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Earnings Variability and Disclosure of R&D: Evidence from Press Releases

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Abstract

This study explores press releases in the pharmaceutical industry to expand our understanding of how investments in R&D outlays influence uncertainty of future earnings. The findings make two contributions to the literature. First, they provide evidence that equal investments in different R&D ventures are associated with differential variability of future earnings. This result suggests that non-financial information contained in press releases captures attributes of firm-specific R&D investments that are not revealed through R&D expenditures reported in financial statements. Second, prior studies have indicated that investments in pharmaceutical R&D are associated with the highest variability of future earnings among all industries. The results, however, suggest that for a large class of low-risk pharmaceutical R&D investments, the relative variability of future earnings is low and similar to that generated by capital expenditures. The findings hold when we control for endogeneity in voluntary disclosure of press releases.

Key words: Disclosure; R&D; Press releases; Earnings variability

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1. Introduction

The communication of information on research and development (hereafter – R&D) ventures has drawn much attention in the accounting literature.[1] Prior studies have tended to rely on information reported in financial statements and to use R&D expenditures as a proxy for the intensity of R&D outlays (e.g. Kothari *et al*., 2002; hereafter KLL; Amir *et al*., 2007; hereafter AGL; Ahmed and Falk, 2009; Pandit *et al*., 2011). However, R&D expenditures may not capture non-financial information conveyed to investors. This study examines press releases as a supplementary source of information that has been less explored in the literature. We investigate how press releases distributed by pharmaceutical firms convey R&D-related information that investors cannot obtain from R&D expenditures reported in financial statements. The objective is to expand our knowledge of how firm-specific investments in high-risk versus low-risk R&D affect uncertainty of future earnings.[2,3]

We perform textual searches in 31 113 press releases distributed by pharmaceutical firms over the course of 11 years (1990–2000) and find that 8425 (27.1 per cent) of the releases report R&D-related events, such as approvals or rejections by the US Food and Drug Administration (hereafter – FDA), acquisitions of compounds and technologies or outcomes of patent litigation. Pharmaceutical firms announce an average of 1.1 R&D-related events per $10 million of R&D expenditures.

We employ press releases to gain insights into how firm-specific investments in high-risk versus low-risk R&D ventures affect the variability of future earnings. To demonstrate the point, consider two pharmaceutical firms of equal size investing equally in R&D. One firm invests in research aimed to develop an innovative breakthrough cure for cancer, while the other develops generic drugs and invests in R&D aimed at replicating the chemical constituency of existing formulas. Although both firms report equal R&D expenditures, the uncertainty of future benefits attributable to an investment in developing a cure for cancer is

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[1] Guo *et al*. (2004) show that extended information on biotech firms reported in IPO prospectuses decreases stock volatility. Davila (2000), however, uses internal communication of information and investigates a relationship between project uncertainty and the effect of management control systems on performance. See also Ditillo (2004).

[2] The International Accounting Standard No. 38 issued in 1998 requires 'probable future economic benefits' as one of the conditions for intangible asset recognition. The FASB Statement No. 2, (1974) states: '… *the relationship between current research and costs and the amount of resultant future benefits to an enterprise is so uncertain that capitalization of any research and development costs is not useful in assessing the earnings potential of the enterprise*' (p. 50, emphasis added). Given the different approaches, we examine how investments in R&D affect the variability of future earnings.

[3] The terms 'uncertainty' and 'risk' are used interchangeably in the text with the same meaning.

likely to be higher than that attributable to investing in the development of generic drugs. In comparison with the development of generic drugs, the development of a cure for cancer involves more frequent acquisitions of advanced pioneering technologies, a larger number of repeated interactions with regulatory authorities such as the FDA and more inventions protected by patents. Thus, an investment in developing a cure for cancer is likely to involve more frequent R&D-related events reported via press releases than is an equal-size investment in developing generic drugs. Therefore, we employ the relative frequency of R&D-related events reported via press releases as our proxy for the degree of variability of future earnings generated by R&D.

Using a multivariate analysis and the methodology in KLL and AGL, we find that the relative frequency of R&D-related press releases is positively and significantly associated with the variability of future earnings. This relationship holds under several alternative risk measures. Our findings expand earlier findings of Ho *et al.* (2004) by highlighting another aspect of the relationship between R&D ventures and firms' risk. We conclude that R&D-related events communicated via press releases signal greater variability in future earnings. Thus, press releases serve as a useful device for communicating uncertainty associated with investments in R&D.

Furthermore, we split our sample into two equal-size portfolios of high-risk and low-risk R&D, classified according to the proposed press release–based measure and we use them to compare the relative degree of uncertainty of future earnings attributable with current investments in low-risk versus high-risk R&D. Variability of future earnings of high-risk R&D observations is about seven times greater than that of low-risk R&D observations, indicating considerable disparity between high-risk and low-risk pharmaceutical R&D. Overall, the findings suggest that the press release–based uncertainty measure expresses meaningful differences in firms' variability of future earnings.

We also find that the variability of future earnings generated by half of the pharmaceutical investments in low-risk R&D is comparable, on average, with that generated by investments in capital assets. The findings draw attention to a sizeable class of pharmaceutical firms that invest in low-risk R&D activities; that is, developers of less innovative drugs. Taken as a whole, the relative frequency of R&D-related events reported in a firm's press releases is shown to capture firm-specific features that affect variability in future earnings generated by investments in R&D.

We note, however, that the ability to utilize press releases to infer uncertainty generated by investments in R&D ventures may be influenced by managerial discretion in making voluntary disclosures. We use instrumental variables to perform sensitivity analyses to verify that the findings are robust to endogenous disclosure choices. The findings indicate that firms with more intensive R&D investments tend to distribute more press releases, in line with Ritter and Wells (2006) and Jones (2007). More importantly, the results show that endogenous disclosure choices do not influence our inferences and conclusions.

The contribution of this study is twofold. First, it provides evidence suggesting that press releases provide information that is not captured by R&D expenditures reported in financial statements. Particularly, an examination of classes of events announced via press releases reveals differential effects on the variability of future earnings. Thus, press releases convey meaningful information for risk assessment and valuation, above and beyond the information reported in financial statements. Overall, our findings extend the literature on communication of information on R&D outlays.

Second, the results extend KLL and AGL in showing that intra-industry investments in R&D are not equally risky. Specifically, we demonstrate that there is a sizeable class of low-risk investments, targeting the development of less innovative drugs, whose future earnings variability is similar to that of investments in capital assets. This is inconsistent with the assumption underlying the FASB No. 2 (1974) and the International Accounting Standard Board 38 (1998), according to which future benefits generated by R&D outlays are highly uncertain and unpredictable. Apparently, for half the investments in pharmaceutical R&D – specifically, the low-risk investments – the resultant future benefits are not more uncertain than those generated by capital expenditures. The low risk of half of the investments in pharmaceutical R&D highlights a meaningful advantage of an option to capitalize intangible assets (Lev, 2001; Matolcsy and Wyatt, 2005).

The rest of the paper is organized as follows: communication of information on value-relevant events via press releases is discussed in the next section. The sample and descriptive statistics are presented in Section 3. Empirical evidence on uncertainty of future earnings generated by R&D outlays is presented in Section 4. Sensitivity analyses are presented in Section 5. Summary is in Section 6.

2. R&D-related press releases

The pharmaceutical industry offers the ultimate setting to explore R&D-related information communicated via press releases for at least two reasons. First, the pharmaceutical industry has the most intensive R&D (AGL). The average cost of bringing a drug for chronic diseases to the market is estimated to be about $800 million, and it takes 10–15 years to develop a new drug. Second, potential differences in firm-specific R&D efforts are likely to result in a significant variety of economically meaningful events.[4] R&D-related events reported in press releases have a vital impact on future performance of pharmaceutical firms.

Publicly traded firms release information on events that affect their income-generating process, including R&D-related events, such as success or failure in a

[4] See a discussion on risks of drug development processes in 'Big Trouble for Big Pharma', *The Economist*, December 4, 2003.

clinical trial and approval by the FDA. Such information may be released through public announcements via the media, that is, press releases or through mandatory immediate accounts to securities regulators, such as the Securities and Exchange Commission or a stock exchange. Dedman *et al.* (2008) report that stock price reactions to product development announcements are stronger than responses to earnings announcements, indicating that announcements regarding events are important and economically meaningful.[5] Further, they argue that considerably more announcements report late-stage outcomes of investments in developing new products, as compared to early-stage outcomes.

Prior to the Internet era, such information was published in *The Wall Street Journal* as firm-specific news items. The *Journal*'s database contains a comprehensive list of firm-specific information items useful to researchers and analysts (Thompson *et al*., 1987) and includes a large proportion of non-financial items (Wright and Groff, 1986; Hoskins *et al*., 1986). Wide publicity through Internet websites further enhances accessibility of press releases. We employ R&D-related events announced via press releases to learn about the variability of future earnings. Our focus on risk of pharmaceutical firms is also in line with Xu *et al.* (2007).

2.1. *Uncertainty of earnings generated by firm-specific R&D*

Different levels of innovation associated with firm-specific R&D investments are likely to result in dissimilar levels of uncertainty of future benefits. KLL report that, on average over a large sample, R&D investments generate future benefits that are far more uncertain (about three times more) than benefits from investments in property, plant and equipment. AGL, published after KLL, show significant variation of R&D risk across industries and time periods. AGL's arguments are grounded in economic intuition because, for instance, earnings variability generated by R&D investments in the innovative pharmaceutical industry is clearly greater than earnings variability generated by R&D investments in the food industry. We further extend this line of thinking by exploring the assertion that among firms within a single industry, not all firm-specific investments in R&D outlays are equally risky. Specifically, we presume that firm-specific investments in R&D outlays made by pharmaceutical firms generate dissimilar levels of earnings uncertainty.

Such variation in future benefits of R&D, which we propose is owing to disparity in the innovation level of firms' R&D ventures, has natural implications for both investors and standard-setters. We empirically examine this variation by employing press releases to infer meaningful differences in firm-specific levels of uncertainty that investors cannot ascertain from R&D expenses reported in financial statements.

[5] See also Aerts and Cormier (2009).

2.2. An uncertainty measure based on R&D-related press releases

While prior research has utilized press releases mainly in the context of their effect on market participants' behaviour (Kothari, 2001), we focus on R&D-related events reported via press releases to learn about the variability of future earnings. We performed textual keyword searches over press releases to categorize the reported events. We classify a press release as reporting an R&D-related event if it mentions one of the following words: 'research', 'development' or 'R&D.'[6] Consequently, the following measures of disclosure levels are proposed for R&D-related and non-R&D-related events:

$RD\text{-}DISC_{it}$ is the ratio of the number of R&D-related press releases distributed by firm i during year t, deflated by annual R&D expenses (Compustat #46).
$Non\text{-}RD\text{-}DISC_{it}$ is the ratio of the number of non-R&D-related press releases distributed by firm i during year t, deflated by annual sales (Compustat #12).

In other words, *RD-DISC* counts the number of R&D-related events announced, scaled by R&D expenditures,[7] whereas *Non-RD-DISC* counts the number of non-R&D-related events announced, scaled by sales.

We assume that R&D-related events occurring during the development of new products signal risks associated with future income generated by R&D investments. Assuming that future benefits arise from a stochastic process, a riskier venture is characterized by a larger spread of future earnings than a less risky venture (Rothschild and Stiglitz, 1970). Further assuming that announcements are made to inform the public about unexpected events, and then, a riskier venture will produce more public announcements than a less risky venture. Accordingly, the relative frequency of firm-specific R&D-related events is our proposed measure of uncertainty of future benefits.

To examine whether the relative frequency of press releases signals uncertainty of future benefits, we construct an indicator, denoted $RD\text{-}EV_{it}$, defined as the ratio of the number of R&D-related press releases distributed by firm i during year t to the total number of press releases distributed by firm i in that year.

The proposed R&D uncertainty measure accounts for both mandatory and voluntary announcements. Gu and Li (2007) report that stock price reactions to voluntary disclosures suggest that such disclosures are credible. Thus, the

[6] Similar textual keyword searches have been applied in accounting research (e.g. Butler *et al.*, 2004).

[7] The proposed ratios may be undermined by announcements with negative meanings, such as 'R&D efforts are discontinued'. We read 100 randomly selected press releases and found only one case of a negative meaning. We also note that a negative meaning is also a shock that is likely to affect future earnings.

number of R&D-related announcements is a reasonable proxy for the number of R&D-related events that occurred in a given period.[8,9]

The use of a ratio implicitly assumes a similar tendency to report R&D-related and non-R&D-related events via press releases.[10] For now, we assume a similar tendency to report R&D-related and non-R&D-related events via press releases. In Section 5, we empirically verify whether endogenous disclosure choices affect our findings.

Prior studies used intensity of R&D expenditures as a measure of risk (e.g. KLL, AGL) with no further firm-specific consideration. The indicator *RD-EV* aims to complement R&D expenditure intensity because it captures different aspects of R&D uncertainty associated with firm-specific pharmaceutical outlays.[11] Four differences between the two measures are noted.

First, press releases may convey good or bad news, affecting future earnings in opposite directions: good news is likely to yield an increase in future earnings, and bad news is likely to lead to a decrease in future earnings. Thus, *RD-EV* does not signal the direction of an event's effect, and both types of events impose a shock on future benefits. While R&D expenditure intensity is also widely used in the literature as a proxy for value relevance, *RD-EV* is an indicator of variability in future earnings generated by investments in R&D.

Second, a firm's R&D expenditure intensity is based on financial/monetary data that are reported in the firm's periodic financial statements in an aggregate manner. In contrast, *RD-EV* reflects the relative frequency of occurrence of events and is based on the enumeration of certain events reported in press releases. Third, different categories of R&D events may affect the firm's future earnings distributions in different ways. While information in press releases may enable events to be clustered according to type, reported R&D expenditure

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[8] We also checked whether non-R&D events reflect some kind of risk by replacing R&D-related events with non-R&D-related events in the numerator of the proposed proxy. Using a regression analysis presented later in the paper, we find that non-R&D-related events announced through press releases offer no incremental information when conventional risk measures are controlled for.

[9] *RD-EV* should not be confused with the measures of disclosure level, RD-DISC and Non-RD-DISC. Whereas Bushee and Noe (2000), Gelb (2002), Gelb and Zarowin (2002), Gu and Li (2003) and Guo *et al*. (2004) use metrics based on the AIMR database or construct specific disclosure-level measures, RD-EV measures risks of investments in R&D, not the level of disclosure. Chen *et al*. (2002), for their part, examine disclosure of balance sheet items with no R&D content and find increased disclosure when future earnings are more uncertain.

[10] Our construct is also similar to that of Berry and Howe (1994), who use frequency of announcements as a measure of flow of information that affects the behaviour of market participants.

[11] The firm persistence of *RD-EV* is 0.55 (α = 1 per cent), indicating reasonable stability over time.

figures are not amenable to such grouping. Thus, while *RD-EV* can be broken down into meaningful event categories, R&D expenditure intensity cannot. The event categories will be shown to be useful in identifying a class of firms with low-risk R&D outlays. Fourth, whereas intensity of R&D expenditures is constructed entirely on the basis of financial information, events that make up *RD-EV* may reflect both non-financial and financial information. Overall, we examine the power of *RD-EV* in capturing uncertainty generated by various investments in R&D above and beyond R&D expenditure intensity.

We employ *RD-EV* to gain insights into the degree of uncertainty of future benefits generated by current investments in low-risk versus high-risk R&D and to compare the relative degree of uncertainty of future benefits generated by investments in low-risk R&D and capital expenditures. We build on KLL and AGL in measuring variability of future earnings generated by current investments in R&D and we use a 5-year window of future earnings for estimating uncertainty of future earnings.

3. The sample and descriptive statistics

Measuring variability of future earnings over a window of five future years, our analyses include all US pharmaceutical firms (SIC code: 2834) for which earnings data and additional accounting variables and stock returns are available on Compustat for the years 1990 through 2005. These criteria yielded a homogenous sample comprising 48 pharmaceutical firms, each with a portfolio containing many products at various stages of development, accompanied by numerous patents. For each of the 48 firms, we computed *RD-DISC, Non-RD-DISC* and *RD-EV* on each of the 11 years, 1990–2000. This resulted in $(48 \times 11 =)$ 528 firm-year observations. Our focus on 48 large firms is consistent with Shevlin's (1966) call for industry studies that allow for an examination of homogenous firms that share an economic context. The firms in the sample are generally mature, with many products in various development stages in their portfolios.

For the sample firms, we searched the PR Newswire archive in the LexisNexis Academic Universe database and found 31 113 press releases issued between 1990 and 2000. We used press releases from only one news agency to ensure that only a single announcement would be counted per event.[12]

Of these releases, 8425 mentioned 'research', 'development' or 'R&D'. We used these data to compute *RD-EV* for the 528 firm-year observations. On average, each of the 48 firms announced about 16 (≈8425/528) R&D-related events per year.

To enhance the insights from R&D-related events reported via press releases, we followed earlier studies on the pharmaceutical industry and further classified the R&D-related events into three categories. The first category consists of

[12] We verified the uniqueness of the announcements for a random sample of 80 firm-year observations. The results indicate only two cases in which PR Newswire announced a single event twice.

R&D-related events concerning the innovative technologies that pharmaceutical firms acquire to enhance the development of new products, their joint development with start-up firms and universities, and the mergers they enter into in attempting to integrate technologies and knowledge to expedite development processes (Angell, 2004; Zinner, 2001).[13] The second category comprises reports of resolutions made by regulators, particularly the FDA. Chacko *et al*. (2001) illustrate how the extreme uncertainty of expected future benefits from a developed drug is resolved through the announcement of a decision made by the FDA. This category is characterized by various layers of crucial approval steps that a drug must pass before marketing is allowed. Ely *et al*. (2003) provide evidence on the usefulness of drug development status in the evaluation of R&D costs, indicating that a change in status influences the distribution of future benefits. The third category consists of patent protection/infringement events (Bloomberg *et al*., 1987; Rai and Eisenberg, 2002).

Thus, we carried out a detailed keyword search procedure to cluster the reported R&D-related events into four categories. The results of this clustering process are summarized in Table 1.[14]

The table presents results from searching the press releases. It indicates that 31.3 per cent of the R&D events announced in press releases belong to the first category, that is, acquisition of new technologies. Interactions with regulators account for 37.9 per cent of the relevant R&D-related events. Finally, patent-related events are the subject of only 2.8 per cent of the relevant releases. Of the 8425 R&D-related press releases, 2359 (28 per cent) were not assigned to any of the three categories. These press releases are grouped into a residual, fourth, category labelled 'others'. This category includes releases of such information as appointments of R&D executives, results of scientific research and launches of new research programs.[15] In sum, a breakdown of *RD-EV* into categories contributes towards identifying the types of R&D-related events reported by firms.

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[13] Pharmaceutical firms began to rely on acquiring innovative developments with the passage of the Bayh-Dole Act and a related piece of legislation, the Stevenson-Wydler Act, in the 1980s. Both permitted government-funded work to be patented and licensed exclusively to drug companies. The trend of licensing government-funded research from universities and small entities has increased during the last two decades (Angell, 2004).

[14] The ability to characterize three types of R&D-related events is another important reason for choosing the pharmaceutical industry, not only because the pharmaceutical industry has the highest investments in R&D. In contrast, our attempts to use word searches to classify R&D-related events in the computer hardware, communication, software and automobile industries were unsuccessful.

[15] Although the R&D-related press release selection criterion calls for a selection of all releases that include the words 'R&D', 'research' or 'development', it is possible that some press releases in the 'others' category are misclassified in that they may not explicitly relate to R&D events. We therefore reviewed a randomly chosen sample of 300 releases in the 'others' category for events that were not R&D-related. Only nine such instances were detected.

Table 1
Classification of press releases

Keywords searched	R&D-related press releases*	Non-R&D-related press releases†
1. Acquisition of new technologies Acquisition, Joint Development, Merger	2637 (31.3%)	742 (3.3%)
2. Interactions with regulators FDA, Food and Drug Administration, Clinical Trial	3193 (37.9%)	40 (0.2%)
3. Patent protection Patent	236 (2.8%)	12 (0.0%)
4. Others	2359 (28.0%)	21 894 (96.5%)
Total‡	8425 (100.0%)	22 688 (100.0%)

Results of textual searches in 31 113 press releases distributed by 48 pharmaceutical firms between 1990 and 2000. The table presents the number of press releases found in each textual search for the corresponding keywords. *The number of press releases that contain one of the searched-for keywords and also 'research', 'development' or 'R&D'. We searched for the first category keyword in each announcement. The number in parentheses indicates the percentage of the total number of R&D-related press releases. †The number of press releases that contain one of the searched-for keywords but do not contain 'research', 'development' or 'R&D'. The number in parentheses indicates the percentage of the total number of non-R&D-related press releases. ‡The totals indicate the total number of R&D-related press releases (including either 'research', 'development' or 'R&D') and the total number of non-R&D-related press releases (not including either 'research', 'development' or 'R&D').

Table 2 presents descriptive statistics of the variables. Results reported in panel A indicate that, on average, annual R&D spending amounts to 7.5 per cent of the firm's market value of equity, and the average leverage size is 0.118. The figures in panel A of Table 2 indicate considerable diversity among the sample observations with respect to their R&D investment attributes.

Descriptive statistics for *RD-DISC* and *Non-RD-DISC* indicate that pharmaceutical firms announce an average of 1.1 R&D-related events per $10 million of R&D expenditures and 0.3 non-R&D-related events per $10 million of sales. The mean relative frequency of R&D-related events, *RD-EV*, is 0.394.

We measure the intensity of R&D expenditures, $RD\text{-}EXP_{it}$, as R&D expenses (Compustat #46) per share of firm i in year t, deflated by share price at the end of fiscal year $t-1$. The correlation between *RD-EV* and the *RD-EXP*, 0.091, is statistically significant (reported in panel B of Table 2), suggesting that the two measures are not independent of each other. On the other hand, the low magnitude of the coefficient does not signal strong dependency either, supporting the notion that each measure captures different aspects of R&D uncertainty. As expected, both measures are positively and significantly correlated with the variability of future earnings.

The correlation between *RD-DISC* and *Non-RD-DISC* is 0.657 and highly significant. Yet, the correlation between *RD-EV* and *RD-DISC*, 0.188, is positive

Table 2
Descriptive statistics and correlations

Panel A – Descriptive statistics

Variable	Description	Mean	Median	SD	Min	Max
$RD\text{-}EXP_t$	Intensity of R&D expenditures	0.075	0.039	0.260	0	3.771
$RD\text{-}EV_t$	Relative frequency of R&D-related events	0.394	0.340	0.355	0	1
$RD\text{-}DISC_t$	Disclosure level of R&D-related information	0.113	0.050	0.654	0	1.508
$Non\text{-}RD\text{-}DISC_t$	Disclosure level of non- R&D-related information	0.030	0.022	0.379	0	2.114
$CAP\text{-}EXP_t$	Intensity of capital expenditures	0.042	0.023	0.093	0	1.342
MV_t	Size	5.784	4.845	2.775	−1.785	11.472
$LEVERAGE_t$	Financial leverage (debt/market value + debt)	0.118	0.056	0.169	0	0.994
$SD(E_{t+1,t+5})$	Standard deviation of future earnings	0.074	0.030	0.107	0.002	0.556

Panel B – Means of annual Pearson correlation coefficients

Variable	$RD\text{-}EXP_t$	$RD\text{-}EV_t$	$RD\text{-}DISC_t$	$Non\text{-}RD\text{-}DISC_t$	$CAP\text{-}EXP_t$	MV_t	$LEVERAGE_t$	$SD(E_{t+1,t+5})$
$RD\text{-}EXP_t$	1.000							
$RD\text{-}EV_t$	0.091*	1.000						
$RD\text{-}DISC_t$	0.137*	0.188*	1.000					
$Non\text{-}RD\text{-}DISC_t$	0.119*	−0.055	0.657*	1.000				
$CAP\text{-}EXP_t$	0.320*	−0.027	−0.071	0.086	1.000			
MV_t	−0.155*	−0.299*	−0.300*	−0.266*	−0.116*	1.000		
$LEVERAGE_t$	0.188*	0.035	0.004	−0.002	0.452*	0.218*	1.000	
$SD(E_{t+1,t+5})$	0.345*	0.333*	0.140*	−0.015	0.278*	−0.463*	0.320*	1.000

*Correlations are significant at the 5 per cent level using a two-sided test. $RD\text{-}EXP_t$ is research and development expenses (Compustat #46) per share, deflated by share price at the end of fiscal year $t-1$ (Compustat #199 and CRSP); $RD\text{-}EV_t$ is the ratio of the number of R&D-related press releases distributed by the firm during year t, to the total number of press releases announced by the firm in that year; $RD\text{-}DISC_t$ is the ratio of the number of R&D-related press releases announced by the firm during year t deflated by annual R&D expenses (Compustat #46); $Non\text{-}RD\text{-}DISC_t$ is the ratio of the number of non-R&D-related press releases announced by the firm during year t deflated by annual sales (Compustat #12); $CAP\text{-}EXP_t$ is capital expenditures (Compustat #128) per share, deflated by share price at the end of fiscal year $t-1$ (Compustat #199 and CRSP); MV_t is the natural logarithm of market valuation of stockholders equity annual sales for fiscal year t (Compustat #12); $LEVERAGE_t$ is the sum of long-term debt (Compustat #9) and debt in current liabilities (Compustat #34), divided by the sum of long-term debt and the market value of equity; $SD(E_{t+1,t+5})$ is the standard deviation of primary earnings per share before extraordinary items and discontinued operations (Compustat #58) and before R&D expenses (Compustat #46) per share, calculated using five annual earnings for years $t+1$ to $t+5$. Per-share values are deflated by share price (Compustat #199 and CRSP) at the end of fiscal year $t-1$ and adjusted for stock splits and stock dividends using a cumulative adjustment factor (Compustat #27). Deflated earnings observations with values of less than −1 are winsorized at −1.

and significant at the 5 per cent level but relatively weak, whereas the correlation between *RD-EV* and *Non-RD-DISC* is negative and insignificant. These correlations are consistent with the argument that *RD-EV* is a proxy for risk generated by R&D and is not merely a measure of disclosure level.

4. Uncertainty of earnings generated by firm-specific R&D

4.1. Earnings variability – two-dimensional analysis

Examining uncertainty of future economic benefits generated by firm-specific investment in R&D, we start by verifying that *RD-EV* captures risk aspects not captured by intensity of R&D expenditures. For two firms with equal R&D expenditure intensity, we expect current investments in high-risk (low-risk) R&D ventures, as measured by *RD-EV*, to generate high (low) uncertainty of future earnings. Accordingly, we apply Fama and French's (1992, p. 446) two-dimensional variation analysis methodology to learn about the effects of the two indicators on the variability of future earnings.[16]

First, we ranked the 528 firm-year *RD-EV* observations from low to high. These observations were then divided into three equal-size clusters of low, medium and high-*RD-EV*. Next, in each of the three *RD-EV* clusters, all observations were ranked according to the value of their respective *RD-EXP* measures and were clustered into three equal-size groups: low, medium and high-*RD-EXP*. This procedure resulted in nine clusters of 58 firm-year observations each.[17] Variability of future earnings in each of the nine clusters is then averaged, and their means were organized into the three-by-three matrix shown in Table 3.

Variability of future earnings, $SD(E_{t+1,t+5})$, is the standard deviation of primary earnings per share before extraordinary items and discontinued operations (Compustat #58) before R&D expenses per share, calculated using five annual earnings, one for each of the years $t + 1$ to $t + 5$. Per-share values are deflated by share price (Compustat #199 and CRSP) at the end of fiscal year $t - 1$ and adjusted for stock splits and stock dividends using a cumulative adjustment factor (Compustat #27).

The mean $SD(E_{t+1,t+5})$ measure in the rows of the matrix increases from low to high. Thus, the variability of future earnings for each of the three RD-EXP-controlled groups increases in *RD-EV*. Further, with one exception, the mean

[16] Diversified R&D projects may also be an important factor in our analysis. However, it is problematic to count the number of projects, not only because this number is generally not disclosed. The project classification routine varies across firms and within firms, and the concept of 'an R&D project' is not well defined. Consequently, our study is limited in this respect.

[17] The middle cell has 64 observations.

Table 3
Mean standard deviation of future earnings – multivariate analysis

	$RD\text{-}EV_{jt}$				
		All	Low	Medium	High
$RD\text{-}EXP_{jt}$	Full sample	0.074	0.049	0.057	0.116
	Low	0.057	0.038	0.047	0.087
	Medium	0.056	0.039	0.038	0.091
	High	0.108	0.070	0.086	0.169
	High minus Low	0.051	0.032	0.039	0.082

The 528 sample observations are clustered into three portfolios of low, medium and high values of *RD-EV*, and then the observations in each of the three portfolios are classified again according to low, medium and high values of *RD-EXP*. Each of the nine portfolios consists of 58 observations (The middle cell has 64 observations). The nine internal table cells present the mean standard deviation of future earnings, $SD(E_{t+1,t+5})$, for each portfolio. $RD\text{-}EV_t$ is the ratio of the number of R&D-related press releases announced by the firm during year t, to the total number of the firm's press releases announced in that year; $RD\text{-}EXP_t$ is research and development expenses (Compustat #46) per share, deflated by share price at the end of fiscal year $t-1$ (Compustat #199 and CRSP); $SD(E_{t+1,t+5})$ is the standard deviation of primary earnings per share before extraordinary items and discontinued operations (Compustat #58) and before R&D expenses per share, calculated using five annual earnings for years $t+1$ to $t+5$. Per-share values are deflated by share price (Compustat #199 and CRSP) at the end of fiscal year $t-1$ and adjusted for stock splits and stock dividends using a cumulative adjustment factor (Compustat #27). Deflated earnings observations with values of less than −1 are winsorized at −1.

$SD(E_{t+1,t+5})$ values in the three columns also increase from low to high.[18] Thus, the variability of future earnings also increases in *RD-EXP* for the *RD-EV*-controlled groups.

The last row in Table 3 depicts the high minus low $SD(E_{t+1,t+5})$ differences for the *RD-EV*-controlled groups, where this value for the high-*RD-EV* group (0.082) is about 2.7 times higher than that for the low-*RD-EV* group (0.032). The order of the variability of future earnings provides further empirical evidence that the variability increases in *RD-EV* for the *RD-EXP*-controlled groups. We conclude, therefore, that both *RD-EXP* and *RD-EV* affect the variability of future earnings.

In similar vein, Matolcsy and Wyatt (2008) argue that technological complexity, above and beyond monetary investment in R&D outlays, affects the dispersion of future economic benefits. Specifically, they employ patent-related data to estimate firm-specific technological complexity and report that technological complexity is positively related to variability in the return on assets.

[18] The one exception relates to the medium *RD-EV* groups, whose related $SD(E_{t+1,t+5})$ means for the low-, medium- and high-*RD-EXP* clusters are 0.047, 0.038 and 0.086, respectively.

Following Matolcsy and Wyatt (2008), we manually collect patent-related data from the US Patent Office Database and approximate technological complexity (*TC*) for each of our sample firms on 3 years, 1998–2000. Similar to Matolcsy and Wyatt (2008), the proxy we use for measuring technological complexity at the firm-year kevel is the average number of scientific papers referenced on the front pages of five randomly chosen patents filed by that firm during 1998–2000. The total number of patents is 720 (= 48 firms × 3 years × 5 patents). A high number of citations of scientific research papers indicate that the firm's developments are based on innovative scientific research. Technologies advancing on a science basis have higher imitation costs and lead to know-how barriers to entry (Matolcsy and Wyatt, 2008). Our approximation is limited by the assumption that each of the firms concentrates on one main area of technology, which is a reasonable assumption in the pharmaceutical setting (Weiss *et al.*, 2009). The mean value of *TC* is 2.86 and the median is 1.89; these values are higher than the corresponding values reported by Matolcsy and Wyatt (2008). Interestingly, the correlation between *TC* and *RD-EV* is 0.18 ($P < 0.01$). This positive and significant correlation is consistent with *RD-EV* capturing technological complexity.

4.2. Regression analyses

Focusing on high- versus low-risk R&D outlays, we employ KLL's equation 5 (p. 361) to estimate a number of regression models designed to provide further evidence on the differential uncertainty of future benefits generated by current investments in R&D. We start by replicating KLL's (Kothari *et al.*, 2002) cross-sectional regression model with our sample (firm subscript suppressed):

$$SD(E_{t+1,t+5}) = \alpha + \beta_{1t} RD\text{-}EXP_t + \beta_{2t} CAP\text{-}EXP_t + \beta_{3t} MV_t + \beta_{4t} LEVERAGE_t + e_{t+1,t+5}, \quad (1)$$

where: $SD(E_{t+1,t+5})$ is the standard deviation of primary earnings per share before extraordinary items and discontinued operations (Compustat #58) and before R&D expenses (Compustat #46) per share, calculated using five annual earnings for years $t+1$ to $t+5$. Per-share values are deflated by share price (Compustat #199 and CRSP) at the end of fiscal year $t-1$ and adjusted for stock splits and stock dividends using a cumulative adjustment factor (Compustat #27). Deflated earnings observations with values of less than −1 are winsorized at −1; $RD\text{-}EXP_t$ is R&D expenses (Compustat #46) per share in year t, deflated by share price at the end of fiscal year $t-1$; $CAP\text{-}EXP_t$ is capital expenditures (Compustat #128) per share, deflated by share price at the end of fiscal year $t-1$ (Compustat #199 and CRSP); MV_t is the natural logarithm of market valuation of stockholders equity for fiscal year t (Compustat #12); $LEVERAGE_t$ is the sum of long-term debt (Compustat #9) and debt in current liabilities (Com-

pustat #34), divided by the sum of long-term debt and the market value of equity.

The *t*-statistic is calculated using the sample mean and standard deviation of the sample's 11 annual coefficient estimates. To incorporate a potential effect of serial correlation, we report the regression results with standard errors adjusted for dependence using the Newey and West (1987) procedure with five lags.[19]

Table 4 reports results from the estimation of model (1). The mean coefficient estimate for *RD-EXP* is positive and significant, and its magnitude, 0.225, is about three times larger than that reported by KLL (0.072, p. 369, Table 3) for their large sample, indicating high risks in pharmaceutical R&D. As expected, the coefficients for the firms' size (*MV*) and financial risk (*LEVERAGE*) are also both statistically significant, and their signs are, respectively, negative and positive, in line with Ciftci and Cready (2011). Unlike in KLL, the coefficient for *CAP-EXP* is only marginally significant, perhaps because of the small sample size.[20] The adjusted R^2 value of the regression is quite high, 37.9 per cent, indicating that a considerable portion of the variability of future earnings is explained.

Testing the incremental information in *RD-EV*, above and beyond *RD-EXP*, we estimate the following cross-sectional regression model to confirm the statistical significance of *RD-EV* (firm subscript suppressed):

$$SD(E_{t+1,t+5}) = \alpha + \beta_{1t} RD\text{-}EV_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} CAP\text{-}EXP_t + \beta_{4t} MV_t + \beta_{5t} LEVERAGE_t + e_{t+1,t+5}, \quad (2)$$

where $SD(E_{t+1,t+5})$ is the standard deviation of primary earnings per share before extraordinary items and discontinued operations (Compustat #58) and before R&D expenses (Compustat #46) per share, calculated using five annual earnings for years $t+1$ to $t+5$. Per-share values are deflated by share price (Compustat #199 and CRSP) at the end of fiscal year $t-1$ and adjusted for stock splits and stock dividends using a cumulative adjustment factor (Compustat #27). Deflated earnings observations with values of less than −1 are winsorized at −1; $RD\text{-}EV_t$ is the ratio of the number of R&D-related press releases distributed during year t to the total number of press releases distributed by firm

[19] See KLL (p. 368) for a detailed discussion on the adjustment for serial correlation. We also follow Petersen (2009) and cluster standard errors for estimating the regression models. Similar results (not reported) are obtained.

[20] We note that investments in pharmaceutical production lines are risky even after the scientific development is complete and FDA approval is obtained. For instance, seven of 10 new drugs that reach the market fail to return the investment of the firm's capital ('Scientific Management at Merck', Harvard Business School Case, 1994). On the other hand, pharmaceutical firms also invest in production lines to supply growing demand for existing drugs.

Table 4
Summary of 11 annual cross-sectional regression models

Variable	Description	Model (1) Dependent variable: $SD(E_{t+1,t+5})$	Model (2) Dependent variable: $SD(E_{t+1,t+5})$	Model (2*) Dependent variable: $SD(\Delta E_{t+1,t+5})$	Model (2**) Dependent variable: $SDRET_t$	Model (2***) Dependent variable: $SDFA_t$
$RD\text{-}EV_t$	Relative frequency of R&D events		0.095** (2.333)	0.082* (2.114)	0.060** (2.774)	0.013** (2.281)
$RD\text{-}EXP_t$	R&D expenditures intensity	0.225* (2.165)	0.255** (2.332)	0.356* (2.111)	0.125** (3.888)	0.077* (1.987)
$CAP\text{-}EXP_t$	Capital expenditures intensity	0.042 (1.551)	0.067* (1.901)	0.035 (0.999)	0.032* (2.199)	0.028 (1.597)
MV_t	Size	−0.010** (−2.778)	−0.009** (−2.664)	−0.007** (−2.778)	−0.006** (−3.224)	−0.002* (−2.001)
$LEVERAGE_t$	Debt/(debt + owners equity market value)	0.155* (2.124)	0.133** (2.448)	0.166* (2.008)	0.006 (1.355)	0.002 (1.388)
Adj R^2		37.9%	40.0%	37.5%	14.0%	5.1%

The table presents mean coefficient estimates and, in parentheses, *t*-statistics adjusted for autocorrelation using the Newey and West (1987) procedure with five lags. The sample consists of 528 firm-year observations for 48 pharmaceutical firms (SIC code: 2834), 1990–2000.
Models*

(1) $SD(E_{t+1,t+5}) = \alpha + \beta_{1t} RD\text{-}EXP_t + \beta_{2t} CAP\text{-}EXP_t + \beta_{3t} MV_t + \beta_{4t} LEVERAGE_t + e_{t+1,t+5}$

(2) $SD(E_{t+1,t+5}) = \alpha + \beta_{1t} RD\text{-}EV_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} CAP\text{-}EXP_t + \beta_{4t} MV_t + \beta_{5t} LEVERAGE_t + e_{t+1,t+5}$

(2*) $(\Delta E_{t+1,t+5}) = \alpha + \beta_{1t} RD\text{-}EV_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} CAP\text{-}EXP_t + \beta_{4t} MV_t + \beta_{5t} LEVERAGE_t + e_{t+1,t+5}$

(2**) $SDRET_t = \alpha + \beta_{1t} RD\text{-}EV_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} CAP\text{-}EXP_t + \beta_{4t} MV_t + \beta_{5t} LEVERAGE_t + e_{t+1,t+5}$

(2***) $SDFA_t = \alpha + \beta_{1t} RD\text{-}EV_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} CAP\text{-}EXP_t + \beta_{4t} MV_t + \beta_{5t} LEVERAGE_t + e_{t+1,t+5}$

**,*Significant at the 5 per cent or 10 per cent level, respectively. $SDRET_t$ is the standard deviation of market-adjusted monthly stock returns calculated over the fiscal year. $SDFA_t$ is the standard deviation of financial analysts' earnings estimates deflated by the consensus earnings estimate. Definitions of other variables are in Table 2. Firms' subscripts suppressed.

i in that year; $RD\text{-}EXP_t$ is R&D expenses (Compustat #46) per share in year t, deflated by share price at the end of fiscal year $t-1$; $CAP\text{-}EXP_t$ is capital expenditures (Compustat #128) per share, deflated by share price at the end of fiscal year $t-1$ (Compustat #199 and CRSP); MV_t is the natural logarithm of market valuation of stockholders equity for fiscal year t (Compustat #12); $LEVERAGE_t$ is the sum of long-term debt (Compustat #9) and debt in current liabilities (Compustat #34), divided by the sum of long-term debt and the market value of equity.

The results from the estimation of model (2) are also presented in Table 4. The mean coefficient estimates for *RD-EV* and *RD-EXP* are positive and significant, indicating a positive incremental association between both risk indicators and $SD(E_{t+1,t+5})$.

We check the sensitivity of the results to alternative dependent variables. First, we employ the variability of future changes in earnings, $SD(\Delta E_{t+1,t+5})$, because the standard deviation of the difference in annual earnings is largely unaffected by growth, which we note has been steady in the pharmaceutical industry during the last two decades (Pharmaceutical Manufacturers Association, 2003). Earnings contain both permanent and transitory components, which may carry cross-sectional and temporal variations, making neither of the two measures superior to the other. In addition, we also employ the standard deviation of monthly market-adjusted stock returns and the dispersion of analyst earnings forecasts as alternative dependent variables. Results of the analyses using each of the three alternative measures, reported in Table 4, support the earlier findings. We conclude that *RD-EV* is positively associated with variability of future earnings above and beyond *RD-EXP*.[21]

Now we take a different perspective and test whether R&D investments lead to greater uncertainty of future earnings than do capital expenditures for a considerable sub-sample of investments in low-risk pharmaceutical R&D.,[22,23] KLL's specification is further extended to provide insights into (i) the relative impact of low- versus high-risk R&D on the variability of future earnings and (ii) the relative impact of low-risk R&D versus capital expenditures on the vari-

[21] We note that industry indicators and size are generally used as controls for litigation risk (e.g. Matsumoto, 2002). With the exception of size, we could not find a reasonable proxy to distinguish among litigation risk levels of firms within the pharmaceutical industry.

[22] We implicitly assume that development risks and production risks of a new drug are independent. This assumption is reasonable because production of a new drug occurs only after development is successfully completed and the drug has been approved by the regulator.

[23] We also searched the 31 113 sample announcements for events related to investments in property, plant and equipment. Not a single press release mentioned 'capital expenditures'. Only seven press releases mentioned 'property', 27 mentioned 'plant' and 102 mentioned 'equipment'.

ability of future earnings. To address both questions, we add an interaction to distinguish between investments in low-risk versus high-risk R&D. Specifically, we construct a dummy variable, $D\text{-}HIGH_{jt}$, which is assigned a value of 1 for firm j on year t if the value of $RD\text{-}EV_{jt}$ is higher than the median value of *RD-EV* for year t and 0 otherwise. Accordingly, $D\text{-}HIGH_{jt}$ equals 1 on 24 observations for each year and 0 on the other 24 observations for that year. We clarify that *RD-EV* is used in the next model only to distinguish between low-risk and high-risk investments in R&D, that is, to set the value of $D\text{-}HIGH_{jt}$. For that reason, using an indicator variable simplifies the interpretation and allows for comparative insights. We estimate the following cross-sectional regression model (firm subscript suppressed):

$$SD(E_{t+1,t+5}) = \alpha + \beta_{1t} D\text{-}HIGH_t + \beta_t RD{-}EXP_t + \beta_{3t} RD\text{-}EXPt \cdot D\text{-}HIGH_t + \beta_{4t} CAP\text{-}EXP_t + \beta_{5t} MV_t + \beta_{6t} LEVERAGE_t + e_{t+1,t+5}, \quad (3)$$

where $SD(E_{t+1,t+5})$ is the standard deviation of primary earnings per share before extraordinary items and discontinued operations (Compustat #58) and before R&D expenses (Compustat #46) per share, calculated using five annual earnings for years $t+1$ to $t+5$. Per-share values are deflated by share price (Compustat #199 and CRSP) at the end of fiscal year $t-1$ and adjusted for stock splits and stock dividends using a cumulative adjustment factor (Compustat #27). Deflated earnings observations with values of less than −1 are winsorized at −1; $D\text{-}HIGH_t$ is assigned a value of 1 on year t if the value of RD-EV$_t$ is higher than the median value of RD-EV for year t and 0 otherwise; $RD\text{-}EXP_t$ is R&D expenses (Compustat #46) per share in year t, deflated by share price at the end of fiscal year $t-1$; $CAP\text{-}EXP_t$ is capital expenditures (Compustat #128) per share, deflated by share price at the end of fiscal year $t-1$ (Compustat #199 and CRSP); MV_t is the natural logarithm of market valuation of stockholders equity for fiscal year t (Compustat #12); $LEVERAGE_t$ is the sum of long-term debt (Compustat #9) and debt in current liabilities (Compustat #34), divided by the sum of long-term debt and the market value of equity.

Model (3) is expected to provide two types of insights. First, β_{3t} indicates the incremental magnitude of the variability of future earnings associated with current high-risk investments in R&D captured by *RD-EV*. A statistically significant and positive coefficient for β_{3t} indicates a meaningful difference between the variability levels of future earnings attributable to current investments in low-risk versus high-risk R&D.

Second, comparing β_{2t} with β_{4t} indicates potential differences between the relative magnitudes of variability of future earnings associated with low-risk investments in R&D versus capital expenditures. In particular, rejecting the hypothesis that $\beta_{2t} = \beta_{4t}$ indicates a statistically significant difference between the variability of future earnings attributable to current investments in low-risk R&D and

that attributable to capital expenditures. Thus, we expect to demonstrate that there exists a class of investments in low-risk pharmaceutical R&D, representing half of the sample observations, for which the variability of future earnings attributable to R&D expenditures is similar to that attributable to capital expenditures.

The results from the estimation of model (3), reported in Table 5, provide comparative evidence on the relative degree of variability of future earnings attributable to investments in low-risk versus high-risk R&D. The mean coefficient estimate for $RD\text{-}EXP_t$·D-HIGH$_t$, 0.488, is positive and significant (t-value = 2.651), indicating an incremental variability of future earnings generated by investments in high-risk R&D relative to investments in low-risk R&D, as captured by *RD-EV*. The results imply that the variability of future earnings is about seven times ((0.488 + 0.080)/0.080 = 7.1) more sensitive to investments in high-risk R&D than it is to investments in low-risk R&D.

The results indicate a mean coefficient estimate of 0.080 for *RD-EXP* and of 0.071 for *CAP-EXP*, with t-values of 2.224 and 2.134, respectively. Consequently, we test the hypothesis that the mean coefficient of *RD-EXP* equals the mean coefficient of *CAP-EXP*. The results indicate no rejection of the hypothesis: a t-test shows no significant difference between the mean coefficients at a P-value of 5 per cent.[24]

These findings indicate a large difference between investments in low-risk versus high-risk R&D ventures in terms of generating variability of future earnings. These results are in line with the observed tendency of US pharmaceutical firms in the last two decades to reduce the risks of developing new drugs by investing in low-risk R&D (see detailed discussion in Angell, 2004). Checking robustness of the findings, we repeat the analysis with the three alternative dependent variables used earlier and find similar results (see Table 5). In sum, results demonstrate a sizeable class of investments in low-risk R&D that generate a degree of variability of future earnings comparable with that generated by capital expenditures.

As a cautionary remark, we note that the analysis is not aimed at measuring the absolute magnitude of the variability of future earnings attributable to investments in low-risk versus high-risk R&D ventures. Rather, our objective is to provide direct evidence on the relative degree of uncertainty of future earnings attributable to current investments in low-risk versus high-risk R&D. Overall, the evidence demonstrates that investments in low-risk pharmaceutical R&D, as captured by the relative frequency of R&D-related events, result in substantially lower variability of future earnings than investments in high-risk pharmaceutical R&D.

[24] The t-statistic accounts for the dependence in the time series of estimated coefficients (see endnote 9 in KLL).

Table 5
Low versus high uncertainty generated by R&D

Variable	Description	Model (3) Dependent variable: $SD(E_{t+1,t+5})$	Model (3*) Dependent variable: $SD(\Delta E_{t+1,t+5})$	Model (3**) Dependent variable: $SDRET_t$	Model (3***) Dependent variable: $SDFA_t$
$D\text{-}HIGH_t$	High (above median) relative frequency of R&D events	0.020* (2.170)	0.022* (2.12)	0.010* (1.88)	0.007 (1.08)
$RD\text{-}EXP_t$	R&D expenditures intensity	0.080** (2.224)	0.068** (2.281)	0.054* (2.188)	0.040* (1.928)
$RD\text{-}EXP_t$·D-HIGH$_t$	Interaction	0.488** (2.651)	0.651** (3.300)	0.141** (2.328)	0.052** (2.526)
$CAP\text{-}EXP_t$	Capital expenditures intensity	0.071* (2.134)	0.062* (1.945)	0.042* (2.000)	0.031 (1.201)
MV_t	Size	−0.021** (−2.501)	−0.017** (−2.442)	−0.003** (−3.314)	−0.002** (2.301)
$LEVERAGE_t$	Debt/(debt + owners equity market value)	0.166* (1.910)	0.180** (2.711)	0.011 (0.901)	0.002 (0.922)
Adj R^2		42.9%	41.0%	14.1%	5.8%

The table shows a summary of 11 annual cross-sectional regressions from 1990 to 2000. Cell entries present mean coefficient estimates and, in parentheses, *t*-statistics adjusted for autocorrelation using the Newey and West (1987) procedure with five lags. The sample consists of 528 firm-year observations for 48 pharmaceutical firms (SIC code: 2834).

Models

(3) $SD(E_{t+1,t+5}) = \alpha + \beta_{1t} D\text{-}HIGH_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} RD\text{-}EXP_t \cdot D\text{-}HIGH_t + \beta_{4t} CAP\text{-}EXP_t + \beta_{5t} MV_t + \beta_{6t} LEVERAGE_t + e_{t+1,t+5}$

(3*) $SD(\Delta E_{t+1,t+5}) = \alpha + \beta_{1t} D\text{-}HIGH_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} RD\text{-}EXP_t \cdot D\text{-}HIGH_t + \beta_{4t} CAP - EXP_t + \beta_{5t} MV_t + \beta_{6t} LEVERAGE_t + e_{t+1,t+5}$

(3**) $SDRET_t = \alpha + \beta_{1t} D\text{-}HIGH_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} RD\text{-}EXP_t \cdot D\text{-}HIGH_t + \beta_{4t} CAP\text{-}EXP_t + \beta_{5t} MV_t + \beta_{6t} LEVERAGE_t + e_{t+1,t+5}$

(3***) $SDFA_t = \alpha + \beta_{1t} D\text{-}HIGH_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} RD\text{-}EXP_t \cdot D\text{-}HIGH_t + \beta_{4t} CAP\text{-}EXP_t + \beta_{5t} MV_t + \beta_{6t} LEVERAGE_t + e_{t+1,t+5}$

**,*Significant at the 5 per cent or 10 per cent level, respectively. $D\text{-}High_{jt}$ equals 1 for firm *j* in year *t* if the value of $RD\text{-}EV_{jt}$ is higher than the median value of *RD-EV* for year *t* and 0 otherwise. $SDRET_t$ is the standard deviation of market-adjusted monthly stock returns calculated over the fiscal year. $SDFA_t$ is the standard deviation of financial analysts' earnings estimates deflated by the consensus earnings estimate. Definitions of other variables are in Table 2. Firms' subscripts suppressed.

4.3. Categories of R&D press releases

We further examine how R&D-related events in each category defined in Table 1 affect the variability of future earnings. For each category, we split our sample into two portfolios: the first portfolio includes all firm-year observations with at least one event in that category, and the second portfolio includes all other firm-year observations. We compare the mean variability of future earnings in the first portfolio with that in the second portfolio. In other words, we examine the impact of the relative frequency of each category of R&D-related events on the variability of future earnings.

Specifically, we split the 528 firm-year sample observations into two portfolios as follows: the first portfolio includes all firms i announcing at least one acquisition event during year t, and the second portfolio includes all other firm-year observations (i.e. investments in R&D that do not involve announcements of any acquisition event in year t). A similar procedure is performed for the other two categories reported in Table 1: interactions with regulators and patent-related events. In this analysis, we note that an announcement including keywords from two categories (e.g. an acquisition of patent rights) is counted in both categories.[25]

For each of the three categories, Table 6 presents the mean standard deviations of future earnings for the two portfolios. For all three categories, the mean variability of future earnings in the portfolio with the classified R&D-related events is significantly higher than that in the portfolio without the classified events. As expected, the findings (i) reconfirm that the R&D-related events of each of the three categories signal increased variability of future earnings and (ii) show differential variability of future earnings signalled by different events categories.

The results reported in Table 6 also indicate at least one acquisition event in most firm-year observations (302 of 528) and at least one interaction with regulators in most firm-year observations (304 of 528). We note that the monetary transaction of obtaining innovative technologies through acquisitions of start-ups or other firms is usually not (or is only partially) reported as R&D expenditures in financial statements according to US GAAP. Therefore, it is reasonable to expect that acquisition events provide supplementary information above and beyond R&D expenditures. A similar rationale holds for events concerning interactions with regulators.

We note that 106 of the 528 firm-year observations pertain to announcements of patent-related events. Reviewing all the patent-related announcements, we find that the vast majority deal with intellectual property litigation, that is, with

[25] The classification of an event may not be unique. For example, a release may include both 'FDA' and 'acquisition', in which case our textual search used the first term for the category classification. Such overlap may affect results on the classified event categories reported in Table 8. However, overlapping does not affect *RD-EV*.

Table 6
Mean standard deviation of future earnings for portfolios of events classified as R&D-related

Classifications – keywords searched	Observations with at least one of the classified events	Observations without the classified event	Difference
1. Acquisition of new technologies* Acquisition, Joint Development, Merger	0.077 (302)†	0.070 (226)†	0.007** (2.38)‡
2. Interactions with regulators* FDA, Food and Drug Administration, Clinical Trial	0.079 (304)	0.068 (224)	0.011** (2.56)
3. Patent protection* Patent	0.096 (106)	0.068 (422)	0.028** (9.46)

Cell entries present mean standard deviation of future earnings for a portfolio of observations. In each row of the table, 528 firm-year sample observations are split into two portfolios as follows: First row: the portfolio on the left includes all firms j announcing at least one acquisition during year t, and the right portfolio includes all other firm-year observations (firms included in the portfolio on the right did not announce any acquisition in year t). Second row: the portfolio on the left includes all firms j announcing at least one interaction with regulators during year t, and the right portfolio includes all other firm-year observations. Third row: the portfolio on the left includes all firms j announcing at least one patent-related event during year t, and the right portfolio includes all other firm-year observations. **,*Significant at the 5 per cent or 10 per cent level, respectively *Press releases include one of the searched-for keywords in the respective category as defined in Table 1. Definitions of other variables are in Table 2. Firms' subscripts suppressed. †The number of firm-year observations in the portfolio is reported in parentheses. ‡t-values are reported in parentheses.

firms either protecting their patents against infringements or attacking competitors' patents. Therefore, we expect patent-related events to signal increased uncertainty of future benefits. The findings are in line with Pandit *et al.* (2011), who report that the volatility of future performance is negatively associated with patent quality.

5. Voluntary disclosure choice as an endogenous variable

In this section, we test the robustness of the earlier findings to potentially endogenous disclosure choices. Specifically, we examine the relationship between the relative frequency of R&D-related press releases and variability of future earnings while accounting for endogenous disclosure choices.

Disclosure of R&D-related events via a press release depends to a large extent on managerial discretion (Guo *et al.*, 2004).[26] Increased risk owing to uncertain R&D ventures may encourage disclosure (Sengupta, 1998; Barth *et al.*, 2001). Yet, managers may avoid distributing press releases owing to adverse actions of competitors, the risk of consequent litigation alleging misleading information and

[26] We note that the immediate disclosure of some material events is mandatory.

a potential increase in the cost of capital resulting from uncertainties in the development process (Berger, 2011; Botosan and Harris, 2000). On the other hand, Clinch and Verrecchia (2011) argue that in a majority of circumstances measures of increased voluntary disclosure are associated with a higher (not lower) cost of capital. Non-disclosure may be costly, too, because investors and competitors are likely to interpret it as bad news (Wagenhofer, 1990). Entwistle (1999) reports that managers consider consequences of choices to disclose R&D-related events. However, the relationships between R&D expenditure intensity and the levels of disclosure of R&D-related or non-R&D-related events are still an open empirical issue. Overall, the empirical evidence on whether increased risk owing to uncertain R&D ventures encourages voluntary disclosure or impedes it is mixed.

We utilize a relatively simple disclosure scenario for testing the sensitivity of *RD-EV* to endogenous disclosure choices. We follow Guo *et al.* (2004) and assume that firms satisfy the demand for information by disclosing value-relevant information. The demand for R&D-related information is driven by both analysts and investors (Barth *et al.*, 2001). Focusing on voluntary disclosure of R&D-related events, we examine potential differences in the disclosure level of R&D-related versus non-R&D-related events.

As a preliminary analysis of the relationship between the intensity of R&D expenditures and disclosure level of R&D-related and non-R&D-related events, we sort our sample observations by the intensity of R&D expenditures. Then we cluster the observations into three equal-size groups: low, medium and high expenditure intensity. For each group, we compute the mean value of *RD-DISC* and *Non-RD-DISC*.

Results reported in Table 7 indicate a significant monotonic relationship between *RD-DISC* and *RD-EXP* as well as between *Non-RD-DISC* and *RD-EXP*. We learn that firms with higher R&D expenditure intensity report significantly more R&D-related events as well as more non-R&D-related events ($\alpha = 5$ per cent).

The results allow us to gain insights into the impact of a potential disparity in firms' tendency to disclose R&D-related and non-R&D-related events on the proposed proxy *RD-EV*. By construction, disclosure choices do not introduce bias into *RD-EV* if a firm is equally inclined to disclose R&D-related and non-R&D-related events. A similar tendency to disclose both R&D-related and non-R&D-related events influences the nominator (i.e. the number of R&D-related announcements) and also the denominator (i.e. the total number of announcements) in the same direction. As managers tend to disclose more R&D-related and more non-R&D-related information under more intensive R&D expenditure intensity, the potential bias in *RD-EV* generated by endogenous disclosure choices is tapered. Overall, the results support our assumption that endogenous disclosure choices influence *RD-EV* to a limited extent.

We further use instrumental variables to explore the impact of potential endogeneity of disclosure choices (Greene, 2008, Chapter 12). Specifically, we apply

Table 7
Voluntary disclosure of R&D-related and non-R&D-related events

$RD\text{-}EXP_t$	$RD\text{-}DISC_t$	$Non\text{-}RD\text{-}DISC_t$	N
Low	0.070	0.008	176
Medium	0.101	0.021	176
High	0.168	0.062	176
High minus Low	0.098**	0.054**	

Sample observations are clustered into three portfolios of low, medium and high values of *RD-EXP*. The table presents mean values of *RD-DISC* and *Non-RD-DISC* for each of the three portfolios. **Significant at 5 per cent level. Firms' subscripts suppressed. $RD\text{-}EXP_t$ is R&D expenses (Compustat #46) per share, deflated by share price at the end of fiscal year $t-1$ (Compustat #199 and CRSP); $RD\text{-}DISC_t$ is the proportion of R&D-related press releases announced by a firm during year t, deflated by annual research and development expenses (Compustat #46). $Non\text{-}RD\text{-}DISC_t$ is the proportion of non-R&D-related press releases announced by a firm during year t, deflated by annual sales (Compustat #12).

an estimation procedure that controls for voluntary disclosure choices by estimating a two-stage regression model. In the first stage, we estimate an instrument for *RD-EV*. Specifically, we estimate the following regression model, in which explanatory variables are lagged dummy variables:

$$RD{-}EV_{it} = \alpha_0 + \alpha_1 ACQU_{i,t-1} + \alpha_2 FDA_{i,t-1} + \alpha_3 PAT_{i,t-1} + \varepsilon_{it}, \quad (4)$$

where $RD\text{-}EV_{it}$ is the ratio of the number of R&D-related press releases distributed during year t to the total number of press releases distributed by firm i in that year; $ACQU_{it}$ equals 1 if firm i announced an acquisition in year $t-1$ and zero otherwise; $FDA_{i,t-1}$ equals 1 if firm i announced an FDA resolution in year $t-1$ and zero otherwise; $PAT_{i,t-1}$ equals 1 if firm i announced patent litigation in year $t-1$ and zero otherwise.

These three variables are natural choices because they are determinants of *RD-EV* as reported above. The vast majority of R&D-related press releases report acquisitions, FDA resolutions or patent-related events. Panel A of Table 8 presents the results from the estimation of model (4), which indicates a significant and positive association between each of the three explanatory variables and *RD-EV*.

In the second stage, we use the predicted *RD-EV* as our instrumental variable for *RD-EV*. The predicted value of *RD-EV* is used to sort the sample observations into low-risk and high-risk investments in R&D. That is, $D\text{-}HIGH^*_{it}$ equals 1 for firm i in year t if the value of the predicted $RD\text{-}EV_{it}$ is higher than the median value of the predicted *RD-EV* for year t and 0 otherwise. As before, we estimate the variability of future earnings as a function of R&D expenditure intensity, capital expenditure intensity, firm size and leverage. Thus, we estimate the following model (firm subscript suppressed):

Table 8
Instrumental variable analysis

Panel A: first-stage regression model

$$RD{-}EV_{it} = \alpha_0 + \alpha_1 ACQU_{i,t-1} + \alpha_2 FDA_{i,t-1} + \alpha_3 PAT_{i,t-1} + \varepsilon_{it}, \quad (4)$$

where $RD\text{-}EV_{it}$ is the ratio of the number of R&D-related press releases announced by the firm during year t, to the total number of the firm's press releases announced in that year, $ACQU_{i,t-1}$ equals 1 if the firm announced an acquisition during the period extending from 9 months before to 3 months after fiscal year $t-1$ end and zero otherwise, $FDA_{i,t-1}$ equals 1 if the firm announced an FDA resolution during the period extending from 9 months before to 3 months after fiscal year $t-1$ end and zero otherwise, $PAT_{i,t-1}$ equals 1 if the firm announced patent litigation during the period extending from 9 months before to 3 months after fiscal year $t-1$ end and zero otherwise

Intercept	$ACQU_{i,t-1}$	$FDA_{i,t-1}$	$PAT_{i,t-1}$	Adj. R^2
0.270** (11.33)	0.019** (2.332)	0.117** (3.214)	0.170** (4.699)	28.9%

Panel B: second-stage regression model

$$SD(E_{t+1,t+5}) = \beta_0 + \beta_{1t} D\text{-}HIGH_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} RD\text{-}EXP_t \cdot D\text{-}HIGH_t^* + \beta_{4t} CAP\text{-}EXP_t + \beta_{5t} MV_t + \beta_{6t} LEVERAGE_t + e_{t+1,t+5}, \quad (5)$$

$D\text{-}HIGH_{it}$* equals 1 for firm i in year t if the value of $RD\text{-}EV_{it}$ is higher than the median value of the *predicted RD-EV* using regression model (4) for year t and 0 otherwise. Definitions of other variables are in Table 2. Firms' subscripts suppressed

Intercept	$D\text{-}HIGH_t^*$	$RD\text{-}EXP_t$	$RD\text{-}EXP_t \cdot D\text{-}HIGH_t^*$	$CAP\text{-}EXP_t$	MV_t	$LEVERAGE_t$	Adj. R^2
0.002 (1.423)	0.018* (1.95)	0.045** (2.403)	0.292** (2.667)	0.056* (1.998)	−0.020** (2.874)	0.134* (1.852)	37.3%

The tables show a summary of 11 annual cross-sectional regressions from 1990 to 2000. Cell entries present mean coefficient estimates and t-statistics are reported in parentheses. The sample consists of 528 firm-year observations for 48 pharmaceutical firms (SIC code: 2834). **, *Significant at the 5 per cent or 10 per cent level, respectively.

$$SD(E_{t+1,t+5}) = \beta_0 + \beta_{1t} D\text{-}HIGH_t + \beta_{2t} RD\text{-}EXP_t + \beta_{3t} RD\text{-}EXP_t \cdot D\text{-}HIGH_t^* + \beta_{4t} CAP\text{-}EXP_t + \beta_{5t} MV_t + \beta_{6t} LEVERAGE_t + e_{t+1,t+5}, \quad (5)$$

where $SD(E_{t+1,t+5})$ is the standard deviation of primary earnings per share before extraordinary items and discontinued operations (Compustat #58) and before R&D expenses (Compustat #46) per share, calculated using five annual earnings for years $t + 1$ to $t + 5$. Per-share values are deflated by share price (Compustat #199 and CRSP) at the end of fiscal year $t - 1$ and adjusted for stock splits and stock dividends using a cumulative adjustment factor (Compustat #27). Deflated earnings observations with values of less than −1 are winsorized at −1; $D\text{-}HIGH_t^*$ which is assigned a value of 1 on year t if the value of the predicted RD-EV$_t$ is higher than the median value of the predicted RD-EV for year t and 0 otherwise; $RD\text{-}EXP_t$ is R&D expenses (Compustat #46) per share in year t, deflated by share price at the end of fiscal year $t - 1$; $CAP\text{-}EXP_t$ is capital expenditures (Compustat #128) per share, deflated by share price at the end of fiscal year $t - 1$ (Compustat #199 and CRSP); MV_t is the natural logarithm of market valuation of stockholders equity for fiscal year t (Compustat #12); $LEVERAGE_t$ is the sum of long-term debt (Compustat #9) and debt in current liabilities (Compustat #34), divided by the sum of long-term debt and the market value of equity.

Results reported in panel B of Table 8 indicate that all the earlier findings hold when controlled for endogeneity introduced by voluntary disclosure choices. That is, greater relative frequency of R&D-related press releases signals increased variability of future earnings.

As another robustness check, we use the relative frequency of R&D-related press releases in a preceding year, $RD\text{-}EV_{t-1}$, to compute $D\text{-}HIGH_t^*$. Specifically, $D\text{-}HIGH_t^*$ equals 1 for firm i in year t if the value of the actual $RD\text{-}EV_{i,t-1}$ is higher than the median value of $RD\text{-}EV$ on year $t - 1$ and 0 otherwise. Then, we replicate the estimation of model (5). We find $\beta_{3t} = 0.329$ (t-value = 2.127), which is in line with our previous results.

In sum, endogenous disclosure choices do not influence the relationship between $RD\text{-}EV$ and variability of future earnings. These findings further reinforce the results reported in the previous sections.

6. Summary

This study utilizes press releases in the pharmaceutical industry to investigate how investments in R&D outlays influence uncertainty of future earnings. The findings indicate differential variability of future earnings generated by equal investments in different R&D ventures. Specifically, the relative frequency of R&D-related events reported via press releases captures variability of future earnings generated by firm-specific R&D outlays. The results emphasize the

impact of non-financial information in predicting future earnings variability and extend KLL and AGL in showing that firm-specific investments in R&D within the pharmaceutical industry are not equally risky. Furthermore, the findings demonstrate that for a sizeable class of R&D investments – specifically, investments in the development of less innovative drugs – the variability of future earnings is not higher than that associated with investments in capital assets.

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