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R&D and CEO departure date: do financial incentives make CEOs more opportunistic?

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Abstract

The purpose of this article is to examine whether Research and Development (R&D) expenditure is biased downward because of self-serving behavior of highly incentivized managers. This offers an insight into the general relationship between incentives and opportunism. Using instrumental variables and panel-data methods for a sample of high R&D spenders in the UK, we examine whether R&D is reduced in cases of imminent departure of the CEO. Results show evidence for this but only for the sample above the median in intensity of stock and options in the compensation package. This suggests that opportunism is enhanced by inappropriately strong incentives. The main results are robust to the inclusion of a number of corporate governance variables.

JEL classification: G30, O30

1. Introduction

Research and Development (R&D) is an important strategic commitment by firms, and one that is often seen as epitomizing the firm's strategic approach to risk. In recent years, some attempts have been made to progress an understanding of the R&D decision beyond standard economics-based models and to incorporate variables related to governance, such as concentrated holdings (Hill and Snell, 1988; Lee and O'Neill, 2003; Chirinko *et al.*, 2004), institutional ownership and finance (Bushee, 1998; Hoskisson *et al.*, 2002; Aghion, Van Reenen and Zingales, 2010; Munari, Oriani and Sobrero, 2010; Brossard, Lavigne and Sakinc, 2013), incentive design (Wu and Tu, 2007; Lhuillery, 2011; Manso, 2011), or the impact of financialization (Deakin, 2011; Lazonick, 2012; Mazzucato, 2013; Montalban and Sakinc, 2013; Hopkins *et al.*, 2013; Krafft *et al.*, 2014). The broad thrust of this literature is that innovation studies need to take account of differences in corporate governance "... that do exist and matter significantly for innovation performance" (Belloc, 2012: 835).

This research agenda has yielded some agreed findings. On ownership form, for example, there now seems some agreement that concentrated or institutional holdings increase the patent count rather than the level of R&D expenditure (Aghion *et al.*, 2010). But many other questions such as the strength of managerial opportunism and the effect of high-powered CEO compensation remain controversial (Hoskisson *et al.*, 1993; Bryan *et al.*, 2000; Rajgopal and Shevlin, 2002; Ryan and Wiggins, 2002; Lerner and Wulf, 2007; Sanders andHambrick, 2007; Van Pottelsberghe, Honore and Munari, 2011; Conyon and Peck, 2012).

Managerial opportunism in relation to investment and R&D has been studied extensively within an agency context. The literature is conflicted on whether such opportunism should produce a downward or an upward bias to investments (Hennessy and Levy, 2002; Stein 2003; Aggarwal and Samwick, 2006). On the one hand, managers may pursue projects that enhance their own prestige, power, or incumbency. On the other hand, it may lead to underinvestment as under the "quiet-life" scenario or where managers perceive risky investments less favorably than investors (Bertrand and Mullainathan 2003). There is support for both of these views in the literature with some suggestion that the direction of bias may differ between fixed investment and R&D. For R&D, the dominant view in the agency-based literature is of underinvestment (Eisenhardt, 1989; Hall, 1990; Palley, 1997; Barker and Mueller, 2002).

The agency framework provides one way of understanding a bias to R&D decision-making. But the issue is complicated by the effects that corporate governance reform have had in reducing managerial autonomy, especially in the UK (Roberts *et al.*, 2006). At least since the 1980s there have been institutional changes to governance (briefly summarized in the next section) that have reined in the independence of managers and attempted to align their interest with those of owners. Any analysis of governance effects on R&D has to take account of how the agency issue has been transformed in recent years from a question of simple opportunism to one where opportunism manifests itself by gaming and taking advantage of the new reforms that supposedly have contained the scope for self-interest. Arguably, the incentive structure does not eliminate the agency problem but is responsible for "exacerbating those concerns when managerial reward structures are linked to movements in reported EPS [earnings per share] levels" (Dhanani and Roberts, 2009: 104).

Financial incentives to meet accounting targets such as earnings or EPS are now a central part of corporate governance. Managers may respond to these targets by attempting to smooth or adjust reported earnings e.g. by cutting R&D or investment when earnings targets might otherwise be missed (Bens *et al.*, 2002; Michenaud, 2008). Just as with the standard agency view, the prediction here is underinvestment. A major survey of corporate financial reporting found first that "(. . .) managers are interested in meeting or beating earnings benchmarks primarily to influence stock prices and their own welfare via career concerns and external reputation. . ." (p. 6). Second, they find that in pursuit of those objectives, managers "(. . .) appear to be willing to burn 'real' cash flows [such as turning down profitable investments] for the sake of reporting desired accounting numbers" (Graham *et al.*, 2005: 35). Empirical evidence supporting this proposition has been documented by a variety of sources (Michenaud 2008; Baker and Wurgler, 2012; Smithers, 2013; Cheng and Heng, 2014).

The ability and motivation for self-serving behavior is likely to be strongest for managers close to departure who may be concerned about the final year effect of reported earnings on their final settlement. There is already some support in the literature for a downward bias to R&D spending in the final years of CEO tenure, apparently reflecting attempts to manipulate reported earnings and the share price (Butler and Newman, 1989; Dechow and Sloan, 1991; Roychowdhury, 2006; Cheng and Heng, 2014). Indirect supportive evidence also comes from the finding of more aggressive earnings management by managers near the end of their careers (Kalyta, 2009; Zhang, 2010) and a preference for incremental over patent-seeking investments (Xu and Yan 2014). Others however have rejected the existence of such a horizon effect (Conyon and Florou, 2006; Cazier, 2011).

In this article we test for a horizon effect in relation to R&D under different incentive systems. Specifically, we test the hypothesis that highly incentivized CEOs cut R&D spending toward the end of their tenure to boost earnings. This offers a complementary and perhaps more reliable way to test for such opportunism than the survey-based work of Graham *et al.* (2005), which suggests that managerial opportunism is indeed a concern.

Our work is based on UK data and thus provides a stringent testing environment given that the UK has one of the most shareholder-friendly corporate systems in the world. Managerial opportunism is often taken for granted in the United States which, having flirted with a system that permitted easy hostile takeover in the 1980s, ended up permitting takeover defenses in most states by the decade's end (Holmstrom and Kaplan, 2001; Bertrand and Mullainathan, 2003; Murphy, 2013). By contrast, in the UK, it is harder for management to fend off a hostile bid, poison pills are illegal, and the framework is seen to be more shareholder oriented (Tylecote and Ramirez 2006; Mallin, 2007; Bruner, 2010). In that sense the traditional agency problem is often thought to be less severe in the UK, while shareholder pressure is felt more keenly.

Our intention in this article is not only to establish an empirical regularity in respect of R&D and the CEO departure date. We also hope that our specific investigation can help to inform the ongoing debate on the efficacy of strong financial incentives to align interests as predicted by the principal-agent model. The original literature on horizon

effects dates from the 1970s, a period in which executive remuneration was more modest and where the performance-based element was focused more on bonuses than on equity-based compensation. Our more recent study can complement this older literature by focusing on equity-based pay which is now the primary element of performance pay. To that end, we aim to detect whether any opportunist bias in R&D is influenced by the intensity of CEO equity-based pay.

The aftermath of the financial crisis has seen renewed interest in the potential adverse effects of high-powered compensation for executives, with some consensus that it poses a potential problem. Nevertheless, in the UK, CEO pay growth has continued to exceed average pay in recent years and boards have not actively countered this (High Pay Centre, 2015). There may have been concessions to the need to make pay more responsive to performance e.g. by introducing claw-backs, but the essential role of incentives in driving risk beyond what basic pay contracts can achieve is still very much a dominant view, and robust defenses of this are found in current literature (Cheng *et al.*, 2015; Edmans and Gabaix, 2016). It is therefore of some importance to see whether this approach has the potential to exacerbate agency concerns such as the horizon problem (Bolton *et al*, 2006).

2. Theoretical background

To set the background for our study of opportunism and R&D, we note here two historical developments. First, the emergence and acceptance of the principal-agent foundation for governance reforms, particularly since the 1980s; second, the evolution of performance-based pay into equity-based pay. Later in the article (under "Extended Discussion") we consider a critique of excessively powerful equity-based compensation.

The typical principal-agent model requires an asymmetry whereby the agent works under a complete but unverifiable contract with the principal. A standard result is then that decision rights should belong to the principal because maximizing the non-contracted or "residual" income also maximizes total welfare. However, the execution of these decision rights is not straightforward because of uncertainty in the measurement of outcomes or effort, or different risk attitudes by the two parties. There is thus a challenge to identify a mix of instruments (generally monitoring of the agent or incentives that will align interests) that will produce a result as close to the optimum as possible.

Principals have different ways of motivating and disciplining agent-managers including the managerial labor market (Fama, 1980). Beginning in the 1980s, the process of hostile takeovers, otherwise known as the market for corporate control, and the process of loading managers with debt through the encouragement of high leverage were employed to rein in executive spending plans. Others advocated increased concentration of investor holdings to economize on monitoring costs (Black, 1997). From the mid-1990s, the emphasis changed towards heavily incentivizing managers using a range of equity-based financial instruments (Murphy, 1998). That is now the favored approach in most international business environments.

Since the early 1990s there has been a sharp increase in the total CEO pay in relation to the median worker (Hall, 2003). Much of that pay has been in the form of performance-based pay comprising bonuses, stocks, and options with the latter two components (equity-based pay) reflecting the financial success of the company as measured by its share price (Jensen and Murphy, 2004; Lazonick, 2012). The proportion of equity-based pay in the United States grew from about 10% in 1990 to two-thirds in the dot-com boom and remained at well over 50% in the late noughties with cash compensation having shrunk to a fifth of the total (Hall, 2003; Conyon and Peck, 2012). Equity pay plans have also increased in the UK since the early 1990s and here stock option exercise is dependent on targets for shareholder return (Conyon and Peck, 2012).

Despite the rapid growth in equity-based pay, the theoretical justification for this is more nuanced than might be immediately apparent. Profit-sharing forces managers to share some risk—as in the classic share-cropping model of Stiglitz (1974). However, as only a portion of the total gains are available to the manager, incentives can never be strong enough for complete alignment of interests (Holmstrom, 1989; Tirole, 2006). Some projects with positive returns may thus be rejected even where managers have an equity stake as long as there are private benefits available from the information advantage that executives possess.

In theory, incentive pay should be least relevant to risky investments such as R&D where the quality of inputs cannot easily be inferred from outcomes. In that environment, incentive systems related to observed performance work less effectively than would be the case, for example, with observable piece-work. Nevertheless, empirical analysis shows that financial incentives in the form of shares or options are more prevalent in risky environments than in others, partly because monitoring is also more difficult in such circumstances (Prendergast, 2002). We should be

aware however that, from a theoretical point of view, equity-based incentive pay in this context is not ideal and that it implies very strong incentives which some argue may involve other risks (Hall, 2003). Overall, therefore there is no compelling case that performance-based pay is a solution to the agency problem even if that were regarded as the main or only way to frame the problem of R&D incentives.[1]

3. Short-termism and the R&D decision: hypotheses

In this article we set out first to see whether R&D reflects short-termist opportunist behavior by CEOs and second whether it is amplified by financial incentives in the form of intensity of equity-based compensation. The R&D decision is susceptible to short-termism because it is characterized by returns that are difficult to estimate and to communicate, due to novelty, lack of comparative benchmarks, complexity, long gestation periods, and secrecy (Tylecote and Ramirez, 2006; Mina *et al.* 2013).

Given this environment, even non-opportunist CEOs may be inclined to invest less than optimally in R&D because the long-term and uncertain returns to R&D cannot be credibly communicated to other investors (David *et al.*, 2001; Chung and Talaulicar, 2010). Even where CEOs act in long-term shareholders' interests, if they believe the market focuses on the current stock price, then, their "rational response" is to reduce investment that yields returns at long horizons; failure to do so may depress the stock price in the short-term (Stein, 1989; Polk and Sapienza, 2009). Indeed, the short-run effect may also prove permanent. Bushee (1998) argues that failure to attend to short-run pressure makes the firm vulnerable in the event of a need to raise equity or the threat of a takeover bid. The underlying problem here may be said to one of financial markets rather than company governance because such markets tend to favor short-term results when liquidity is valued highly (Chirinko *et al.*, 2004).

In this article our empirics are focused on the specific issue of a bias introduced by opportunist CEOs seeking to take advantage of private information by hidden action viz. the manipulation of earnings so as to meet board expectations or targets set by analysts who follow the company. Such behavior—including the cutting of R&D to adjust reported earnings—can benefit managers financially, especially where their rewards are linked to profitability or to the current stock price (Bushee, 1998: 308; Murphy, 1998; Ghosh *et al.*, 2007; Zhang and Gimeno, 2010; Gentry and Shen, 2013; He and Tian, 2013).

One way to test for such opportunist behavior by senior managers is to examine how they behave when there is most at stake. It has been argued that just prior to departure, a "no tomorrow" attitude may motivate CEOs to reduce investment in R&D to boost immediate earnings and the level of the separation package (Dechow and Sloan, 1991; Kalyta, 2009). By observing R&D expenditure decisions just before departure, it should be possible to detect opportunistic behavior. Of course the characteristics of the CEO at departure will also be relevant, resulting in a need to treat departure as an endogenous variable. We have data that allow us to observe R&D expenditure in the years that bracket the departure of CEOs. Our simple proposition is that CEOs reduce R&D in the period immediately before departure to raise the short-term reported profitability of the company and reap personal benefits. This leads to our first hypothesis.

Hypothesis 1. CEOs facing imminent departure will reduce R&D expenditure.

Any effect of imminent CEO departure on R&D should be amplified by the intensity of performance-based compensation in place. As observed earlier, the major trend in recent years has been to increase the proportion of equity-based pay in CEO remuneration. Accordingly, we use a split sample based on median intensity of equity-based pay and examine the departure effect for both of these sub-samples.[2] This explains our second hypothesis.

1 For a survey and critique of the agency approach, see Belloc (2012) and Driver (2012).

2 See Core *et al.* (2003) for a survey of forms of managerial compensation. The complex effects of equity-based compensation are examined from a financial economics framework in Coles *et al.* (2006) and Shen and Zhang (2013), where the separate effects of remuneration in stock or by option grants are analyzed. Standard stock-based compensation will involve sharing both upside and downside risk. By contrast, the effect of stock-option compensation is to expose managers only to upside risk. Expected gains from options rise with risk, but the utility of these gains depends on managers' risk aversion. The overall effect on inputs thus depends on the interaction of positive option effects and negative risk aversion effects. Potentially, due to their nonlinear effects, options can have a greater influence on risky input decisions than simple stock-based compensation. A complication here is that risk aversion may itself be endogenous to the share

Hypothesis 2. The effect in H1 will be stronger for CEOs with a high intensity of equity-based pay.

Corporate governance practices may also have a direct impact on the R&D spend. Under standard principal-agent theory, appropriate controls and incentives should be designed to counter any reluctance of managers to incur risk. Opportunism in managing earnings may be limited by governance measures such as board composition and structure (Baysinger et al., 1991; Kor, 2006; Farrell *et al.*, 2013) though the literature generally records ambiguous findings (Zattoni and Pugliese, 2012).[3] The debate over whether certain forms of institutional investor may underpin better governance or simply contribute short-term pressure is also unresolved (Burkart *et al*, 1997; Belloc, 2013). Performance pay intensity has been argued to positively influence R&D, particularly in the presence of high risk or high slack (Wu and Tu, 2007). Consistent with the latter, Eng and Shackell (2001) find an effect on CEO risk-taking for equity-based pay. Other work shows a similar effect for indicators of executive stakeholding (Conyon and Peck, 2012; Esilä *et al.*, 2013). Lhuillery (2011), however, finds no effects of compensation on R&D. Furthermore, several studies find that some governance practices, including high-powered incentives, are in fact *negative* for investment or R&D (Bauer *et al.*, 2008; Driver and Guedes, 2012), possibly reflecting a greater short-term focus for firms (Deakin, 2013).

Hypothesis 3. Governance measures such as board oversight, ownership, or performance pay will be associated with higher R&D through mitigating the principal-agent problem.

The rest of the article is organized as follows: the next section constructs a specification for the R&D equation and shows how opportunism can be tested. Sample and data issues are then detailed, followed by the empirical results, robustness tests, discussion, and conclusions.

4. Model specification

We first test the hypothesis that CEOs cut R&D spending toward the end of their tenure to boost earnings. Our dependent variable is the ratio of R&D expenditure to sales (R&D intensity). We focus on innovation expenditure rather than an outcome measure such as patents because it is easier to interpret in a way that is directly linked to incentives.[4] Sales is chosen as the denominator because it is an indicator of future prospects that R&D investment tends to track (Klette and Griliches, 2000; Coad and Rao, 2010) and because it is an index of internal funds that can constrain R&D (Mina *et al.*, 2013). We adopt a basic specification for R&D expenditure that embeds a long-term target R&D-to-sales ratio in a dynamic adjustment equation. This model is fairly standard in the economics and innovation literature (Mairesse *et al.*, 1999; Bond *et al.*, 2005; Guellec and De la Potterie, 1997; Driver and Guedes, 2012). We supplement it with a control variable for size that has frequently been used (Barker and Mueller, 2002; Bogliacino and Pianta, 2013). Finally, we include a binary dummy variable for CEO departure in the following year. The basic specification is shown in equation (1) where the coefficient β_1 represents the disequilibrium adjustment or "correction" term (with an expected negative coefficient) that represents the assumed intent to keep R&D in line with sales.

of their wealth that managers have concentrated in their own firm, and cumulative gains from successful innovation may increase risk aversion (Ryan and Wiggins, 2002). Contrariwise, risk aversion may decrease due to managerial entrenchment rising with R&D (Beyer *et al.*, 2012). It is therefore hard to specify an exact functional form relating incentives to performance and it is difficult to identify separate effects for the different components of equity-based compensation. This conclusion is strengthened if we extend consideration to behavioral theory e.g. where prospect theory treats gains and losses separately; it is then more difficult to adopt an *a priori* view of the separate effects of simple stock and stock options and we do not attempt to do so in this article (Devers *et al.*, 2008).

3 Earlier work also found conflicting evidence on the relationship between governance and performance with Core *et al.* (2006) finding counter-evidence to the claim in Gompers *et al.* (2003) that stock market underperformance was caused by weak governance.

4 Furthermore much patenting activity is defensive (Ziedonis, 2010) and thus may need to be understood differently from the R&D decision. Patenting success is also due to scientific effort, and in this article we focus only on direct pecuniary incentives of managers rather than on non-pecuniary incentives for scientists that have been argued also to affect their productivity (Sauermann and Cohen, 2010; Lacetera and Zirulia, 2012).

$$\Delta \ln\left(\frac{R\&D}{Sales}\right)_{i,t} = \alpha_0 + \beta_1 \ln\left(\frac{R\&D}{Sales}\right)_{i,t-1} + \beta_2 (Departure)_{i,t} + \beta_3 \ln(Size)_{i,t} + u_i + e_{i,t} \quad (1)$$

The variables employed in equation (1) are standard official R&D expenditure and sales figures, with size measured by employment. The variable Departure is a dummy variable that is equal to 1 if the CEO leaves the firm in year $t+1$ when the current year is t. We use this variable to test if R&D is lowered in the final year of the CEO's tenure (i.e. that the coefficient β_2 is negative) as might be expected under the hypothesis of strong opportunism (*H1*) and especially if a good earnings figure were important for the CEO's final year reward (*H2*).

For our approach to make sense, we have to assume that the CEOs have some idea of their departure date. Our initial data do not permit a split between voluntary and involuntary departures so that we will need to instrument the Departure variable so as to render it as an expected variable with at least some determinants observable at $t-1$. It is likely that Departure is itself determined by other CEO and firm characteristics and so we take account of endogeneity by instrumenting Departure by variables such as age, tenure, and shocks to performance. The former two variables are standard in the literature (Murphy and Zimmermann, 1993; Barker and Mueller, 2002; Huson *et al.*, 2001). The profit shock variable is measured by the difference between analyst mean forecast and outcome values of EBITDA scaled by sales. It is intended to capture the pressure on CEOs to depart when they are not performing according to shareholders' expectations.

We also address the influence of governance procedures on R&D which will operate simultaneously to any departure effect. These procedures are labeled by the generic term "Index" in equation (2). In this extended specification, the expected sign of β_4 is expected to be positive under Hypothesis H3 if the agency perspective is correct.

$$\Delta \ln\left(\frac{R\&D}{Sales}\right)_{i,t} = \alpha_0 + \beta_1 \ln\left(\frac{R\&D}{Sales}\right)_{i,t-1} + \beta_2 (Departure)_{i,t} + \beta_3 \ln(Size)_{i,t} + \beta_4 (Index)_{i,t} + u_i + e_{i,t} \quad (2)$$

Where "Index" is a generic term corresponding to five separate governance measures that will be tested for, viz: Index A is an indicator of CEO ownership; Index B records the intensity of total performance pay in CEO remuneration; and Indices C–E comprise standard measures of board oversight in respect of board size, non-executive directors, and institutional ownership. Further details are given in the "Results" section and in the footnote to Table 5.

5. Sample and data

Our sample consists of an unbalanced panel of the top 100 R&D spenders (averaged over the sample years) in manufacturing and services (excluding financial firms) in the UK. Our full data period is 2000–2006 which corresponds to an interval between the year in which the UK corporate governance code (the "combined code") was put into statute and the last year before the turbulence preceding the financial crisis emerged in the UK with the failure of the Northern Rock Bank. As we use a 1-year lead in some variables, the R&D data are estimated for the 6 years 2000–2005. After inspection of the data, we excluded 12 firms due to inconsistency or missing values for R&D. Although it may be that these firms did not perform any R&D in that year, we think it is quite unlikely, as the sample is composed of the top R&D spenders. Hence, following Bond *et al.* (2005), we excluded this set of observations. Furthermore we excluded as probable outliers three observations where R&D to sales ratios are higher than 100%. The final sample consists of 88 firms and 505 year observations. Firms are predominantly from the Electronic and Electric equipment, Software and Computers and Pharmaceuticals sectors (totaling 33 firms and 37.5% of total sample). The whole sample accounts for about three-quarters of total R&D expenditure by UK business and is equivalent to about half of the gross domestic expenditure on R&D.

Data on R&D, sales, and employees were downloaded from Datastream. With these variables, we calculate R&D intensity (ratio of R&D to sales). Table 1 shows a mean of 7.28% for R&D. The period contains reasonable time variation with mean yearly R&D intensity varying from 6.12% to 7.79%.[5] Size is defined as the log (ln) of

5 In Table 1, the range of values shown is for observations, not the mean values for individual firms. The observation with 88 employees refers to a specialized pharmaceutical company that was established in the UK in 1995 and grew rapidly. The 88 employees are for the first year in our sample but subsequently employment and R&D grew exponentially. The observation for £1.6 million is for a high-technology informatics and services company. The figure of £1.6 million is for the first year in the sample—it doubled in the next year and subsequently achieved an R&D intensity of about 10%.

Table 1. Definition, data sources, and descriptive statistics of the variables

Variable	Definition	Data source	Mean	Median	Minimum	Maximum	S.D.
		Variables used in Tables 3–6					
R&D (£'000)	Expenditure on R&D.	Datastream	113,151	13,200	1610	3,136,000	386,839
R&D intensity (%)	Ratio of R&D to sales.	Calculated	7.28	4.04	0.08	83.37	10.02
Employees	Employees.	Datastream	20,749	4642	88	295,000	41,251.5
Profit_shock	Difference between the mean forecast values (by financial analysts) of EBITDA and the actual EBITDA, scaled by sales.	IBES and Datastream	0.001	0.000	−0.026	0.099	0.009
CEO tenure	The total length of time that the CEO has been in the firm.	Calculated (from Manifest)	4.99	4.00	1	29	4.81
CEO age	CEO age in the end of the year.	Manifest	51.67	52	31	72	6.89
Departure	Dummy variable that is equal to 1 if the CEO leaves the firm in the year $t+1$ and this is year t.	Calculated (from Manifest)	0.12	0	0	1	0.33
Index_A (CEO ownership)	Dummy variable for the case where the CEO has more than 1% of the total stock of the company.	Calculated (from Manifest)	0.18	0	0	1	0.38
Index_B (performance pay intensity index)	Sum of two dummy variables. The first is Bonus, that is equal to one if total bonus payment to total compensation is $>20\%$. The second dummy is Stock and Options, equals one if this type of payment exceeds 30% in total compensation. The thresholds are inferred from Conyon et al. (2013).	Manual/ Calculated (from Manifest)	0.59	1	0	2	0.60
Index C (board size)	Number of directors	Calculated (from Manifest)	8.66	8	2	21	3.27
Index D (nonexecutive directors)	Dummy variable (= 1 if a clear majority of directors are nonexecutive)	Calculated (from Manifest)	0.56	0.57	0	1	0.16
Index E (institutional ownership)	Dummy variable (=1 if the largest stake [of at least 5%] is an institutional one held by an insurance companies, bank, pension fund, or investment company)	Calculated (from Manifest)	0.097	0.096	0	0.545	0.081

employees. Other financial information was extracted from Datastream, including return on assets and a "profit shock" variable obtained from the Datastream companion database IBES. This measures the deviation of profitability from the mean predicted by participating stock analysts.[6] Departure information, performance pay details, board characteristics, and CEO attributes such as age and tenure were obtained by purchased access to the Manifest global

Winsorizing the data at 1%, which removes these and other outliers, produced similar estimates, with identical conclusions to those reached without this process.

6 The Institutional Brokers Estimate System (I/B/E/S) is a global database of analysts' forecast earnings per share, cash flow per share, dividends per share, and net profits per share plus additional measures such as sales, EBIT, and EBITDA.

Table 2. Correlation matrix

Variable	1	2	3	4	5	6	7	8	9
1 R&D intensity	1								
2 Lag R&D intensity	0.9154***	1							
3 Size	−0.524***	−0.530***	1						
4 Profit shock	0.133**	0.112***	−0.064	1					
5 CEO tenure	0.040	0.059	−0.042	−0.045	1				
6 CEO age	−0.107**	−0.072	0.266***	−0.099*	0.250***	1			
7 Departure	−0.042	0.003	0.036	−0.015	0.052	0.158	1		
8 CEO ownership (Index A)	0.240***	0.239***	−0.404***	0.022	0.303***	−0.216***	−0.044	1	
9 Performance pay (Index B)	−0.029	−0.066	0.157***	0.012	−0.049	0.015	−0.016	−0.219	1

*$P < 0.10$; **$P < 0.05$; ***$P < 0.01$.

proxy governance and voting service database.[7] Table 1 details the exact data source of each variable reported in the results tables and includes descriptive statistics for these variables. Table 2 presents a correlation matrix for the variables reported in the results tables.

6. Estimation results

We use fixed-effects instrumental variable panel-data estimation, using different sets of instruments for the departure variable as noted in the results tables for each of the columns. Table 3 presents the results of the basic model.

In Columns 1–3 the main results are presented; these confirm that the model is well determined. The correction term (β_1) is correctly signed and highly significant showing a tendency for R&D to track sales closely. Size is insignificant. The departure variable is negative and significant at least at the borderline 10% level for all three sets of instruments, and at the 5% level in one, suggesting the presence of opportunistic managers. The endogeneity of departure and the need for IV estimation is confirmed by the Hausman statistic being significant or borderline significant in all cases. The instrumental variables used are independent of the estimators as indicated by the Sargan–Hansen test. Additional Sargan C-tests do not show any problem with the individual instruments. Column 4 repeats the analysis using a 2-year horizon.[8] The results are similar with a 10% significance level for departure, which may not be surprising given the shorter sample size needed for this sample. Overall these results support Hypothesis *H1*.

It is of interest to see whether the negative effect of the CEO's imminent departure on R&D operates uniformly across different remuneration systems. Were opportunism to be the cause of the observed effect we should anticipate that a higher component of compensation in the form of equity-based pay would correspond to a stronger negative relationship than otherwise between departure and R&D, on the maintained assumption that managers are able to manipulate the share price upward by cutting R&D. To test for the presence of such opportunism, we split the sample into two at the median level of equity-based pay (shares and options) as a proportion of total remuneration. Results for both samples are shown in Table 4.

The results here again support the opportunism arguments. Managers whose pay is skewed more toward high-powered compensation appear to be those whose imminent departure triggers a fall in R&D. The coefficient on departure for the "above" group—those above median levels of stock and options intensity in compensation—is consistently and significantly negative (now at the 5% level) while that for the below group is positive. It is hard to think of another clear explanation apart from opportunism for this finding. Hypothesis *H2* is supported.

7 Manifest—Global Governance and Voting Solutions is a Europe-wide shareholder voting and corporate governance support service that aims to support shareholders' global stewardship responsibilities with comprehensive research and voting services (http://www.manifest.co.uk/). Manifest's governance data have been used in previous governance research studies such as Conyon and Sadler (2010) and Ferri and Maber (2013).

8 In Dechow and Sloan (1991) a reduction in R&D growth was identified up to 2 years prior to departure, and a longer horizon is also reported in several other studies (Cazier, 2011).

Table 3. Testing Hypothesis 1

Variables	(3A)	(3B)	(3C)	(3D) 2 years horizon
$\ln\left(\frac{R\&D}{Sales}\right)_{i,t-1}$	−0.6103***	−0.5041***	−0.6159***	−0.7142***
	(−4.9845)	(−4.9985)	(−4.5748)	(−8.6303)
$\ln(Size)_{i,t}$	0.0001	−0.0039	0.0481	0.0358
	(0.0007)	(−0.0482)	(0.5329)	(0.3017)
Departure	−0.2769*	−0.2216	−0.3390**	−0.3202*
	(−1.9591)	(−1.6394)	(−2.0225)	(−1.6656)
Sargan–Hansen	0.2984	0.5798	0.7015	0.2258
Hausman endogeneity test	0.0734*	0.0602*	0.1046	0.1314
Exogeneity/orthogonality				
Age C-statistic	0.2984	0.4204	0.3272	0.2258
Tenure C-statistic	0.2984	0.3881	0.6924	0.2258
Lag departure C-statistic			0.7178	
Profit shock C-statistic		0.4783	0.5418	
F test	0.0000	0.0001	0.0003	0.0000
Number of observations	403	356	355	316
Additional IV	Age	Age	Age	Age
	Tenure	Tenure	Tenure	Tenure
		Profit shock	Profit shock	
			Lag departure	

Notes: The dependent variable is $\ln\left(\frac{R\&D}{Sales}\right)_{i,t}$.

Estimation was carried out on STATA 11 using the command XTIVREG 2 for FE. Robust estimates are reported. In parentheses are the robust z statistics. F test is the *P* value for the overall test of significance. Departure is endogenous. The Sargan–Hansen test reports the *P* value for the validity of the instruments. The Hausman endogeneity test reports the *P* value for the exogeneity of the regressors. The Sargan C-statistic reports the *P* value that the particular subset of the model's overidentifying restrictions (associated with individual instruments in this case) are satisfied as assumed under the null. Significance levels: $*P < 0.10$; $**P < 0.05$; $***P < 0.01$.

Table 4. Testing Hypothesis 2—split by equity-based pay

Variables	(4A) Above median	(4B) Below median	(4C) Above median	(4D) Below median	(4E) Above median	(4F) Below median
$\ln\left(\frac{R\&D}{Sales}\right)_{i,t-1}$	−0.8047***	−0.7234***	−0.6054***	−0.7233***	−0.8172***	−0.7055***
	(−5.1853)	(−6.5018)	(−4.7278)	(−6.4891)	(−5.1223)	(−6.1353)
$\ln(Size)_{i,t}$	0.2868***	−0.1889*	0.2404**	−0.1884*	0.3007**	−0.1302*
	(2.4674)	(−1.7921)	(2.1933)	(−1.7847)	(2.4124)	(−1.8462)
Departure	−0.3287**	0.2293	−0.2559**	0.2335*	−0.4053**	0.1681
	(−2.3990)	(1.6429)	(−2.0538)	(1.6633)	(−2.5699)	(1.1608)
Sargan–Hansen	0.3116	0.4601	0.4671	0.1177	0.2553	0.0675*
Hausman endogeneity test	0.0493**	0.0442*	0.1686	0.0605*	0.0505*	0.2828
Exogeneity/orthogonality						
Age C-statistic	0.3116	0.4601	0.2906	0.2970	0.1446	0.8468
Tenure C-statistic	0.3116	0.4601	0.7605	0.9503	0.1115	0.1089
Lag departure C-statistic			0.6110	0.0532*		
Profit shock C-statistic					0.4752	0.0225*
F test	0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
Number of observations	192	171	189	171	178	144
Additional IV	Age	Age	Age	Age	Age	Age
	Tenure	Tenure	Tenure	Tenure	Tenure	Tenure
			Lag departure	Lag departure	Profit shock	Profit shock

See notes to Table 3.

Table 5. Effects of CEO ownership, performance pay, and other governance measures

Variables	(5A) CEO ownership	(5B) Performance pay	(5C) Board size	(5D) Ratio nonexecutives	(5E) Institutional ownership
$\ln\left(\frac{R\&D}{Sales}\right)_{i,t-1}$	−0.6191***	−0.6224***	−0.6181***	−0.6163***	−0.6031***
	(−4.5624)	(−4.6457)	(−4.6055)	(−4.5735)	(−4.1272)
$\ln(Size)_{i,t}$	0.0549	0.0614	0.0429	0.0431	0.0494
	(0.5909)	(0.6718)	(0.4675)	(0.4880)	(0.5492)
Departure	−0.3422**	−0.3282*	−0.3370**	−0.3319**	−0.3195*
	(−2.0023)	(−1.9016)	(−2.0541)	(−1.9760)	(−1.8824)
Index_I	0.3915*	−0.0577	0.0046	−0.1325	−0.0018
	(1.9165)	(−1.6444)	(0.4368)	(−0.8136)	(−0.5687)
Sargan–Hansen	0.5918	0.5776	0.5744	0.5837	0.5550
Hausman endogeneity test	0.0608*	0.0773*	0.0620*	0.0710*	0.0716*
Exogeneity/orthogonality					
Age C-statistic	0.5098	0.4221	0.4288	0.4055	0.3786
Tenure C-statistic	0.4460	0.3934	0.3268	0.3788	0.3440
Profit shock C-statistic	0.4078	0.4700	0.4749	0.4990	0.4770
F test	0.0004	0.0001	0.0003	0.0003	0.0020
Number of observations	353	353	355	355	352
Additional IV	Age	Age	Age	Age	Age
	Tenure	Tenure	Tenure	Tenure	Tenure
	Profit shock	Profit shock	Profit shock	Profit shock	Profit shock

See notes to Table 3.

Each column (A)–(E) has Index (.) defined differently where the column number is (.). In terms of the definitions, Index A is defined as a dummy variable for the case where the CEO has more than 1% of the total stock of the company; Index B is sum of two dummy variables. The first is Bonus, that is equal to 1 if total bonus payment to total compensation is >20%. The second dummy is Stock and Options, equals 1 if this type of payment exceeds 30% in total compensation; Index C is the board size (number); Index D is a dummy variable equal to 1 if a clear majority of directors are nonexecutive; Index E is an indicator of institutional ownership formed by multiplying the largest institutional owner stake by a dummy taking the value of 1 if the main shareholder has more than 5% of stock and is an institutional shareholder such as a life insurance, pension, or mutual fund.

We next consider Hypothesis *H3*. In Table 5 we repeat the analysis of Table 3, entering as additional variables, a number of governance variables often used in the literature. Governance measures may affect R&D positively or negatively as discussed earlier. Corresponding to the specification in equation (2) we use five governance measures. Index A is an indicator of CEO ownership, taking the value of 1 for the case where the CEO has more than 1% of the total stock of the company and zero otherwise. Index B records the intensity of total performance pay in CEO compensation (bonus and equity-based pay as a proportion of the total). The remaining three variables are standard measures of board oversight in respect of board size, non-executive directors, and institutional ownership. Index C is the size of the board (total members); Index D is an indicator =1 if a clear majority of directors are non-executive; and Index E is an indicator of institutional ownership formed by multiplying the largest institutional owner stake by a dummy =1 if the main shareholder has more than 5% of stock and is an institutional shareholder such as a life insurance, pension, or mutual fund. The justification for the latter variable is that institutions with large stakes may be thought to be more effective monitors in countering R&D opportunism (Bushee, 1998).[9]

The results in Table 5 show that the earlier estimated coefficients remain broadly stable. The first column shows Index A, CEO ownership, to be positively significant at 5%, consistent with support for H3 that incentives matter as a component of governance. However, the finding also fits with other explanations such as relative independence or entrenchment of the CEO that is a buffer against short-term pressure from owners. For Index B (total performance pay intensity) we find a *negative* sign that is just short of robust significance at the 10% level. While the standard assumption is that performance-based incentives result in common objectives for managers and owners and should

9 Institutional ownership may be argued to support innovation where there is concentrated ownership, reducing the free-rider problem but it may be argued that the sign of the effect is conditional on industry attributes such as technology level and asset specificity (Belloc *et al.*, 2016).

correct any tendency to R&D underinvestment, others have argued that it allows well-informed managers to intensify any existing tendency to short-termism. The negative sign observed here is inconsistent with *H3*.

None of the other governance variables reported in the last three columns came close to significance and a joint test could not reject their exclusion in the specification (Chi^2 (3) = 1.04 with a *P* value of 0.79). We also entered the simple dummy for institutional ownership (without multiplying by the actual percentage stake) in place of Index E but that too was insignificant. Variants of Index C (using a threshold size of 10) and Index D (using the raw percentages) were also found to be insignificant.

Overall, there is therefore only limited evidence for hypothesis H3.

7. Robustness checks

We carried out a number of robustness checks on the estimation. In particular, we considered seven issues.

i. *Additional endogeneity review*. It is not always possible to convincingly deal with endogeneity using instrumental variables. That is an important concern in this article where it may be argued that some results—in particular the negative coefficient on departure—could be interpreted as simply a coincidence of poor performance, low R&D, and a consequent forced CEO departure, so that impending departure's negative effect on R&D would not necessarily be due to opportunism. While we have sought to guard against such a confounding influence by the use of instruments to control for performance, we recognize the need for additional confirmation. To implement a robustness check, we examined individually the reports on each of the 62 departures in news sources such as Bloomberg. Five departures were identified as possibly resulting from board pressure (forced resignations) such as the case of Oxford Instruments or Shire.[10] For such cases it would be reasonable to assume that R&D may have been constrained by poor performance and it would be hard to attribute low R&D to agency effects. Further evidence that this may indeed be the case was obtained by examining the share-price reaction around the day of the announcement, which was generally in advance of the departure date. Using a 5-day event window around the announcements, we computed the differential between the firms' daily closing share-price percent change and that of the TechMark index of innovative and technology firms on the London Stock Exchange (INDEXFTSE:T1X). The price of shares averaged over the affected companies, relative to the index, fell on the announcement by 2.26% but then recovered sharply with a rise of 3.34% over the following 2 days, so that despite the turmoil, shareholders seemed content with the move. If these departures were indeed seen as positive, the presence of such firms in the sample might complicate the testing of agency effects.[11] We thus omitted these cases from the sample, obtaining results shown in Columns 1 and 2 of Table 6. The main results continue to hold.

ii. *Restriction on the profit shock*. Arguable the profit shock instrumental variable would be better entered as a negative shock only. This restriction has little impact on the results as shown in the final two columns of Table 6.

iii. *Consideration of bonus pay*. We constructed our split sample in Table 4 using equity-based compensation, as this has been the dominant form of reward during the sample period. It could be argued that the bonus element of pay is an important separate motivator and one which is more short-term in its effects than equity-based pay. However we found no support for this when replicating the analysis with the sample divided into above and below median bonus intensity.

iv. *Anticipatory board action*. It is possible that the results could be affected by board action in adjusting performance pay in anticipation of the CEO departure (Cheng, 2004). In our data, future departure and the index

10 The identification of five firms of 88 with forced retirement may be compared with other similar studies. A rather lower figure of 2.3% was observed for a large sample of US firms between 1994 and 2005, with a peak rate of just over 5% in 2000 (Gao *et al.*, 2012). On the other hand, a French study reported the incidence of overt forced retirements at 10% of all departures (which would predict six in our case) and suggested that the true number might be higher (Dherement-Ferere and Renneboog, 2002).

11 The fifth firm, now delisted, was examined by press reports. It also saw its share price fall after the announcement—in this case coincident with a profit warning. However, the appointment of a new CEO within 2 weeks was reported as having raised the share price by 3%.

Table 6. Robustness tests

Variables	(6A) Above median, excluding forced departures	(6B) Below median, excluding forced departures	(6C) Above median omitting positive profit shock	(6D) Below median omitting positive profit shock
$\ln\left(\frac{R\&D}{Sales}\right)_{i,t-1}$	−0.8368***	−0.7511***	−0.8127***	−0.7016***
	(−5.2303)	(−5.7702)	(−5.1624)	(−5.9927)
$\ln(Size)_{i,t}$	0.3420**	−0.1399*	0.2932**	−0.1337*
	(2.5244)	(−1.9387)	(2.4042)	(−1.7188)
Departure	−0.4812***	0.1878	−0.3815***	−0.0508
	(−2.6938)	(1.2499)	(−2.6005)	(−0.3594)
Sargan–Hansen	0.5247	0.0370**	0.2759	0.0029***
Hausman endogeneity test	0.0114**	0.1989	0.0726*	0.8337
Exogeneity/orthogonality				
Age C-statistic	0.2964	0.6504	0.2780	0.8637
Tenure C-statistic	0.2676	0.0687*	0.1191	0.0050***
Profit shock C-statistic	0.6504	0.0136**	0.2325	0.0007***
F test	0.0000	0.0000	0.0000	0.0000
Number of observations	166	137	178	144
Additional IV	Age	Age	Age	Age
	Tenure	Tenure	Tenure	Tenure
	Profit shock	Profit shock	Profit Negative shock	Profit Negative shock

See notes to Table 3.

of performance pay are not significantly correlated, suggesting no anticipated additional influence of the board (Table 2). Furthermore a set of regressions of performance pay (either equity-based intensity or bonus intensity) on their own lag and the departure did not reveal significance for current or future departure, suggesting again that there is no evidence that compensation design is adapted for years of departure. This is perhaps not surprising, at least for the UK context, since it appears that the major corporate governance reforms culminating in the combined code have not resulted in closer involvement in decision-making by the board (Dedman, 2003).

v. *Model specification*. R&D and investment equations sometimes include measures of investment opportunity and profitability. The most common approach is to use Tobin's Q. It has proved difficult, however, to separate out the effect of profit expectation from cash flow effects implicit in sales data. For UK data, many of the main R&D studies have not identified a strong profitability effect for the level of R&D of innovative firms (Bond *et al* 2005; Becker, 2015). For European data, there is some evidence of a lagged profitability effect but only at 10% significance (Bogliacino and Pianta, 2013). US studies have found a role for new equity but for young firms only (Brown *et al*, 2009). In our study we experimented with the return on assets both current and lagged; both were insignificant and incorrectly signed. We also used Tobin's Q which was signed correctly but not close to significance.

vi. *Tenure*. Tenure has been argued to be a determinant of R&D. It is possible to rationalize strong commitment to R&D either in the junior or senior phase of tenure depending on whether initial career concerns matter most (Narayanan, 1985; Palley, 1997) or whether managerial confidence is a dominant consideration (Gibbons and Murphy, 1992; Barker and Mueller, 2002; Kor, 2006; Francis *et al*., 2008). The literature also contains arguments for a nonlinear relationship rising in the early years before peaking and declining toward retirement (Ryan and Wiggins, 2002; Henderson *et al*., 2006; Mezghanni, 2010; Zhang, 2010). In our estimation, tenure did not influence R&D intensity whether entered linearly or nonlinearly.

vii. *Additional industry controls*. Fixed-effects estimation already takes account of firm-level idiosyncrasies. However the dynamics of the R&D adjustment may be affected by the degree of appropriability, often captured by an industry-based taxonomy (Pavitt, 1984). Given that our sample is of the most research-intensive firms and is thus not representative of all industry, we use just the Pavitt discriminator for science-based industries (aerospace, computers and office machinery, electronic components, and pharmaceuticals). Interacting this dummy

with the correction term in equation (1) produces a significantly higher absolute coefficient for this coefficient (β_1), indicating a more rapid adjustment. However the departure variable is now even more significant with a coefficient that is virtually unchanged, indicating that the main finding is robust. Some literature has also identified appropriability effects for R&D defense subsidies which may also be identified by industry (Aerospace, Electronic & Electrical Equipment, and Fixed and Mobile telecommunication sectors). However, we found no significance for an effect on the correction term for this grouping, while the departure coefficient is unchanged with the same level of significance.

8. Extended discussion

The empirical results above have implications for the wider issue of incentive systems for innovation. Our findings suggest that governance measures such as strong forms of pay for performance may exacerbate any agency problem by increasing the motivation for opportunistic behavior in relation to R&D spending. Our results are compatible with the view that CEO incentives have become so strong that they have had the unintended consequence of focusing managers' attention on their own rewards. Ironically, therefore, the recent emphasis on shareholder value, operationalized through equity-based performance pay, may have given substance to what had been merely a shadow and encouraged the growth of the opportunism that it was meant to counter.[12] If that is so, the experiment in equity-based pay may come to be seen not so much a minor matter of compensation design as a fundamentally mistaken approach in focusing so much on powerful pecuniary incentives.

A counter argument is that it is simply the form in which performance pay has been implemented that is problematic and that governance measures can be adopted to control opportunistic behavior. Nevertheless the failure to observe robust governance effects in our results is not encouraging for the view that brake and accelerator measures can be combined to good effect. Others argue for specific measures to reduce short-termism—options that vest over longer periods and measures that reduce the career risk and insecurity such as golden parachutes and even managerial entrenchment (Aghion *et al.*, 2010; Manso, 2011; Ederer and Manso, 2013; Edmans *et al.*, 2013). However the practicality of incentive reform such as long-term vesting is in doubt. Even if future stock prices accurately value the current contribution of executives, any metric computed years ahead will be confounded by a greater number of shocks, the effects of which will be difficult to discern from the results of managerial effort and risk-taking.

While this article has shown that high-powered compensation is problematic, the issue must be seen in the wider context of corporate governance systems. There is an open research agenda to systemize and extend research on alternative forms of control and motivation. While compensation incentives may indeed be counter-productive, the alternative of close monitoring has also been shown to discourage the revelation of project information by managers (Adams and Ferreira 2007). In other work too, excess monitoring and a lack of autonomy for managers have been linked to short-termism (Grant, 1996; Aghion and Tirole, 1997; Burkart *et al*, 1997; Lacetera, 2001; Chirinko *et al.*, 2004; Garretsen and Sterken, 2005; Krafft and Ravix, 2005). This has been argued to have particular implications for innovation (Deakin, 2011; Zattoni and Pugliese, 2012; Ferreira *et al.*, 2014). In such contexts, pressure to meet investor expectations can lead to value-destroying actions and poor performance (Hall, 2003; Filatotchev and Allcock, 2010; Francis *et al.*, 2011; Van Pottelsberghe *et al.*, 2011; Fisman *et al.*, 2013; Landier *et al* 2013).[13] In future work, it may be useful to test these ideas in a larger sample where good proxies could be found for *expected* tenure or tenure uncertainty of managers facing investor pressure.

Counterposed to the shareholder-oriented governance approaches are alternative allocations of control rights that better support risk-taking in the form of firm-specific commitments. Eliciting such commitments may require guarantees of stakeholder protection in the event of firm failure or change of ownership. Stakeholder approaches include

12 An overview of the reasons for the increase in executive pay in Murphy (2013) shows long-standing disagreements over whether it is due to managerial capture against the interests of shareholders or driven by shareholder pressure for managers to take more risk. In our view these are not necessarily substitutes but the latter can stimulate aspects of the former.

13 There also appear to be a negative effect of decreased autonomy on intrinsic motivation (Frey and Osterloh, 2005). The perspective here has some affinity with the New Institutional Theory view that the firm is a combination of formal contracted obligations and informal ones, such as social norms and contingent expectations (Menard and Shirley, 2005).

the "team production" where the argument for shared control across all risk-takers in the firm is based on the theory of property rights. Such an extension of control rights beyond the providers of finance could be achieved by constituting boards as neutral arbiters, thus encouraging engagement by non-shareholder agents such as employees and suppliers (Blair and Stout, 1999; Klein *et al.*, 2012). A challenge for this approach is to show that it can accommodate an appropriate level of dynamism in firm decision-making. This is the subject of other stakeholder approaches that favor control rights for strategic managers who "possess the cognitive capabilities to allocate resources to the innovation process" (Lazonick, 2010: 335). These issues constitute a research agenda that is still characterized by many knowledge gaps.

9. Summary and conclusions

This article has addressed a broad and a narrow question. The broad question concerns the role of incentives in risky decision-making such as R&D spending. Our concern here is that incentives might be overly strong, thus resulting in opportunistic behavior and the unintended consequence of lower R&D. In the "Extended Discussion" section we briefly considered alternative motivating systems.

The narrow question—which aims to offer a window on the first one—is whether CEOs opportunistically reduce R&D spending so as to enhance their own rewards in the period immediately prior to departure and whether that tendency is particularly marked for CEOs who are strongly incentivized through stock and option forms of remuneration.

Based on a sample with an average CEO departure rate of about 10% per year in the period 2000–2006, using an error correction model and appropriate econometric procedures to deal with endogeneity, our empirical results support the existence of a horizon effect: R&D intensity decreases in the year before the CEO leaves the firm. In macroeconomic terms, a 10% increase in departures in a year, from the mean level, would reduce R&D expenditure for a given level of sales by between one-third and one-half of 1% corresponding to the range of values obtained for the departure coefficient in the various tables. Thus the results obtained are not only statistically significant but the magnitude is also of economic significance.

When the total sample is split between those above and below median intensity of equity-based compensation, the negative effect of imminent CEO departure on R&D intensity is significantly negative only for the above sample, where opportunism is most predicted, i.e. those with the highest intensity of remuneration in the form of equity-based pay.

Thus, we find support for Hypothesis *H1* (that departure predicts lower R&D) and Hypothesis *H2* (that this effect operates only for the sample above median intensity of stock and option compensation). Our interpretation of these results is that opportunism does indeed feature in CEO's consideration of pre-departure planning of R&D. Furthermore, there is little robust evidence that governance measures operate as a check on this behavior pattern (*H3*).

Our evidence on the horizon effect confirms results obtained by Dechow and Sloan (1991) and more tentative findings in Roychowdhury (2006), who show that R&D is manipulated for opportunist reasons to manage earnings. Our results are strongest for highly incentivized managers, in keeping with the findings of Kalyta (2009) who established a horizon effect only for CEOs whose settlement agreement is based on firm performance. Our results contrast with US studies by Murphy and Zimmermann (1993) and Cazier (2011), though the latter work does not specifically report results for a 1-year horizon. Our results also conflict with the UK study by Conyon and Florou (2006), who find little support for a horizon effect during a CEO's final year in office. The authors remark that the observed lack of opportunism in their sample may be due to the low level of options compensation in the UK during the sample years (1990–1998). A further difference between our work and Conyon and Flourou is that our sample consists of high R&D spenders whereas for these authors there was not enough variability in the sub-sample of R&D intensive firms to pursue the analysis at that level. Cazier (2011) argues that some previous studies may have confounded the effects of departure and CEO age. Our study, however, has instrumented departure with several variables including age. To guard against endogeneity arising from poor performance affecting both departure and R&D simultaneously, we examined financial press reports of the announcements of departure and omitted from the sample those firms with forced departures. The results were robust to this change.

The horizon effects tested for in Hypotheses *H1* and *H2* are complemented by a direct test of governance on R&D in Hypothesis *H3*. We find a *negative* effect for performance pay intensity on R&D which is close to

conventional significance. That is not consistent with a principal-agent view of governance but is in keeping with much of the literature surveyed earlier that argues that the overall effect of performance-based pay and board reforms tends to operate through a number of separate channels, leaving the ultimate effect to be determined empirically. We also find a positive effect of CEO stock ownership (confirming a result in Dechow and Sloan, 1991), though whether this implies support for the agency model or for managerial entrenchment and independence is difficult to sort out.

Finally, we need to emphasize some limitations of this study. It builds largely on econometric evidence that would usefully be supported by other methodological approaches including case studies and more extensive textual analyses. In particular, a larger sample with more complete information on the career history of CEOs and evidence of their interaction with their boards, would allow for more refinement of the hypotheses and closer investigation of the issues raised under "Extended Discussion." Our findings relate to a single country (the UK) where the governance system is advanced and where there has been considerable pressure on firms to confirm to strict codes. In other contexts, some moderate convergence toward standard governance procedures seems to improve measured company returns over short periods (Krafft *et al.*, 2014) though these authors also stress that country-level differences need to be taken into account (p. 25). Further work in different countries will be needed to see if the UK results reported here are simply an aberrant effect of too much of a particular type of governance derived from an exclusive reliance on the Principal Agency framework.

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