerial compensation schemes adopted by the firm. Finally, while several studies document a positive relation between incentives and innovation, the channels through which incentivized managers improve

firm value are not well understood. In this study, we argue, and provide supporting evidence, that compensation packages which align the managers' and shareholders' objectives create value by motiving managers to engage in innovative projects with the potential to generate economic rents.

The remainder of the paper is organized as follows. The next section outlines our theoretical framework and develops our hypotheses. Then, data and empirical methodology are presented. We discuss our results, then report additional results and robustness checks before concluding.

## Theory and hypotheses

*Theoretical background*

Innovation is an experimental and risky process, which often involves significant resources, long investment periods and highly uncertain outcomes (Holmstrom, 1989). Because of the risks involved in exploration activities, risk-averse managers tend to dislike investment in innovation and opt for other projects with lower costs, shorter time spans and more predictable outcomes. This underinvestment in innovation may, in turn, have a detrimental effect on the firm's competitive position and its market value.

From an agency perspective, Baker, Jensen and Murphy (1988) argue that internal incentives determine how managers behave. Managers may be reluctant to invest in innovation unless they are adequately compensated for doing so (Eisenhardt, 1989; Sanders and Hambrick, 2007). In a theoretical model, Manso (2011) shows that the standard principal–agent contract motivates managers to repeat routine activities rather than engage in innovation. To address this problem, Manso (2011) argues for the use of incentive schemes that reward long-term success. An experimental study by Ederer and Manso (2013) also confirms the importance of such schemes in stimulating innovation.

Manso's (2011) theoretical framework suggests that another essential element to motivate innovation is tolerance of failure. He argues that because of the risky and opaque nature of R&D investments, investors may undervalue R&D. This, in turn, may increase the exposure of R&D-intensive firms to takeover threats. Shleifer and Summers (1988) also argue that acquirers can make risk-free profit from targets that invest heavily in innovation. In a similar vein, Ali, Ciftci and Cready (2012) show that shareholders underestimate the future benefits of R&D investments, making R&D-intensive firms easy takeover targets. Takeover threats, in turn, may lead managers to focus more on short-term profits rather than long-term objectives. Gillan, Hartzell and Parrino (2009) also find that comprehensive and explicit employment agreements are more popular when the work relationship is at risk of termination. Humphery-Jenner (2014) and Manso (2011) argue that one way to overcome managerial myopia and induce investment in innovation is by ensuring that incumbent managers are entrenched enough to retain their jobs in the face of hostile takeovers. To put it differently, it is reasonable to argue that some degree of job protection is required to align managers' innovation decisions with shareholders' objectives.

However, moral hazard models suggest that takeover protection can be detrimental to innovation. Specifically, without monitoring, managers can prioritize their own interests over the interests of shareholders (Masulis, Wang and Xie, 2009). The lack of discipline allows risk-averse managers to focus on routine activities with quicker and safer returns rather than activities which maximize shareholder value (Jensen, 1988; Jensen and Ruback, 1983). In other words, entrenched managers are less likely to engage in risky activities, such as innovation, when they are protected from takeover pressure.

As the effect of takeover protection on innovation is inconclusive, we attempt to investigate the potential moderating role of takeover protection in the relationship between incentives and innovation (see Figure 1). We expect incentives to promote innovation and protection to either strengthen or weaken this effect, depending on whether tolerance for failure motivates managers to pursue innovation or leads them to prioritize their own interests over the interests of shareholders. More specifically, compensation schemes that reward long-term success may not be sufficient to motivate risk-averse managers to engage in innovation, as innovative projects are inherently risky and tend to be undervalued by the market (Thanassoulis, 2013). Thus, investing in such projects may increase the firm's riskiness and its exposure to takeover threats. This implies that if anti-takeover provisions can protect managers from the negative consequences of hostile takeover, such provisions would have a positive moderating effect on the

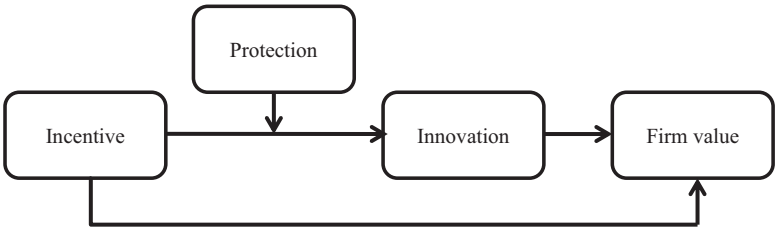


*Figure 1. Moderation and mediation model*

relationship between equity-based incentives and innovation. However, if the reduction in takeover threats promotes managerial shirking by allowing managers to receive high compensation without investing in risky innovative projects (Jensen and Meckling, 1990), we would expect the takeover protections to negatively moderate the impact of incentives on innovation.

In addition to the direct effect of equity-based compensation on firm value (Jensen and Meckling, 1976; Palmon *et al.*, 2008), incentives may also affect firm value indirectly through innovation. Existing evidence on the impact of innovation on firm value is largely mixed. Some studies find that innovation enhances performance (Bayus, Erickson and Jacobson, 2003; Pauwels *et al.*, 2004), whereas others suggest that innovating is detrimental to firm value (Foster and Kaplan, 2011). In an attempt to reconcile the diverging evidence, Sorescu and Spanjol (2008) argue that innovation can only create value if it helps the firm to generate economic rents. Since innovative projects with the potential to generate economic rents tend to be highly risky (Sorescu and Spanjol, 2008), compensation packages that align managers' interests with those of shareholders would be required in order to motivate managers to invest in such projects. Therefore, we expect innovation to (partially) mediate the relationship between managerial incentives and firm value.

### *Hypothesis development*

*Incentives and innovation.* The link between executive compensation and firms' investment strategies, such as R&D, has been widely investigated in the literature (Chang *et al.*, 2015; Sanyal and Bulan, 2010). Several studies report a significantly positive association between equity-based compensation and R&D expenditure. Kim, Patro and Pereira (2017) show that executive stock options increase the sensitivity of CEOs' wealth to their firms' stock volatility and promote investment in risky projects. Similarly, Kini and Williams (2012) find that higher tournament incentives motivate senior managers to take more risks in order to increase their chance of promotion to the rank of CEO. Lerner and Wulf (2007) also show that long-term managerial incentives result in greater R&D output. Similar results are obtained by Sanyal and Bulan (2010), who document a positive association between long-term managerial incentives and both patents and citations to patents.[1]

To sum up, existing studies generally suggest that long-term incentive plans promote innovation. Therefore, we hypothesize that:

*H1*: Firms that use more long-term incentives in their CEO compensation plans are more likely to engage in innovation.

*The moderating effect of protection.* It is commonly argued that carefully designed incentive schemes, such as equity-based compensation, can alleviate possible conflicts between shareholders and managers and motivate managers to engage in risky activities (Francis, Hasan and Sharma, 2011; Lerner and Wulf, 2007). However, while equity-based compensation rewards long-term success, it may not be sufficient to induce risk-averse managers to invest in innovation (Ederer and Manso, 2013; Manso, 2011). This is because investing in innovation is a long and costly process, which can leave a firm financially vulnerable, severely harm its reputation and put it at a strategic disadvantage relative to its competitors. Evidence also shows that the risk of becoming a takeover target can inhibit a firm's R&D activity (Narayanan, 1985; Pugh, 1992). Thus, firms that are interested in stimulating innovation should not only reward

[1]Only a few studies show that long-term incentives are detrimental to innovation (see e.g. Ryan and Wiggins, 2002).

long-term success, but also discourage the myopic behaviour of managers by protecting them from takeover pressure. In other words, we expect long-term managerial incentives to have a stronger impact on innovation in firms with more anti-takeover provisions. Hence, we hypothesize that:

*H2a*: The effect of CEO incentives on innovation is positively moderated by takeover protection.

However, academic research has not reached a consensus on the relationship between takeover protection and innovation. DeAngelo and Rice (1983) argue that takeover threats serve as a disciplinary device that forces managers to engage in value-maximizing activities (Jain, 2012; Mahoney, Sundaramurthy and Mahoney, 1997). Thus, anti-takeover provisions may encourage managerial entrenchment and undermine the ability of long-term managerial incentives to promote innovation. In other words, protection from takeover threats may allow managers to receive high compensation without engaging in risky innovative projects. More formally:

*H2b*: The effect of CEO incentives on innovation is negatively moderated by takeover protection.

*Innovation and firm value.* Many studies show that innovation has a significantly positive effect on firm value (Camisón and Villar-López, 2014; Toivanen, Stoneman and Bosworth, 2002). However, others argue that innovation has little or no effect on firm value (Foster and Kaplan, 2011; Geroski, Machin and Van Reenen, 1993). Sorescu and Spanjol (2008) argue that these apparently conflicting findings reflect the differences in types of innovation that firms go after. They argue that incremental innovations can easily be imitated by competitors and do not generate competitive advantage for firms, whereas breakthrough innovations, which are often protected by patents, can effectively augment a firm's position in market competition. They also argue that breakthrough innovations tend to increase firm riskiness, but generate economic rents. This type of innovation may therefore appeal to shareholders, who would be more than compensated for the additional risk, but not to managers, as the increase in risk may endanger the firm's survival and have negative consequences on managers and other stakeholders. Thus, without adequate rewards for taking additional risks, managers are less likely to invest in risky innovative projects even when such projects have the potential to generate economic rents. Since appropriately designed incentives are shown to alleviate possible conflicts between shareholders and managers (Francis, Hasan and Sharma, 2011; Lerner and Wulf, 2007), such incentives can also motivate CEOs to invest in value-creating projects, including innovation. More specifically:

*H3*: The positive effect of CEO incentives on firm value is (partially) mediated by the firm's innovation performance.

## Data and descriptive statistics

Our initial sample includes all US firms listed on AMEX, NYSE or NASDAQ over the period 1996–2014. We chose 1996 as the start of our sample because it was the earliest we could retrieve compensation and financial data with sufficient quality. We downloaded the financial data from Compustat, corporate governance, board characteristics and executive compensation data from Execucomp, takeover protection data from ISS (formerly Riskmetrics) and patent and citation data from the NBER patent citation database, which is based on the USPTO Patent and Citation Data.[2] After removing financial firms and firms with missing values, we winsorized all the variables at the 1st and 99th percentiles to mitigate the influence of extreme observations. The sample used in the regression analysis contains 15,586 firm-year observations for 1,932 unique firms.

We use both input- and output-oriented measures of *innovation*. We use the value of R&D investment scaled by total assets to capture the R&D intensity (He and Tian, 2013; O'Connor and Rafferty, 2012). However, R&D intensity as a measure of R&D activity has a number of drawbacks. First, it is not always clear whether the recorded R&D expenses truly reflect investment

[2]The USPTO website states that: 'Patent classification systems are largely designed for administrative purposes, limiting their value for most research purposes. To address this deficiency, Hall, Jaffe and Trajtenberg (2001) developed a higher-level classification for the National Bureau of Economic Research (NBER) Patent Citation Data File by aggregating US Patent Classification (USPC) classes into economically relevant technology categories.'

in innovation (Chambers, Jennings and Thompson, 2003). Second, not all R&D investments result in innovation. Just as corporate assets may be wasted through empire building, so too may misconducted R&D investments generate little value but cost shareholders dearly. Hence, it is important to investigate the outcome of the R&D process. Following others, we evaluate a firm's R&D productivity via the number of patents it has successfully applied for. Since years of R&D investment are required before a patent application can be submitted, we match the number of patent applications to other control variables of the previous two years.[3] Besides the number of patents, the quality of patents is also an important measure of innovation. Patents with high value can receive more citations over time than minor innovations. Thus, we use the number of non-self-citations received by all patents that a company has developed in a year to quantify the value of patents acquired by the company in that year. Since citation data suffer from a truncation problem (Hall, Jaffe and Trajtenberg, 2001), we adjust the number of citations according to the estimated citation distribution based on industry and year.[4]

Table 1 reports the descriptive statistics for the variables used in the sample. Most firms in our sample do not have R&D expenditure. The average R&D-to-total assets ratio is 5.8%. We evaluate a firm's innovation productivity by the number of patents and citations it obtained in a given year. Both measures are highly skewed, as most firm-years in our sample record zero patents and citations. Our analysis indicates that, on average, firms develop 1.4 patents and receive 15 citations every year.

Following others (Francis, Hasan and Sharma, 2011; Lerner and Wulf, 2007), we define long-term CEO incentives (*incentive*) as the percentage of equity-based compensation (i.e. restricted stocks, stock options and long-term incentive plans) in the total compensation. Because of the stock options' unique focus on long-term performance (Hall and Murphy, 2002), we also use the percentage of stock options in total compensation as an alternative measure in the robustness analysis. Table 1 presents the statistics of the total compensation (in thousands of US dollars), the percentage of equity-based compensation and the percentage of stock options in total compensation. It shows that 57.9% of the total CEO compensation is paid in the form of equity or equity-related compensation, with stock options having greater value than restricted stock and other long-term incentive plans. In untabulated results, we find that CEO compensation in the US market has increased substantially over the sample period, with two temporary setbacks in 2001 and 2007, and that the percentage of equity-based compensation increased steadily from 38% in 1996 to 74% in 2014.

To measure the extent to which managers are protected from market discipline (*protection*), we construct an index that reflects their firm's use of anti-takeover provisions, such as classified boards, dual-class shares, super-majority voting, unequal voting rights, confidential voting, cumulative voting, poison pills, golden parachutes and fair price provision. Similar to Atanassov (2013), Chemmanur and Tian (2017) and Jain (2012) for each firm in a given year, we give a score of one to each provision that increases the difficulty of replacing the incumbent management (e.g. poison pill) or strengthens managerial entrenchment (e.g. absence of cumulative voting), and zero otherwise. We then sum up the scores to construct a measure for a firm's overall takeover protection in that year. This measure takes values from zero (for the least protected firms) to eight (for the most protected firms). Table 1 shows that the majority of the sample firms score between three and five.[5]

Table 1 also reports the descriptive statistics of the various variables used in our regressions. Our set of control variables consists of the well-known determinants of innovation, including return on assets (ROA), Tobin's Q, CEO tenure, capital expenditure ratio, tangibility, financial constraints (Kaplan and Zingales, 1997), institutional ownership (Choi, Park and Hong, 2012), leverage (Zhang, Chen and Feng, 2014), total assets and financial analysts' coverage (He and Tian, 2013). A detailed definition of these variables is provided in the Appendix and their correlation matrix is

[3] In the robustness tests we use time lags of one year and three years to verify the results.

[4] Since the patent and citation data only covers the period until 2010, regressions with patent/citation as dependent variables are based on 4,947 firm-year observations.

[5] In the early period of the sample, corporate governance data is recorded once in every two years. We interpolate the CG index for the missing years. This explains the larger sample size of the CG index than individual provisions.

*Table 1. Descriptive statistics*

| Variable | N | Mean | SD | Min | $p_{50}$ | Max |
|---|---|---|---|---|---|---|
| *Innovation measures* | | | | | | |
| R&D expenditure ($m) | 218,100 | 15.091 | 72.819 | 0 | 0 | 611.000 |
| R&D ratio | 186,391 | 0.058 | 0.164 | 0 | 0 | 1.121 |
| Patents | 129,794 | 1.406 | 7.372 | 0 | 0 | 62 |
| Citations | 129,794 | 14.481 | 79.437 | 0 | 0 | 665.858 |
| *Incentives measures* | | | | | | |
| CEO's total compensation ($000) | 33,392 | 5,319.277 | 9,894.839 | 0.001 | 3,000.757 | 655,448.000 |
| CEO's equity compensation (of total compensation) | 33,323 | 0.579 | 0.286 | 0 | 0.650 | 0.979 |
| CEO's stock options (of total compensation) | 33,323 | 0.181 | 0.274 | 0 | 0 | 0.935 |
| *Protection measures* | | | | | | |
| CG index | 22,463 | 4.102 | 1.293 | 1 | 4 | 7 |
| Classified board | 17,141 | 0.529 | 0.499 | 0 | 1 | 1 |
| Dual-class shares | 17,141 | 0.082 | 0.275 | 0 | 0 | 1 |
| Super-majority voting | 17,141 | 0.429 | 0.495 | 0 | 0 | 1 |
| Unequal voting rights | 17,141 | 0.021 | 0.143 | 0 | 0 | 1 |
| Poison pill | 17,141 | 0.361 | 0.48 | 0 | 0 | 1 |
| Golden parachute | 17,141 | 0.695 | 0.46 | 0 | 1 | 1 |
| Fair price | 17,141 | 0.177 | 0.382 | 0 | 0 | 1 |
| No confidential voting | 17,141 | 0.879 | 0.326 | 0 | 1 | 1 |
| No cumulative voting | 17,141 | 0.918 | 0.274 | 0 | 1 | 1 |
| *Firm characteristics* | | | | | | |
| ROA | 17,9871 | −0.050 | 0.350 | −1.204 | 0.061 | 0.264 |
| Tobin's Q | 15,0564 | 2.432 | 2.554 | 0.699 | 1.412 | 11.041 |
| CEO tenure | 32,374 | 6.849 | 6.120 | 0 | 5 | 22.000 |
| Capital expenditure | 175,157 | 0.053 | 0.062 | 0 | 0.030 | 0.232 |
| PPE | 181,191 | 0.258 | 0.266 | 0.001 | 0.152 | 0.837 |
| KZ index | 124,635 | −8.489 | 20.728 | −79.000 | −0.772 | 10.598 |
| Institutional shareholding (%) | 28,567 | 24.972 | 19.131 | 0 | 20.600 | 67.000 |
| Analysts coverage | 218,100 | 1.934 | 3.508 | 0 | 0 | 12.417 |
| Debt ratio | 184,926 | 0.252 | 0.260 | 0 | 0.180 | 0.905 |
| Firm size ($m) | 186,391 | 1,891.135 | 4,106.544 | 1.118 | 194.254 | 16,467.000 |

This table presents summary statistics for variables collected from a sample of listed US firms from 1996 to 2014. A detailed definition of all variables used in our analysis is provided in the Appendix.

reported in Table 2. The highest correlation (of 0.69) is between capital expenditure ratio and tangibility; all other correlations are below 0.5. The rightmost column of Table 2 reports the variance inflation factor (VIF). The highest value for the VIF is 3.19, which is much smaller than the benchmark of 10 for severe multicollinearity.

## Methodology

We use two-stage least squares (2SLS) and simultaneous equations to examine the impact of incentives, protection and their interaction on innovation. We argue that these methods are better suited to our analysis than the standard ordinary least squares (OLS), mainly because of endogeneity concerns. Specifically, the associations between R&D, incentives and protection may reflect causalities other than those described in the hypothesis development section. For example, the decision to invest in R&D is linked to firm performance, which may in turn affect the CEO's compensation package (Sanyal and Bulan, 2010). Chemmanur and Tian (2017) also argue that takeover protection and innovation policy may be simultaneously determined. For example, hidden factors, such as the risk aversion of top management, may affect both protection and innovation, as risk-averse CEOs may choose to invest very little in R&D and convince the board to install more takeover protection.

The 2SLS model is estimated by first regressing *incentive* and *protection* against all the control variables discussed in the above section and the instrumental variables discussed below (first stage). Then, we use the predicted values of *incentive* and *protection* from the first stage as the

*Table 2. Correlation matrix*

| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | VIF |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Incentive (% equity compensation) | 1 | | | | | | | | | | | | 1.45 |
| 2 | Protection (CG index) | 0.0013 | 1 | | | | | | | | | | | 1.07 |
| 3 | ROA | 0.0549*** | −0.0186** | 1 | | | | | | | | | | 1.38 |
| 4 | Tobin's Q | 0.0635*** | −0.0799*** | 0.4073*** | 1 | | | | | | | | | 1.49 |
| 5 | CEO tenure | −0.1482*** | −0.0405*** | 0.0089 | 0.033*** | 1 | | | | | | | | 1.06 |
| 6 | Capital expenditure | −0.0075 | −0.0226*** | 0.2622*** | 0.0592*** | 0.0124 | 1 | | | | | | | 2.40 |
| 7 | PPE | −0.0459*** | 0.0084 | 0.1623*** | −0.1271*** | −0.0459*** | 0.6869*** | 1 | | | | | | 3.19 |
| 8 | KZ index | −0.0067 | 0.0378*** | 0.0263*** | −0.0786*** | −0.0257*** | 0.2044*** | 0.2858*** | 1 | | | | | 1.20 |
| 9 | Institutional shareholding | −0.2175*** | 0.0254*** | −0.0213*** | 0.0044 | 0.0248*** | −0.0074 | −0.0174** | 0.0198** | 1 | | | | 2.06 |
| 10 | Analysts coverage | 0.3187*** | −0.0686*** | 0.1798*** | 0.1586*** | −0.0433*** | 0.1238*** | 0.0649*** | −0.0072 | −0.1467*** | 1 | | | 1.62 |
| 11 | Debt ratio | 0.0448*** | 0.0585*** | −0.064*** | −0.188*** | −0.0738*** | 0.0819*** | 0.3048*** | 0.127*** | −0.0328*** | 0.009 | 1 | | 1.29 |
| 12 | Firm size ($m) | 0.3101*** | −0.0747*** | −0.0493*** | −0.1836*** | −0.0986*** | −0.0483*** | 0.0978*** | −0.0229*** | −0.2675*** | 0.4811*** | 0.2505*** | 1 | 2.13 |

This table presents the correlation of the explanatory variables. The main independent variables are CEO incentives, defined as the proportion of equity-based compensation in total compensation, and takeover protection, measured by a corporate governance (CG) index, which reflects firms' use of anti-takeover provisions, including classified boards, dual-class shares, super-majority voting, unequal voting rights, confidential voting, cumulative voting, poison pills, golden parachutes and fair price provision. Other control variables are return on assets (ROA), Tobin's Q, CEO tenure (in years), capital expenditure-to-total assets ratio (Capital exp), percentage of fixed assets-to-total assets ratio (PPE), Kaplan and Zingales index (KZ index), institutional shareholding percentage (Institutional shareholding), number of analysts following the company (Analysts coverage), debt-to-total assets ratio (Debt ratio) and total assets (Firm size). A detailed definition of all the variables used in our analysis is provided in the Appendix.

***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

explanatory variables in the following regression (second stage):

$$\begin{aligned}\text{innovation}_{i,t+1} = {} & \alpha_0 + \beta * \text{predicted incentive}_{i,t} \\ & + \beta * \text{predicted protection}_{i,t} \\ & + \beta * \text{predicted incentive}_{i,t} * \\ & \times \text{predicted protection}_{i,t} \\ & + \beta * \text{control variables}_{i,t} \\ & + \text{year dummy}_{i,t} + \text{industry dummy}_{i,t} \\ & + \varepsilon_{i,t} \end{aligned} \quad (1)$$

Following Kini and Williams (2012), we use the industry median of the proportion of equity-based compensation in the total CEO compensation package as the instrument for CEO incentives. A firm's compensation size and structure may well be related to other firms in the same industry, but it is unlikely that the industry-level compensation would have a direct effect on the firm's innovation strategy. Following Humphery-Jenner (2014), we use state-level protection, the anti-takeover provisions in the state law and industry-level protection as instruments for a firm's takeover protection. Given the legal setting in the USA, firms in the same state tend to have similar takeover defences. Likewise, as takeover activities are industry specific, firms in the same industry face similar takeover threats. However, while state laws and industry patterns may shape a firm's protection, they should have no direct effect on its R&D process.

We realize that some of the independent variables in our study might be related to one another. For instance, Buchholtz and Ribbens (1994) show that the resistance to takeover is negatively related to the CEO's stock ownership. In order to address this issue, we use a simultaneous equation framework in which *innovation*, *incentive* and *protection* are assumed to be jointly determined. In this framework, each endogenous variable in the system (*innovation*, *incentive* and *protection*) is first regressed on the relevant instruments and control variables and then their predicted values are computed.[6] The instruments for incentives and protection remain the same as in the 2SLS models above. Following Kini and William (2012), we use industrial average R&D intensity as the instrument for a firm's R&D intensity. The simultaneous equations are:

$$\begin{aligned}\text{innovation}_{i,t} = {} & \alpha_0 + \beta * \text{predicted incentive}_{i,t} \\ & + \beta * \text{predicted protection}_{i,t} \\ & + \beta * \text{predicted incentive}_{i,t} * \\ & \times \text{protection}_{i,t} + \beta * \text{control variables}_{i,t} \\ & + \text{year dummy}_{i,t} + \text{industry dummy}_{i,t} \\ & + \varepsilon_{i,t} \end{aligned} \quad (2)$$

$$\begin{aligned}\text{incentive}_{i,t} = {} & \alpha_0 + \beta * \text{predicted innovation}_{i,t} \\ & + \beta * \text{predicted protection}_{i,t} \\ & + \beta * \text{control variables}_{i,t} + \text{year} \\ & \times \text{dummy}_{i,t} + \text{industry dummy}_{i,t} \\ & + \varepsilon_{i,t} \end{aligned} \quad (3)$$

$$\begin{aligned}\text{protection}_{i,t} = {} & \alpha_0 + \beta * \text{predicted incentive}_{i,t} \\ & + \beta * \text{predicted innovation}_{i,t} \\ & + \beta * \text{control variables}_{i,t} + \text{year} \\ & \times \text{dummy}_{i,t} + \text{industry dummy}_{i,t} \\ & + \varepsilon_{i,t} \end{aligned} \quad (4)$$

All the above models include year and industry dummies to control for time and industry fixed effects and all estimates are based on robust standard errors clustered at firm level.

## Results

### *Incentives, protection and innovation*

The Durbin–Wu–Hausman test suggests that *incentive* and *protection* are endogenous (not tabulated). To mitigate the endogeneity concerns, we use both 2SLS and simultaneous equations. As explained earlier, we use multiple instruments for the endogenous variables in the first stage of the 2SLS model. The Kleibergen–Paap test and the Cragg–Donald–Wald F-test show that our selected instruments are individually and jointly related to the endogenous variables with strong significance; the

[6]We use simultaneous equations to explain R&D intensity rather than R&D productivity because the latter only materializes several years later. Thus, it is difficult to argue that R&D productivity is jointly determined with incentive and protection.

*Table 3. Innovation – intensity*

| Model | (1) 2SLS | (2) 2SLS | (3) System | (4) FE |
|---|---|---|---|---|
| Dependent variable | R&D ratio | R&D ratio | R&D ratio | R&D ratio |
| Equity compensation | 0.133*** | 0.268*** | 0.158*** | 0.055** |
| | (0.025) | (0.091) | (0.035) | (0.024) |
| CG index | | 0.012 | −0.020*** | 0.007** |
| | | (0.012) | (0.005) | (0.003) |
| Equity * CG index | | −0.041** | −0.007 | −0.009* |
| | | (0.020) | (0.007) | (0.005) |
| ROA | −0.111*** | −0.160*** | −0.166*** | −0.031*** |
| | (0.028) | (0.018) | (0.005) | (0.003) |
| Tobin's Q | 0.005*** | 0.005*** | 0.006*** | 0.000** |
| | (0.001) | (0.001) | (0.000) | (0.000) |
| CEO tenure | 0.001*** | 0.000** | 0.000*** | 0.000** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Capital exp | −0.011 | 0.029 | 0.000 | 0.008 |
| | (0.025) | (0.022) | (0.013) | (0.007) |
| PPE | −0.031*** | −0.031*** | −0.022*** | 0.000 |
| | (0.007) | (0.006) | (0.003) | (0.004) |
| KZ index | −0.000 | −0.000* | −0.000 | −0.000*** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Institutional shareholding | −0.000*** | −0.000*** | −0.000*** | −0.000** |
| | (0.000) | (0.000) | (0.000) | (0.000) |
| Analysts coverage | 0.002* | 0.005*** | 0.003*** | 0.001** |
| | (0.001) | (0.002) | (0.001) | (0.000) |
| Debt ratio | −0.008 | −0.023*** | −0.015*** | −0.007*** |
| | (0.009) | (0.006) | (0.003) | (0.002) |
| Firm size | −0.017*** | −0.015*** | −0.017*** | −0.011*** |
| | (0.002) | (0.001) | (0.001) | (0.001) |
| Constant | 0.111*** | 0.066 | 0.193*** | 0.070*** |
| | (0.016) | (0.044) | (0.019) | (0.014) |
| Year dummy | Yes | Yes | Yes | Yes |
| Industry dummy | Yes | Yes | Yes | Yes |
| N | 17,957 | 14,214 | 14,632 | 14,214 |
| F-statistic/R-squared[a] | 24.475 | 20.703 | N/A | 0.202 |

This table presents the 2SLS (Columns (1) and (2)), simultaneous (Column (3)) and fixed-effects (Column (4)) regressions of innovation intensity on CEO incentives and takeover protection. The dependent variable *innovation* is measured by R&D-to-total assets ratio. The main explanatory variables are CEO incentives, defined as the proportion of equity-based compensation in total compensation, and takeover protection, measured by a corporate governance (CG) index, which reflects firms' use of anti-takeover provisions, including classified boards, dual-class shares, super-majority voting, unequal voting rights, confidential voting, cumulative voting, poison pills, golden parachutes and fair price provision. Other control variables are return on assets (ROA), Tobin's Q, CEO tenure (in years), capital expenditure-to-total assets ratio (Capital exp), percentage of fixed assets-to-total assets ratio (PPE), Kaplan and Zingales index (KZ index), institutional shareholding percentage (Institutional shareholding), number of analysts following the company (Analysts coverage), debt-to-total assets ratio (Debt ratio) and total assets (Firm size). A detailed definition of all variables used in our analysis is provided in the Appendix.

Statistical significance is based on the heteroscedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

[a]F scores are reported in Columns (1) and (2). Overall R-squared is reported in Column (4). We do not report R-squared for 2SLS regressions since, with the use of instruments, the residual sum of squares is no longer constrained to be smaller than the total sum of squares. Therefore, it is possible to have negative R-squared and R-squared does not have the same meaning for goodness-of-fit as in OLS regressions.

Hansen's J-test suggests that our instruments are uncorrelated with the error term.[7]

Table 3 reports the results from the 2SLS (Eq. (1)) and simultaneous equations framework (Eqs (2) to (4)). Columns (1) and (2) present the 2SLS estimates with R&D expenditure as the innovation

[7]Occasionally, Hansen's J-test rejects the null hypothesis that the instruments are uncorrelated with the error term. In this situation, we adjusted the set of instruments by removing anti-takeover provisions in the state law and/or industry average level of protection.

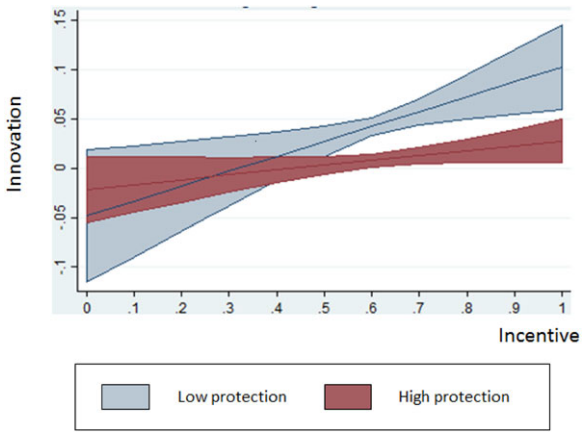


*Figure 2. Effect of incentive and protection on innovation – intensity [Colour figure can be viewed at wileyonlinelibrary.com]*

measure. Column (1) shows that a firm's R&D expenditure is significantly positively associated with the percentage of equity-based compensation in its CEO's compensation package. This finding is consistent with Kini and Williams (2012) and Xue (2007), and supports H1.

Column (2) reports the results with *incentive*, *protection* and their interaction as the main explanatory variables in Eq. (1). The effect of *incentive* on R&D expenditure is both statistically and economically significant, with a one-standard-deviation increase in equity-based compensation resulting in a 7.7% (i.e. 0.268 × 0.286) increase in R&D ratio. However, the effect of *protection* on R&D is insignificant and the interaction between *incentive* and *protection* is significantly negative, implying that takeover protection weakens the positive effect of incentives on innovation. In economic terms, one additional anti-takeover provision reduces the effect of incentives on innovation by 15.3% (i.e. 0.041/0.268). The 2SLS results confirm that equity-based compensation motivates CEOs to invest more in R&D. We also show that when CEOs are protected against takeover threats, they tend to avoid investing in R&D. The diminishing effect of *incentive* on *innovation* in the presence of protection is consistent with the prediction of H2b, but not with that of H2a.

In line with Mazzola, Perrone and Kamuriwo (2016), we also plot the moderating effect in Figure 2. The low protection line shows the effect of incentives on innovation when protection is weak (i.e. below median), while the high protection line presents the effect of incentive on innovation when protection is strong (i.e. above median). Figure 2 confirms that incentives have stronger effects on innovation when protection is low.

Similar results are obtained when *incentive*, *protection* and R&D are assumed to be determined in a system of equations (see Column (3), but with protection having an insignificant moderating effect) and when firm fixed effects are considered (Column (4)). As for the control variables, we find that firms with better accounting performance (ROA) invest less in R&D. We also find that CEOs with longer tenure invest more in R&D. This result is consistent with the 'career concern' argument of Barker and Mueller (2002), who maintain that the longer the CEO is in position the less myopic she becomes.[8] Tobin's Q is positive and significant, implying that firms with strong performance invest more in R&D. Companies with larger institutional ownership invest less in R&D, consistent with the findings of Choi, Park and Hong (2012) and Tribo, Berrone and Surroca (2007). Finally, consistent with the literature (He and Tian, 2013; Kini and Williams, 2012), we show that smaller firms with less fixed assets, less leverage and more analyst coverage spend more on innovation.

In Table 4, we show that a firm's expenditure on R&D is correlated with both CEO compensation and takeover protection. However, a firm's decision to conduct and disclose R&D may not be random and may be driven by the same factors that affect incentives and protection. To resolve this potential selection bias, we apply a Heckman two-stage selection model. In the first stage, we regress a treatment variable, which equals one if a firm has reported positive R&D spending and zero otherwise, on the explanatory variables included in Eq. (1). In the second stage, we regress R&D expenditure on the same set of explanatory variables and the inverse Mills ratio from the first stage. The result of the second stage confirms our earlier finding that incentives stimulate R&D spending

[8]It is also possible to argue that CEOs with longer tenure are more likely to be awarded with equity-based compensation and may therefore have more opportunity to engage in R&D. We test this by replicating Table 3 using a subsample of CEO of short tenure (less than the median of five years). We show that the relation between incentives and innovation is not driven by CEOs with longer tenure.

*Table 4. Innovation – productivity*

| Model | (1) 2SLS | (2) 2SLS | (3) Poisson GMM | (4) 2SLS | (5) 2SLS | (6) Poisson GMM |
|---|---|---|---|---|---|---|
| Dependent variable | (log)Patents$_{t+2}$ | (log)Patents$_{t+2}$ | Patents$_{t+2}$ | (log)Citation$_{t+2}$ | (log)Citation$_{t+2}$ | Citation$_{t+2}$ |
| Equity compensation | 1.553** | 7.433** | 18.755* | 2.102* | 11.781*** | 25.801 |
| | (0.771) | (3.049) | (10.327) | (1.100) | (4.509) | (45.790) |
| CG index | | 0.743* | 2.683 | | 1.238** | 3.727 |
| | | (0.415) | (1.641) | | (0.618) | (7.219) |
| Equity * CG index | | −1.909** | −4.153** | | −3.019** | −5.118 |
| | | (0.877) | (1.771) | | (1.293) | (7.381) |
| ROA | −0.132 | −0.355 | −0.811 | −0.110 | −0.293 | 0.144 |
| | (0.102) | (0.363) | (1.680) | (0.152) | (0.533) | (2.050) |
| Tobin's Q | 0.070*** | 0.092*** | −0.066 | 0.083*** | 0.109** | −0.129 |
| | (0.020) | (0.033) | (0.059) | (0.030) | (0.050) | (0.156) |
| CEO tenure | 0.002 | −0.006 | 0.009 | 0.003 | −0.007 | 0.018 |
| | (0.005) | (0.008) | (0.018) | (0.007) | (0.012) | (0.037) |
| Capital exp | 0.339 | 1.510 | 5.801** | 0.472 | 2.097 | 7.180 |
| | (0.689) | (1.093) | (2.860) | (0.999) | (1.623) | (4.748) |
| PPE | −0.423* | −0.928** | −2.808** | −0.553 | −1.277** | −2.922 |
| | (0.250) | (0.393) | (1.205) | (0.339) | (0.555) | (4.588) |
| KZ index | 0.001 | 0.002 | 0.009 | 0.001 | 0.003 | 0.030 |
| | (0.001) | (0.002) | (0.022) | (0.001) | (0.003) | (0.043) |
| Institutional shareholding | −0.008*** | −0.003 | 0.001 | −0.011*** | −0.004 | −0.008 |
| | (0.002) | (0.003) | (0.007) | (0.003) | (0.005) | (0.016) |
| Analysts coverage | 0.064** | 0.153** | 0.357*** | 0.087** | 0.209** | 0.418*** |
| | (0.032) | (0.069) | (0.096) | (0.044) | (0.100) | (0.150) |
| Debt ratio | −0.400*** | −0.345 | −1.327 | −0.524*** | −0.507 | −2.522 |
| | (0.131) | (0.217) | (1.268) | (0.188) | (0.320) | (4.149) |
| Firm size | 0.145*** | 0.207*** | 0.542*** | 0.143** | 0.227** | 0.613 |
| | (0.044) | (0.062) | (0.209) | (0.062) | (0.089) | (0.805) |
| Constant | −0.816*** | −3.269** | −99.104 | −0.325 | −4.406** | −25.435 |
| | (0.184) | (1.456) | (.) | (0.259) | (2.195) | (44.337) |
| Year dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 4,848 | 4,251 | 4,251 | 4,848 | 4,251 | 4,251 |
| F-statistic/pseudo-R-squared[a] | 25.125 | 17.379 | 0.065 | 20.302 | 15.188 | 0.064 |

This table presents results of the 2SLS regressions of innovation productivity on CEO incentives and takeover protection. The dependent variable *innovation* is measured by the number of patents successfully applied for (Columns (1) to (3)) and the number of citations received on patents (Columns (4) to (6)). The main explanatory variables are CEO incentives, defined as the proportion of equity-based compensation in total compensation, and takeover protection, measured by a corporate governance (CG) index, which reflects firms' use of anti-takeover provisions, including classified boards, dual-class shares, super-majority voting, unequal voting rights, confidential voting, cumulative voting, poison pills, golden parachutes and fair price provision. Other control variables are return on assets (ROA), Tobin's Q, CEO tenure (in years), capital expenditure-to-total assets ratio (Capital exp), percentage of fixed assets-to-total assets ratio (PPE), Kaplan and Zingales index (KZ index), institutional shareholding percentage (Institutional shareholding), number of analysts following the company (Analysts coverage), debt-to-total assets ratio (Debt ratio) and total assets (Firm size). A detailed definition of all variables used in our analysis is provided in the Appendix.

Statistical significance is based on the heteroscedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

[a]F scores are reported in Columns (1), (2), (4) and (5). Pseudo-R-squared is reported in Columns (3) and (6).

and this relationship is weaker in the presence of takeover protection.[9]

Table 4 reports the results of the 2SLS and Poisson equations with patents and citations as innovation measures. We use the logarithm of the number of patents (Columns (1) and (2)) and citations (Columns (4) and (5)) in t + 2 as the innovation measures. We find that firms with more equity-based compensation develop more patents and have more citations, consistent with H1. Moreover, the interaction terms in Columns (2) and (5) are negative, indicating that takeover protection weakens the positive effect of incentives on innovation (consistent with H2b). Figure 3 also shows that the effect of incentives on patents and citations

[9]Estimation results can be found in Table A of the Internet Appendix.

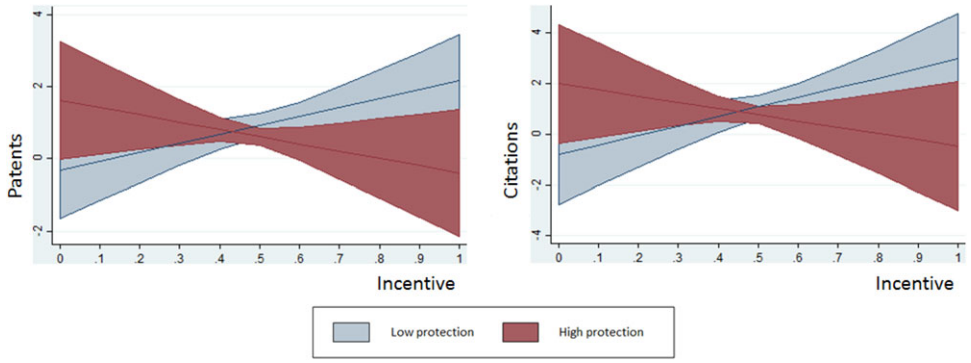


*Figure 3. Effect of incentive and protection on innovation – productivity [Colour figure can be viewed at wileyonlinelibrary.com]*

can turn negative when the firm is well protected, suggesting that managers tend to underperform in innovation productivity when they are insulated from takeover pressure.

Since the original patent and citation data is not continuous, we repeat our analysis using Poisson regressions to treat the number of patents and citations as count variables. We use the two-step GMM estimator with the Poisson regressions in order to tackle endogeneity concerns. The results from the Poisson regressions are similar to those obtained from the 2SLS (Column (3)), except that in the Poisson regressions, incentives and protection do not significantly affect citations (Column (6)).

The results pertaining to the control variables are also largely consistent with the literature (Fang, Tian and Tice, 2014; He and Tian, 2013). Specifically, we find that firms with strong stock market performance acquire more high-quality patents (measured by citations). Consistent with the results of the R&D intensity, we also find that firms with less fixed assets and less leverage have better R&D productivity. Furthermore, we find that large firms develop better-quality patents. Finally, we report a positive association between analyst coverage and R&D productivity, suggesting that financial analysts serve as external monitors to improve management decisions (Barron, Byard and Yu, 2008; Healy, Hutton and Palepu, 1999).

### *Innovation and firm value*

To test the mediating effect of innovation on firm value, measured by Tobin's Q in the future periods, we use a stepwise method similar to that in Baron and Kenny (1986) and Xia and Liu (2017) and report the results in Table 5. Column (1) shows that *incentive* is a significant predictor of the next period firm value, consistent with Chemmanur and Tian (2017). In line with our earlier findings, Column (2) of Table 5 shows that *incentive* is significantly related to the mediator (i.e. the number of patents acquired in the future period). We also show that the independent variable (*incentive*) and the mediator (number of patents) are positive and significant when both are included in the firm value regression (Column (3)). The estimated coefficient on *incentive* in Column (3) is lower than its counterpart in Column (1), implying a partial mediation of innovation on firm value. This partial effect suggests that innovation is only one of the many channels through which incentives can affect firm value. We also show that our results are not sensitive to the length of the lag between R&D investment and innovation output (Columns (4) to (6)).

Overall, our findings support H3, which suggests that innovation is essential to the long-term survivability of the firm and can be motivated by higher levels of equity-based incentives in the CEO compensation packages.

## Additional analysis and robustness checks

### *Alternative estimation methods*

As a robustness check on our results, we apply structural equation modelling (SEM) to evaluate all relationships presented in Figure 4 in a single framework.[10] Compared to the regression

[10]See He and Wong (2004) for further discussions on the application of SEM.

*Table 5. Future firm value, accounting profitability and mediating effect of innovation*

| Model | (1) | (2) | (3) | (4) | (5) | (6) |
|---|---|---|---|---|---|---|
| Dependent variable | $Q_{t+1}$ | $Patents_{t+1}$ | $Q_{t+1}$ | $Q_{t+2}$ | $Patents_{t+2}$ | $Q_{t+2}$ |
| Equity compensation | 0.361*** | 0.189*** | 0.193*** | 0.193*** | 0.160*** | 0.183*** |
| | (0.048) | (0.039) | (0.062) | (0.049) | (0.044) | (0.068) |
| $Patents_{t+1}$ | | | 0.180*** | | | |
| $Patents_{t+2}$ | | | (0.020) | | | 0.157*** |
| | | | | | | (0.022) |
| Control variables | Yes | Yes | Yes | Yes | Yes | Yes |
| Year dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry dummy | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 17,687 | 6,590 | 6,470 | 15,546 | 5,214 | 5,053 |
| Overall R-squared | 0.139 | 0.391 | 0.145 | 0.096 | 0.400 | 0.108 |

This table presents the relations between innovation, incentive and firm value. Columns (1) to (3) present the three-step regressions of mediating effects of innovation on firm value in the future (t + 1). Columns (4) to (6) present the three-step regressions of mediating effects of innovation on firm value in the future (t + 2). Control variables for CEO and firm characteristics are included. Statistical significance is based on the heteroscedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

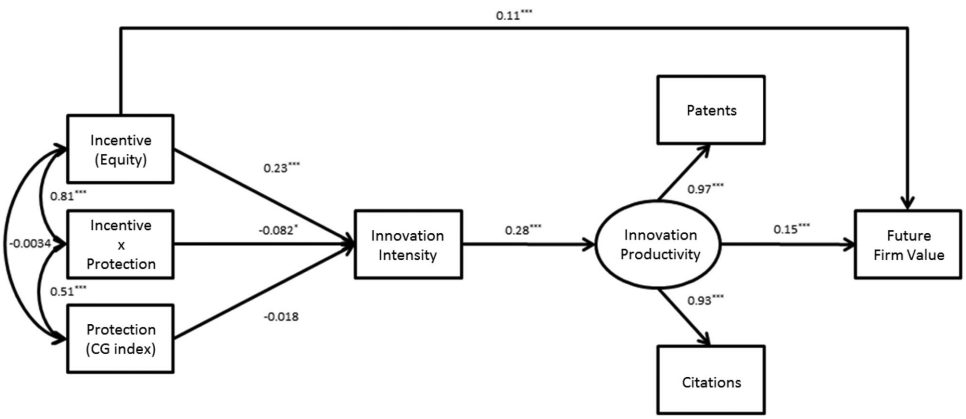


*Figure 4. Structural equation modelling*

analysis, which focuses on a limited number of variables and relationships, SEM is able to evaluate multiple model construct relationships simultaneously (Chen, Bharadwaj and Goh, 2017; Iacobucci, 2009). We map all hypothesized relationships in a path analysis in Figure 4. The observed variables, including protection, incentive, innovation intensity and firm value, are presented in rectangles, while innovation productivity, measured by the number of patents and citations, is a latent construct in oval. All control variables are included in SEM, but omitted in Figure 4 for brevity. We use robust standard errors and standardized estimates. The goodness-of-fit statistics indicate satisfactory model fit: the standardized root mean square residual of our model is 0.041, which is below the benchmark of 0.08 suggested by Hu and Bentler (1999). The path analysis results, which are shown in Figure 4, confirm our findings in the regression analysis. Specifically, incentives have significantly positive effects on innovation intensity and productivity and such effects are weakened by protection. Innovation productivity contributes to firm value, which, in turn, is positively related to incentives. The covariance between incentives and protection is low and insignificant.

### *Alternative measure of incentives and protection*

Table 6 reports the robustness of our results to alternative measures of managerial incentives and takeover protection. Since the 2SLS method alleviates endogeneity concerns and since the causality issue addressed by the system of equations is less of a concern when examining innovation productivity, we choose to report the 2SLS only. Stock

*Table 6. Robustness analysis: alternative measure of incentive and protection*

| Model | (1) Options | (2) Options | (3) Stocks | (4) Stocks | (5) C_board | (6) Golden | (7) Fairprice | (8) Non-CEO | (9) Non-CEO | (10) Non-CEO |
|---|---|---|---|---|---|---|---|---|---|---|
| Dependent variable | $Patents_{t+2}$ | $Citations_{t+2}$ | $Patents_{t+2}$ | $Citations_{t+2}$ | $Patents_{t+2}$ | $Patents_{t+2}$ | $Patents_{t+2}$ | R&D ratio | $Patents_{t+2}$ | $Citations_{t+2}$ |
| Equity compensation | 7.342** | 13.617*** | 44.107 | 52.484 | 3.163* | 6.131** | 3.783** | 0.379*** | 6.642*** | 11.576*** |
| | (2.975) | (4.450) | (96.208) | (122.445) | (1.690) | (2.549) | (1.546) | (0.134) | (2.292) | (3.386) |
| CG index | 0.502* | 1.057** | −0.497 | −0.706 | 2.251 | 3.365** | 1.801 | 0.013 | 0.410* | 0.810** |
| | (0.279) | (0.423) | (0.586) | (0.750) | (1.489) | (1.599) | (1.257) | (0.012) | (0.231) | (0.345) |
| Equity * CG index | −1.560** | −2.877*** | −4.435 | −4.848 | −5.368** | −8.541** | −5.844** | −0.055* | −1.357** | −2.359*** |
| | (0.637) | (0.962) | (16.539) | (21.075) | (2.475) | (3.944) | (2.824) | (0.029) | (0.595) | (0.875) |
| Control variables | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 4,251 | 4,251 | 4,251 | 4,251 | 2,513 | 2,513 | 2,513 | 5,531 | 4,266 | 4,266 |
| F-statistic | 19.637 | 15.949 | 3.263 | 4.136 | 16.964 | 14.155 | 13.614 | 18.698 | 20.882 | 17.604 |

This table reports the regression results with alternative measures of innovation, incentive and protection. The measures of innovation are R&D expense, the number of patents and the number of citations. CEO incentives are measured by the proportion of equity-based compensation in total compensation (Columns (5) to (7)), the proportion of stock options in total compensation (Columns (1) and (2)) and the proportion of restricted stock (Columns (3) and (4)). Columns (11) to (13) are based on the median equity compensation of the executive and non-executives on the board (excluding the CEO). Anti-takeover protection is measured by specific anti-takeover provisions: whether the company has a classified board (Column (5)), whether the company has a golden parachute scheme (Column (6)) and whether the company has fair price provision (Column (7)). In other columns, takeover protection is measured by a corporate governance (CG) index, which reflects firms' use of all anti-takeover provisions. Equity compensation in Columns (8) to (10) is based on board members excluding the CEO. Other control variables, namely return on assets (ROA), Tobin's Q, CEO tenure (in years), capital expenditure-to-total assets ratio (Capital exp), percentage of fixed assets-to-total assets ratio (PPE), Kaplan and Zingales index (KZ index), institutional shareholding percentage (Institutional shareholding), number of analysts following the company (Analysts coverage), debt-to-total assets ratio (Debt ratio) and total assets (Firm size), are also included. A detailed definition of all variables used in our analysis is provided in the Appendix.
Statistical significance is based on the heteroscedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

options have experienced the most remarkable increase over the sample period and are shown to have a stronger link with the long-term stock price performance than other types of compensation (Ryan and Wiggins, 2002). We repeat our analysis using the ratio of stock options to total compensation and the ratio of restricted stock granted to total compensation as alternative measures of CEO incentives (Columns (1) to (4) in Table 5). Consistent with the earlier results, we report a significantly positive association between the percentage of stock options in total compensation and innovation (Columns (1) and (2)). However, Columns (3) and (4) suggest that the percentage of restricted stock in total compensation is not significantly related to innovation. This evidence is consistent with Ryan and Wiggins (2002), who argue that options are more effective than restricted stock in providing long-term incentives and offsetting negative outcomes in the case of unsuccessful R&D investments. The signs and significance of the coefficients on *protection* and the interaction between *incentive* and *protection* are consistent with those in Table 4, indicating that anti-takeover provisions weaken the positive effect of options on innovation.

We also replace the incentive measure in the regressions presented in Table 4 with the CEO's pay-for-performance sensitivity (delta) and then with the wealth to volatility sensitivity (vega).[11] In unreported results, we find that delta does not affect innovation, consistent with Guay's (1999) argument that higher delta increases managers' risk exposure and lowers the propensity for risk taking. However, the significantly positive association between vega and innovation suggests that the increased sensitivity of CEOs' wealth to stock return volatility helps to align managerial risk-taking behaviour with shareholders' interests (Chang *et al.*, 2015; Coles, Daniel and Naveen, 2006). We also show that the interaction term between vega and the anti-takeover measures is negatively and significantly associated with innovation, providing further support for the weakening effect of anti-takeover protection (H2b).[12]

[11] Following others (Chang *et al.*, 2015; Coles, Daniel and Naveen, 2006), we define delta as the dollar change in the CEO's wealth for a 1% change in stock price and vega as the dollar change in the CEO's wealth associated with a 1% change in standard deviation of stock returns.

[12] Further details on these analyses are available upon request.

Next, we investigate whether some protection measures are more effective than others in motivating innovation by using dummy variables for individual anti-takeover provisions instead of the CG index in our regressions. Columns (5) to (7) show that classified board, golden parachute and fair price have a more detrimental impact on the positive relation between incentives and innovation. Other provisions are either statistically or economically insignificant. We also repeat our analysis using the median value of the equity-based compensation of the board of directors as an alternative measure for incentives. Columns (8) to (10) show that the board incentives are significantly positively related to innovation, consistent with Chang *et al.*'s (2015) finding that non-executive stock options spur innovation. Furthermore, the interaction between board incentives and anti-takeover provisions is significantly negative, confirming our earlier findings that anti-takeover provisions dampen the positive effect of incentives on innovation. Thus, our results are not only restricted to the CEO, but the incentives granted to other directors also influence innovation.

### *The role of competition and innovation pressure*

Inspired by Chemmanur and Tian (2017), we also analyse whether a firm's decision to invest in R&D is affected by its competitive environment. We use the Herfindahl–Hirschman index (HHI) to evaluate the degree of competitiveness in a sector (4-digit SIC). We split our sample into two subgroups based on their sector median HHI. Columns (1) to (4) of Table 7 show that the effect of *incentive* on *innovation* is almost exclusive to firms in highly competitive environments (low HHI). The direct effect of protection on innovation is also positive, but only significant for firms in more competitive industries and when R&D expenditure is used as the innovation measure. However, the moderating effect of takeover protection is only significant in the low-HHI subsample, implying that takeover protection encourages managers to shirk even when external competition is high. In Columns (5) to (8), we analyse the effects of *incentive* and *protection* in the subsamples of innovation-active and non-innovation-active industries, using the median number of patents acclaimed by an industry as benchmark. We find that the positive effect of CEO incentives on innovation is only significant in innovation-active industries. In industries where

*Table 7. Product market competition and size effect*

| Model | (1) Low HHI | (2) High HHI | (3) Low HHI | (4) High HHI | (5) Active | (6) Inactive | (7) Active | (8) Inactive | (9) Small & medium | (10) Large | (11) Small & medium | (12) Large |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dependent variable | R&D ratio | R&D ratio | $Patents_{t+2}$ | $Patents_{t+2}$ | R&D ratio | R&D ratio | $Patents_{t+2}$ | $Patents_{t+2}$ | R&D ratio | R&D ratio | $Patents_{t+2}$ | $Patents_{t+2}$ |
| Equity compensation | 0.613*** | 0.229* | 6.268** | 6.612 | 0.635** | 0.008 | 7.458* | −0.767 | 0.692*** | 0.133** | 8.767*** | 2.694 |
| | (0.197) | (0.124) | (3.138) | (5.581) | (0.255) | (0.018) | (4.360) | (1.822) | (0.216) | (0.054) | (3.195) | (12.490) |
| CG index | 0.054** | 0.010 | 0.610 | 0.777 | 0.037 | 0.001 | 0.787 | −0.095 | 0.048* | 0.017** | 0.859** | −0.117 |
| | (0.026) | (0.016) | (0.399) | (0.788) | (0.035) | (0.002) | (0.720) | (0.196) | (0.026) | (0.009) | (0.375) | (2.034) |
| Equity * CG index | −0.116** | −0.027 | −1.446* | −2.124 | −0.074 | −0.002 | −2.299 | 0.196 | −0.112** | −0.031** | −2.467*** | −0.442 |
| | (0.045) | (0.024) | (0.836) | (1.548) | (0.052) | (0.003) | (1.492) | (0.422) | (0.047) | (0.013) | (0.909) | (3.433) |
| Control variables | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Year dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Industry dummy | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| N | 6,963 | 7,188 | 2,308 | 1,942 | 8,296 | 5,918 | 2,688 | 1,563 | 9,135 | 5,079 | 2,951 | 1,300 |
| F-statistic | 37.000 | 37.000 | 28.000 | 28.000 | 25.023 | 0.900 | 17.191 | 1.541 | 12.603 | 1,353.760 | 7.960 | 17.389 |

This table presents the relations between innovation, incentive and protection in various environments. Columns (1) and (3) present the results for the subsample of industries with low concentration, while Columns (2) and (4) show the results from the subsample of firms in highly concentrated industries. Columns (5) and (7) present the results for the subsample of industries with high innovation activity, while Columns (6) and (8) show the results from the subsample of industries with low innovation activity. Columns (9) and (11) present regression results based on the subsample of companies less than or equal to the 66th percentile in size. Columns (10) and (12) are based on the subsample of companies larger than the 66th percentile in size. Control variables for CEO and firm characteristics are included.

Statistical significance is based on the heteroscedasticity robust firm-clustered standard errors reported in parentheses. ***, ** and * indicate significance at 1%, 5% and 10% levels, respectively.

innovation is less important, additional incentives do not spur innovation. Our results also suggest that protection does not have any significant effect in these subsample regressions.[13]

The relationship between equity-based compensation and innovation may be more pronounced among small firms, possibly because these firms are more likely to become takeover targets. We investigate whether firm size affects the relationships between *incentive*, *protection* and *innovation*. We partition the sample into terciles based on total assets and report the results in Table 7 (Columns (9) to (12)). The results pertaining to small and medium firms are consistent with those reported in Section 5.1. We show that *incentive* and *protection* have a positive, but their interaction term has a negative, effect on the R&D expenditure of large firms.[14] Finally, neither *incentive* nor *protection* affects the innovation output of large firms.[15]

## Discussion and conclusions

In Manso's (2011) theoretical framework, the keys to motivate innovation are long-term incentives and protection from failure. However, according to agency theory, entrenched managers are more likely to shirk and underinvest in risky and time-consuming R&D activities. While most studies show that long-term incentives stimulate innovation, existing evidence on the effect of protection on innovation is largely mixed. Some studies show that anti-takeover provisions are detrimental to innovation (Atanassov, 2013; O'Connor and Rafferty, 2012), while others find that takeover protection promotes innovation (Chemmanur and Tian, 2017; Zeng, 2014). In this paper, we provide the first empirical evidence of the moderating effect of incentives and protection on innovation.

Our analysis reveals a significantly positive association between equity-based compensation and innovation, consistent with the literature suggesting that long-term success incentives motivate innovation (Makri, Lane and Gomez-Mejia, 2006; Manso, 2011; Sanyal and Bulan, 2010). However, when incentives and protection are considered together, we find that the latter reduces the ability of the former to promote innovation. This implies that takeover protection encourages risk-averse managers with high equity-based compensation to avoid risky innovation in order to reduce the sensitivity of their compensation portfolios to their firms' stock price movements (Carpenter, 2000; Ross, 2004). Thus, our finding suggests that the discipline of takeover markets is essential for managers who receive high long-term incentives to perform, as intended.

This study also extends the literature by showing that the relationship between takeover protection and innovation depends on the context in which anti-takeover provisions are implemented. Specifically, we find that anti-takeover protections have a positive direct effect and a negative effect when used in conjunction with equity-based compensation. We also show that both these effects are stronger for small firms and in highly competitive environments. The positive effect of protection is stronger in these contexts because protection from opportunistic takeovers is likely to be more important for small firms and firms in highly competitive industries, as these firms are more exposed to takeover threats and expected to invest more in innovation to withstand competitive pressure. Nevertheless, the interactive effect of protection and incentives remains negative and significant even for small firms and firms in highly competitive industries, implying that competition cannot replace takeover threats as a mechanism for reducing managerial shirking. Collectively, our results help explain the mixed evidence documented by existing studies on the innovation effect of anti-takeover amendments (Chemmanur and Tian, 2017; Pugh, 1992). Finally, given the

[13]We also investigate whether our main finding is more pronounced among firms in high-technology sectors. However, we do not find significant relations between innovation, incentive and protection in the reduced sample of companies belonging to high-tech groups. Estimation results can be found in Table B of the Internet Appendix.

[14]The economic significance of *incentive*, *protection* and their interaction term is larger for small and medium firms than larger firms (20.15%, 60.72% and −15.49%, respectively vs. 3.38%, 2.28% and 4.10%, respectively).

[15]We also verify this size effect using alternative model specifications. Consistent with the 2SLS results, the fixed-effects regressions suggest that *incentive* and *protection* only have significant effects on innovation intensity in the small and medium subsample. Similarly, the Poisson regressions indicate that *incentive*, *protection* and their interaction have a significant impact on the number of patents in the small and medium subsample, but only the interaction term is shown to be significant (negative) in the case of large firms. Estimation results can be found in Table C of the Internet Appendix.

ambiguity of innovation's contribution to firm value, we propose innovation as a partial mediator of the relationship between incentives and firm value. In this framework, incentive induces managers to maximize shareholders' wealth. Innovation represents one of the effective approaches that managers can take in order to improve firm value. However, not all innovations can create value. For this reason, we focus our analysis on patented innovation outputs, which has the potential to generate competitive advantage.

This study has practical implications for shareholders, managers and policymakers. It explains how incentives and protection should be used to spur innovation. It shows that equity-based incentives are more likely to stimulate innovation when combined with market discipline and that anti-takeover provisions can motivate innovation when used alone, but not when used in conjunction with equity-based compensation. Companies should be aware of the costs and benefits of anti-takeover provisions. While these provisions mitigate takeover pressure, their hidden costs of management entrenchment are often overlooked and can have a detrimental effect on innovation and future performance. Furthermore, given the crucial role of innovation in promoting economic growth, our results suggest that policymakers should carefully consider the side-effect of anti-takeover laws on innovation. Limited use of anti-takeover laws helps maintain competition in the market, which in turn delivers better innovation performance overall. Lastly, managers and shareholders need to realize that although R&D investment can be a long and uncertain process, the success of innovation, especially when the outputs are protected by patents, can significantly increase firm value. Thus, managers who are compensated by share-based plans can enhance shareholders' wealth by investing in innovative projects with the potential to generate economic rents.

Our empirical analysis is based on a sample of US listed companies. Since the US market has well-developed regulations and laws, particularly in the area of anti-takeover, our results may not be generalizable to other markets without caution. Future studies in the USA or other countries should consider these factors. Furthermore, the finding that anti-takeover provisions reduce the effectiveness of equity-based compensation in promoting innovation does not necessarily suggest that all failure protection mechanisms are detrimental to innovation. For example, Acharya and Subramanian (2009) show that debtor-friendly bankruptcy laws encourage firm-level innovation and Acharya *et al.* (2013) find that stringent labour laws restricting the dismissal of employees lead to more innovation. Future research should focus on whether combining long-term incentives with protection mechanisms other than anti-takeover provisions spurs innovation. Finally, there are at least two important limitations with using patent data: (i) not all innovation outputs are patented (Hall, Jaffe and Trajtenberg, 2001);[16] and (ii) data on patents is only available up to 2010. However, despite these limitations, no other widely available measure can better capture corporate innovation (Griliches, 1992).

[16]Some inventions do not meet USPTO's patentability criteria and other inventors may rely on means other than patents (e.g. secrecy) to protect their inventions.

# Appendix

## Variable definitions

| | |
|---|---|
| Innovation measures | |
| R&D expenditure | Total R&D expenditure ($m) |
| R&D ratio | Total R&D expenditure/total assets |
| Patents | Number of patents applied for by a firm in a year |
| Citations | Number of non-self-citations received on patents applied for by a firm in a year |
| Incentive measures | |
| CEO's total compensation | Total compensation ($000) for the CEO in the firm year |
| CEO's equity compensation | CEO's equity-based compensation/total compensation |
| CEO's stock options | CEO's value of stock options/total compensation |
| Protection measures | |
| CG index | Self-constructed measure for anti-takeover protection |
| Control variables | |
| ROA | Operating income/total assets |
| Tobin's Q | (Market value of equity + book value of assets – book value of equity – deferred tax)/book value of assets |
| CEO tenure | Number of years the CEO has served in the firm |
| Capital exp | Capital expenditure/total assets |
| PPE | Value of fixed assets/total assets |
| KZ index | Kaplan and Zingales index (see Kaplan and Zingales, 1997) |
| Institutional shareholding | Percentage of shares held by institutional investors |
| Analysts coverage | Number of analysts following the firm |
| Debt ratio | Total debt/total assets |
| Firm size | Total assets |

# References


Acharya, V. V., R. P. Baghai and K. V. Subramanian (2013). 'Labor laws and innovation', *The Journal of Law and Economics*, **56**, pp. 997–1037.

Acharya, V. V. and K. V. Subramanian (2009). 'Bankruptcy codes and innovation', *Review of Financial Studies*, **22**, pp. 4949–4988.

Adams, J. D. (1990). 'Fundamental stocks of knowledge and productivity growth', *Journal of Political Economy*, **98**, pp. 673–702.

Ali, A., M. Ciftci and W. M. Cready (2012). 'Market underestimation of the implications of R&D increases for future earnings: the US evidence', *Journal of Business Finance & Accounting*, **39**, pp. 289–314.

Atanassov, J. (2013). 'Do hostile takeovers stifle innovation? Evidence from antitakeover legislation and corporate patenting', *Journal of Finance*, **68**, pp. 1097–1131.

Baker, G. P., M. C. Jensen and K. J. Murphy (1988). 'Compensation and incentives: practice vs. theory', *Journal of Finance*, **43**, pp. 593–616.

Barker III, V. L. and G. C. Mueller (2002). 'CEO characteristics and firm R&D spending', *Management Science*, **48**, pp. 782–801.

Baron, R. M. and D. A. Kenny (1986). 'The moderator–mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations', *Journal of Personality and Social Psychology*, **51**, p. 1173.

Barron, O. E., D. Byard and Y. Yu (2008). 'Earnings surprises that motivate analysts to reduce average forecast error', *The Accounting Review*, **83**, pp. 303–325.

Bayus, B. L., G. Erickson and R. Jacobson (2003). 'The financial rewards of new product introductions in the personal computer industry', *Management Science*, **49**, pp. 197–210.

Buchholtz, A. K. and B. A. Ribbens (1994). 'Role of chief executive officers in takeover resistance: effects of CEO incentives and individual characteristics', *Academy of Management Journal*, **37**, pp. 554–579.

Camisón, C. and A. Villar-López (2014). 'Organizational innovation as an enabler of technological innovation capabilities and firm performance', *Journal of Business Research*, **67**, pp. 2891–2902.

Carpenter, J. N. (2000). 'Does option compensation increase managerial risk appetite?', *Journal of Finance*, **55**, pp. 2311–2331.

Chambers, D., R. Jennings and R. B. Thompson (2003). 'Managerial discretion and accounting for research and development costs', *Journal of Accounting, Auditing & Finance*, **18**, pp. 79–114.

Chang, X., K. Fu, A. Low and W. Zhang (2015). 'Non-executive employee stock options and corporate innovation', *Journal of Financial Economics*, **115**, pp. 168–188.

Chemmanur, T. and X. Tian (2017). 'Do anti-takeover provisions spur corporate innovation? A regression discontinuity analysis', *Journal of Financial and Quantitative Analysis*, https://doi.org/10.2139/ssrn.1572219

Chen, Y., A. Bharadwaj and K. -Y. Goh (2017). 'An empirical analysis of intellectual property rights sharing in software development outsourcing', *MIS Quarterly*, **41**, 131–161.

Choi, S. B., B. I. Park and P. Hong (2012). 'Does ownership structure matter for firm technological innovation performance? The case of Korean firms', *Corporate Governance: An International Review*, **20**, pp. 267–288.

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

Conyon, M. and R. B. Freeman (2004). 'Shared modes of compensation and firm performance: UK evidence'. In D. Card, R. Blundell and R. B. Freeman (eds), *Seeking a Premier Economy: The Economic Effects of British Economic Reforms, 1980–2000*, pp. 109–146. Chicago, IL: University of Chicago Press.

DeAngelo, H. and E. M. Rice (1983). 'Antitakeover charter amendments and stockholder wealth', *Journal of Financial Economics*, **11**, pp. 329–359.

Ederer, F. and G. Manso (2013). 'Is pay for performance detrimental to innovation?', *Management Science*, **59**, pp. 1496–1513.

Eisenhardt, K. M. (1989). 'Agency theory: an assessment and review', *Academy of Management Review*, **14**, pp. 57–74.

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

Foster, R. and S. Kaplan (2011). *Creative Destruction: Why companies that are built to last underperform the market – and how to successfully transform them*. New York: Crown Business.

Francis, B. B., I. Hasan and Z. Sharma (2011). 'Incentives and innovation: evidence from CEO compensation contracts', Bank of Finland Research Paper 17/2011.

Geroski, P., S. Machin and J. Van Reenen (1993). 'The profitability of innovating firms', *The Rand Journal of Economics*, pp. 198–211.

Gillan, S. L., J. C. Hartzell and R. Parrino (2009). 'Explicit versus implicit contracts: evidence from CEO employment agreements', *Journal of Finance*, **64**, pp. 1629–1655.

Griliches, Z. (1992). 'The Search for R&D Spillovers', *The Scandinavian Journal of Economics*, pp. S29–S47.

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

Hall, B. H., A. B. Jaffe and M. Trajtenberg (2001). 'The NBER patent citation data file: lessons, insights and methodological tools', NBER Working Paper 8498.

Hall, B. J. and K. J. Murphy (2002). 'Stock options for undiversified executives', *Journal of Accounting and Economics*, **33**, pp. 3–42.

He, J. J. and X. Tian (2013). 'The dark side of analyst coverage: the case of innovation', *Journal of Financial Economics*, **109**, pp. 856–878.

He, Z. -L. and P. -K. Wong (2004). 'Exploration vs. exploitation: an empirical test of the ambidexterity hypothesis', *Organization Science*, **15**, pp. 481–494.

Healy, P. M., A. P. Hutton and K. G. Palepu (1999). 'Stock performance and intermediation changes surrounding sustained increases in disclosure', *Contemporary Accounting Research*, **16**, pp. 485–520.

Holmstrom, B. (1989). 'Agency costs and innovation', *Journal of Economic Behavior & Organization*, **12**, pp. 305–327.

Hu, L. t. and P. M. Bentler (1999). 'Cutoff criteria for fit indexes in covariance structure analysis: conventional criteria versus new alternatives', *Structural Equation Modeling: A Multidisciplinary Journal*, **6**, pp. 1–55.

Humphery-Jenner, M. (2014). 'Takeover defenses, innovation, and value creation: evidence from acquisition decisions', *Strategic Management Journal*, **35**, pp. 668–690.

Iacobucci, D. (2009). 'Everything you always wanted to know about SEM (structural equations modeling) but were afraid to ask', *Journal of Consumer Psychology*, **19**, pp. 673–680.

Jain, R. (2012). 'Antitakeover protection and R&D expenditure', *The Journal of Business and Economic Studies*, **18**, p. 96.

Jensen, M. C. (1988). 'Takeovers: their causes and consequences', *Journal of Economic Perspectives*, **2**, pp. 21–48.

Jensen, M. C. and W. H. Meckling (1976). 'Theory of the firm: managerial behavior, agency costs and ownership structure', *Journal of Financial Economics*, **3**, pp. 305–360.

Jensen, M. C. and K. J. Murphy (1990). 'Performance pay and top-management incentives', *Journal of Political Economy*, **98**, pp. 225–264.

Jensen, M. C. and R. S. Ruback (1983). 'The market for corporate control: the scientific evidence', *Journal of Financial Economics*, **11**, pp. 5–50.

Kaplan, S. N. and L. Zingales (1997). 'Do investment–cash flow sensitivities provide useful measures of financing constraints?', *The Quarterly Journal of Economics*, **112**, pp. 169–215.

Kim, K., S. Patro and R. Pereira (2017). 'Option incentives, leverage, and risk-taking', *Journal of Corporate Finance*, **43**, pp. 1–18.

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

Lerner, J. and J. Wulf (2007). 'Innovation and incentives: evidence from corporate R&D', *Review of Economics and Statistics*, **89**, pp. 634–644.

Low, A. (2009). 'Managerial risk-taking behavior and equity-based compensation', *Journal of Financial Economics*, **92**, pp. 470–490.

Mahoney, J. M., C. Sundaramurthy and J. T. Mahoney (1997). 'The effects of corporate antitakeover provisions on long-term investment: empirical evidence', *Managerial and Decision Economics*, **18**, pp. 349–365.

Makri, M., P. J. Lane and L. R. Gomez-Mejia (2006). 'CEO incentives, innovation, and performance in technology-intensive firms: a reconciliation of outcome and behavior-based incentive schemes', *Strategic Management Journal*, **27**, pp. 1057–1080.

Manso, G. (2011). 'Motivating innovation', *Journal of Finance*, **66**, pp. 1823–1860.

March, J. G. (1991). 'Exploration and exploitation in organizational learning', *Organization Science*, **2**, pp. 71–87.

Martin, I. (2012). 'On the valuation of long-dated assets', *Journal of Political Economy*, **120**, pp. 346–358.

Masulis, R. W., C. Wang and F. Xie (2009). 'Agency problems at dual-class companies', *Journal of Finance*, **64**, pp. 1697–1727.

Mazzola, E., G. Perrone and D. S. Kamuriwo (2016). 'The interaction between inter-firm and interlocking directorate

networks on firm's new product development outcomes', *Journal of Business Research*, **69**, pp. 672–682.
Narayanan, M. (1985). 'Managerial incentives for short-term results', *Journal of Finance*, **40**, pp. 1469–1484.
O'Connor, M. and M. Rafferty (2012). 'Corporate governance and innovation', *Journal of Financial and Quantitative Analysis*, **47**, pp. 397–413.
Palmon, O., S. Bar-Yosef, R. -R. Chen and I. Venezia (2008). 'Optimal strike prices of stock options for effort-averse executives', *Journal of Banking & Finance*, **32**, pp. 229–239.
Pauwels, K., J. Silva-Risso, S. Srinivasan and D. M. Hanssens (2004). 'New products, sales promotions, and firm value: the case of the automobile industry', *Journal of Marketing*, **68**, pp. 142–156.
Pugh, S. (1992). 'Balancing discipline and innovation', *Manufacturing Breakthrough*, **1**, pp. 9–13.
Romer, P. M. (1987). 'Growth based on increasing returns due to specialization', *The American Economic Review*, **77**, pp. 56–62.
Romer, P. M. (1990). 'Endogenous technological change', *Journal of Political Economy*, **98**, pp. S71–S102.
Ross, S. A. (2004). 'Compensation, incentives, and the duality of risk aversion and riskiness', *Journal of Finance*, **59**, pp. 207–225.
Ryan Jr, H. E. and R. A. Wiggins III (2002). 'The interactions between R&D investment decisions and compensation policy', *Financial Management*, **31**, pp. 5–29.
Sanders, W. G. and D. C. Hambrick (2007). 'Swinging for the fences: the effects of CEO stock options on company risk taking and performance', *Academy of Management Journal*, **50**, pp. 1055–1078.
Sanyal, P. and L. Bulan (2010). *'Innovation, R&D and managerial compensation', Draft Paper, Brandeis University*.
Shleifer, A. and L. H. Summers (1988). 'Breach of trust in hostile takeovers'. In A. J. Auerbach (ed.), *Corporate Takeovers: Causes and Consequences*, pp. 33–68. Chicago, IL: University of Chicago Press.
Solow, R. M. (1957). 'Technical change and the aggregate production function', *Review of Economics and Statistics*, **39**, pp. 312–320.
Sorescu, A. B. and J. Spanjol (2008). 'Innovation's effect on firm value and risk: insights from consumer packaged goods', *Journal of Marketing*, **72**, pp. 114–132.
Stein, J. C. (1988). 'Takeover threats and managerial myopia', *Journal of Political Economy*, **96**, pp. 61–80.
Sun, J., S. F. Cahan and D. Emanuel (2009). 'Compensation committee governance quality, chief executive officer stock option grants, and future firm performance', *Journal of Banking & Finance*, **33**, pp. 1507–1519.
Thanassoulis, J. (2013). 'Industry structure, executive pay, and short-termism', *Management Science*, **59**, pp. 402–419.
Toivanen, O., P. Stoneman and D. Bosworth (2002). 'Innovation and the market value of UK firms, 1989–1995', *Oxford Bulletin of Economics and Statistics*, **64**, pp. 39–61.
Tribo, J. A., P. Berrone and J. Surroca (2007). 'Do the type and number of blockholders influence R&D investments? New evidence from Spain', *Corporate Governance: An International Review*, **15**, pp. 828–842.
Xia, T. and X. Liu (2017). 'Foreign competition and innovation: the mediating role of imitation', *British Journal of Management*, **29**, pp. 464–482.
Xue, Y. (2007). 'Make or buy new technology: the role of CEO compensation contract in a firm's route to innovation', *Review of Accounting Studies*, **12**, pp. 659–690.
Zeng, H. (2014). 'Financial constraints, antitakeover protection, and corporate innovation: an empirical analysis using antitakeover legislation', *Review of Economics & Finance*, **4**, pp. 1–15.
Zhang, Q., L. Chen and T. Feng (2014). 'Mediation or moderation? The role of R&D investment in the relationship between corporate governance and firm performance: empirical evidence from the Chinese IT industry', *Corporate Governance: An International Review*, **22**, pp. 501–517.

Khelifa Mazouz has been Professor of Finance at Cardiff Business School since January 2014. He previously held full-time academic appointments at Bradford School of Management, Aston Business School and Portsmouth Business School. His main research interests are in the areas of corporate finance, corporate governance and empirical asset pricing.

Yang Zhao joined Newcastle University Business School in 2017 following previous full-time academic appointments at Cardiff Business School. His research focuses mainly on the impact of corporate networks on various issues in corporate finance and corporate governance, including executive compensation, mergers and acquisitions, executive turnover and insider trading.

## Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

**Table A.** Sample selection
**Table B.** High technology sectors
**Table C.** Size effect – alternative regression models