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Analysts' forecast revisions and firms' research and development expenses

Li-Chin Jennifer Ho · Chao-Shin Liu · Thomas F. Schaefer

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Abstract This study examines whether reported values for firms' research and development (R&D) affect analysts' annual earnings forecast revisions following quarterly earnings announcements. Because R&D introduces uncertainty into earnings forecasts, analysts may benefit from additional information searches in an effort to increase forecast accuracy. Also, accounting standards mandate an immediate expensing of R&D, in essence projecting a zero value for the R&D. To the extent that R&D will produce future payoffs, the expense treatment reduces the informativeness of reported earnings for forecasting future earnings. Thus, the marginal benefit of analysts' efforts to produce more information may increase with the magnitude of the R&D component of earnings announcements and trigger additional forecast revisions. Alternatively, if the cost of information searches exceeds the benefit, analysts' forecast revisions may decrease.

Our results show a positive relation between R&D expenses and analysts' forecast revision activity. We also find a positive and significant association between the level of R&D expenses and the magnitude of analysts' forecast revisions following quarterly announcements. These results point to a greater amount of analyst scrutiny when reported earnings are accompanied by high levels of R&D expenses.

Keywords Analysts' forecast revisions · Revision activity · R& D expenses

JEL Classification: G14 · M41

L.-C. J. Ho (✉)
Department of Accounting, College of Business Administration, University of Texas, Arlington, Texas 76019–0468, USA
e-mail: lichinho@uta.edu

C.-S. Liu · T. F. Schaefer
Department of Accountancy, University of Notre Dame, Notre Dame, IN

1 Introduction

This study examines the association between forecast revision activity among financial analysts and firms' research and development (R&D) expenses. The presence of R&D typically increases the uncertainty associated with future earnings (Lev, 2001). Although this increased uncertainty complicates the analyst's task of forecasting future earnings, potential rewards for superior interpretation of current R&D implications for future earnings also arise. If the marginal benefit from collecting and interpreting additional information about a firm's R&D exceeds the cost, we can expect to find greater forecast revision activity among analysts following earnings announcements for firms with large amounts of R&D.

U.S. accounting standards for R&D also may detract from the informativeness of current earnings. Reporting standards require firms to report R&D expenditures as current year expenses reducing net income in the period the R&D costs occur. To the extent that a firm's R&D has a future benefit, it experiences a higher incidence and/or larger magnitude of mismatched revenues and expenses reported in its financial statements (Lev, 2001; Barron et al., 2002). As a result, analysts—in revising their future earnings forecasts for firms with large amounts of R&D expenses—will likely perceive current earnings as less informative. To maintain forecast accuracy, analysts may have greater incentives to produce and disseminate additional information for R&D intensive firms, and forecast revision activity is likely to be higher for such firms.

Alternatively, it may be the case that reported R&D reduces analysts' forecast revision activity. Given the higher uncertainty in the earnings generation process and less informative earnings disclosures for firms with R&D, analysts will weigh the costs of the additional information search against the benefits. To the extent that these costs exceed the benefits, analysts will not conduct additional information searches and the prevalence of analysts' forecast revisions will be reduced as the level of R&D expense increases.

The above discussion suggests that the amount of reported R&D expense may affect both the demand and supply of analysts' forecasts. It is not clear whether the net effect on revision activity is positive or negative. Thus, whether firms' R&D expenses affect analysts' forecast revision activity remains an empirical question. By studying their forecast revisions, we provide evidence on the effect of R&D on the role of financial analysts as information intermediaries.

We measure analysts' earnings forecast revision activity occurring soon after quarterly earnings announcements. Prior research (e.g., Stickel, 1989; Francis et al., 1997) suggests that analysts tend to delay revising their annual forecasts until quarterly earnings information is disseminated. Thus, the use of post-quarterly earnings forecasts may increase the power of our tests. In testing our hypothesis, we also control for other variables that are likely to be associated with analysts' forecast revision activity. These variables include the magnitude and sign of earnings surprise in the quarterly announcements, firm size, and trading volume.

Our results report that both the analysts' forecast revision activity and the magnitude of the revisions are significantly and positively related to the amount of currently reported R&D expense. These findings are consistent with the view that the earnings

uncertainty introduced by reported R&D creates a demand for analysts to acquire additional information resulting in more forecast revisions. Our results may also add to the ongoing debate on the FASB requirement that R&D expenditures must reduce reported income in the period they are incurred.[1]

Our control variable analysis shows that the revision activity after quarterly announcements increases with the magnitude of the quarterly earnings surprise. In addition, revision activity is positively associated with firm size and trading volume. In assessing the relation between the sign of the earnings surprise and revision activity, we find mixed to negative associations. These results suggest that either revision activity is lower when actual earnings are less than expected or that the relation between actual and expected earnings has little, if any, effect.

Our study extends prior research that has largely focused on investors' perceptions of and reactions to R&D. Lev and Sougiannis (1996) report that the association between R&D expenses and subsequent earnings is, in general, both statistically significant and economically meaningful. Aboody and Lev (2000) provide further market evidence that for firms with large amounts of reported R&D, insider gains are substantially larger and investors' reaction to the public disclosure of insiders' trade is statistically stronger. The relevance of R&D for future earnings and the evidence of potential current trading gains suggest that analysts will invest in additional information searches and analyses to assess future impacts of current R&D.

Barron et al. (2002) and Barth et al. (2001) also examine financial analysts' behavior in the presence of reported R&D expenses. Barron et al. (2002) find that the consensus in analysts' forecasts is negatively associated with a firm's level of R&D spending, indicating that a higher level of information uncertainty accompanies R&D. Barth et al. (2001) show that the level of analyst following is significantly greater for firms with more R&D expenses, suggesting potential economic advantages in following these firms. Our study extends this research by directly examining the link between earnings uncertainty in the presence of R&D and the revision activity of analysts.

Finally, our study adds to the literature on analysts' forecast revision behavior. Prior research indicates that analysts tend to revise their forecasts in response to information releases (e.g., Stickel, 1989; Baginski and Hassell, 1990; Francis et al., 1997). Moreover, Stickel (1989) suggests that analysts' forecast revision activity depends on the characteristics of the information released and other factors affecting analysts' private incentives to collect information. This study contributes to this literature by showing that another firm-specific characteristic, R&D, is associated with the activity and magnitude of analysts' revisions after quarterly earnings announcements.

The remainder of the paper is organized as follows. Section 2 reviews prior literature and develops our hypothesis. Section 3 presents the research design and empirical models. Section 4 describes the sample and data. Our empirical results are provided in Section 5, followed by concluding remarks in the final section.

[1] For example, the June 30, 2005 FASB Exposure Draft "Business Combinations, a Replacement of SFAS 141," calls for recording purchased in-process research and development acquired in a business combination as an asset, not an expense as currently required.

2 Prior literature and hypothesis development

2.1 Literature on R&D expenses

A primary motivation of this study stems from prior research findings on R&D. These studies show that R&D investments contribute significantly to the productivity and output of firms (see e.g., Hall, 1993; Mansfield, 1991; Acs et al., 1994). Another set of studies indicate that capital markets consider R&D as a significant value increasing activity. For example, (Chan et al., 1992) document a significantly positive market reaction to corporate announcements of new R&D, particularly for firms in high-technology sectors that employ cutting edge technology.

Despite the apparent benefits, R&D costs are immediately expensed in corporate financial reports under current U.S. accounting standards, leaving no trace of R&D capital on firms' balance sheets and causing potential material distortions of reported earnings numbers (Lev, 1999). A major reason for not recognizing these expenses as assets in financial statements is the concern that their estimated values are unreliable. Lev (2001) argues that the inherent uncertainty associated with intangible investments such as R&D is higher than that associated with physical and financial assets because (1) these investments are most intensive at the early, high-risk stages of a firm's innovation and value creation process; (2) there is no organized market for trading such investments; and (3) property rights tend to be less well defined for these investments. Consistent with this argument, Kothari et al. (1998) report that the earnings volatility (as a proxy for risk) associated with R&D is, on average, three times higher than that associated with physical investments.

Several studies assess capital market consequences of deficiencies in financial reporting for R&D expenses. For example, Lev et al. (1999) document a substantial reporting bias over the life cycle of R&D-intensive companies and find a systematic capital market misevaluation associated with such biases. Lev and Zarowin (1999) report an association between the decrease in the informativeness of earnings and changes in R&D spending. Aboody and Lev (2000) find that, for firms with intensive R&D, insider gains are substantially larger and investors' reaction to the public disclosure of insiders' trade is statistically stronger. They interpret this evidence to be consistent with the argument that information asymmetry is an increasing function of a firm's level of R&D spending. Because information asymmetry is often cited as a reason for share repurchases, Barth and Kasznik (1999) predict and find that firms with substantial R&D expenses are more likely to repurchase shares in the open market. Using bid-ask spreads as a proxy for information asymmetry, Boone and Raman (1999) report a statistically significant association between increases in R&D spending and the widening of stocks' spreads. In addition, Shi (2003) provides evidence that increases in R&D expenses are associated with increases in the cost of debt of public companies, suggesting a positive link between R&D expense and firms' cost of capital.

Two recent studies examine the relation between R&D expenses and financial analysts' behavior. Barth et al. (2001) show that firms with more R&D expenses have greater analyst coverage and that analysts spend more efforts to follow such firms. Barron et al. (2002) find that the consensus in analysts' forecasts is negatively

associated with a firm's level of R&D spending. Both findings suggest that analysts have greater incentives to acquire and disseminate additional information for firms with substantial R&D expenses.

2.2 Literature on analysts' forecast revision behavior

Our study is also motivated by existing literature on analysts' forecast revision behavior. Extant research indicates that analysts tend to revise their forecasts in response to information releases. For example, Stickel (1989) finds fewer forecast revisions before interim earnings announcements and more revisions after interim earnings announcements. This evidence is consistent with the notion that analysts anticipate and respond to the information in interim earnings announcements when revising their annual earnings forecasts. Baginski and Hassell (1990) provide evidence that analysts revise their forecasts in response to management earnings forecasts. Francis et al. (1997) find an increase in forecasting activity following management communications with analysts at corporate presentations.

Prior studies also suggest that analysts' revision behavior depends on the characteristics of the information released and other factors influencing analysts' incentives to collect information. For example, Stickel (1989) finds that analysts' revision activity is significantly related to the magnitude and sign of unexpected earnings in the interim announcement, firm size, and the level of competition among analysts. Williams (1996) suggests that the magnitude of the analysts' forecast revisions is a function of the usefulness of previous managerial forecasts. Using the data from the Report of the Financial Analysts Federation Corporate Information Committees, Lang and Lundholm (1996) indicate that firms with more informative disclosures policies have less volatility in forecast revisions. Barron and Stuerke (1998) document a positive association between the dispersion in analysts' forecasts updated shortly after an earnings release and analysts' activity in producing and disseminating further information during the period leading up to the next earnings release.

2.3 Hypothesis development

In this study, we assume that analysts maximize their expected utility in deciding whether to revise their forecasts and thus consider the relative benefits and costs of revisions. Two sets of arguments form the background for our hypothesis regarding the association between R&D expense and analysts' forecast revision activity. First, firms with more R&D are associated with more uncertain future earnings and/or cash flow streams (Lev, 2001). This higher uncertainty is likely to create a higher information demand by investors and increase the benefits from information production by analysts. Following this argument, analysts have an incentive to collect additional information for firms with larger amounts of R&D, which, in turn, will trigger more conveyance to investors via revised forecasts.

Second, the current financial reporting for R&D under current U.S. accounting standards (i.e., immediate expensing) is likely to limit the informativeness of earnings reports for firms with intensive R&D. The reduced informativeness of current earnings may lead to private incentives for analysts to acquire and produce information for firms

with large R&D expenses. Forecast revision activity is then likely to be higher for such firms.

Alternatively, it may be the case that large R&D expenses reduce analysts' forecast revision activity. Lang and Lundholm (1996) find that firms with more precise disclosures are more widely followed by analysts, suggesting that improved disclosures are likely to lower the costs to analysts of collecting information and following a firm. Barth et al. (2001) find that analysts expend greater effort to follow firms with larger amounts of R&D expenses, implying that the costs to analysts of collecting information are higher for such firms. Given the more uncertainty in the earnings generation process and less informative earnings disclosures for firms with intensive R&D, we would expect the costs of the information search by analysts are greater for such firms, which, in turn, may reduce their revision activity.

The preceding discussion suggests that both the demand and supply of analysts' forecasts could be affected by the degree of a firm's R&D expenses. It is not clear whether the net effect on revision activity is positive or negative. Thus, it remains an empirical issue to examine the relation between analysts' forecast revision activity and firms' R&D expenses. The following hypothesis stated in the null form is tested in this study:

H_0: There is no association between analysts' annual earnings forecast revision activity for a firm and the current level of the firm's R&D expenses.

3 Research design and empirical models

3.1 Measuring analysts' forecast revision activity

We measure revision activity by computing the percentage of financial analysts who revise their annual earnings forecasts during the 21-day period following a quarterly earnings announcement (days $[+0, +20]$, where day 0 is the earnings announcement date). We focus on the forecasts that are revised after earnings announcements because prior research (Stickel, 1989; Francis et al., 1997) indicates that analysts tend to revise their forecasts after earnings information is disseminated. Thus, using this group of forecasts may increase the power of our tests. We also assess the sensitivity of our results to the length of the window after earnings announcements using two shorter periods (i.e., days $[+0, +5]$ and $[+0, +10]$).

3.2 Control variables

To help isolate the incremental effects of R&D expenses, we control for other firm-specific attributes that might affect financial analysts' revision activity following earnings announcements. Stickel (1989) argues that financial analysts have more incentives to revise an annual earnings forecast if the magnitude of the unexpected earnings (i.e., earnings surprise) in the interim earnings announcement is larger. Lang and Lundholm (1996) observe that the characteristics of analysts' earnings forecasts are likely to be affected by the magnitude of earnings surprise. Therefore, we control

for earnings surprise in our analysis using the absolute value of unexpected earnings in quarterly earnings announcements.

Stickel (1989) indicates that analysts respond differently to negative earnings surprises than to positive earnings surprises of the same magnitude. Stickel reports that negative earnings surprises are more likely to result in analysts' forecast revision activity following an interim announcement. We therefore include an indicator variable for the sign of earnings surprise as another control variable in our analysis.

We also control for other variables that, as suggested by prior research, might affect analysts' incentives to gather information about a firm's future earnings and, consequently, are likely to affect the properties of their forecast revision behavior. Prior studies document that firm size is associated with (1) the number of analysts following a firm (e.g., Bhushan, 1989), (2) the amount of the pre-announcement information available for a firm (e.g., Atiase, 1985; Shores, 1990), and (3) the speed with which information is impounded into security price (e.g., Dempsey, 1989; Brennan et al., 1993). It is also used as a proxy for investor interest (e.g., Shores, 1990). To the extent that firm size is related to investor interest, analyst following, or the level of pre-disclosure information, firm size will likely affect analysts' incentives to collect and disseminate information, and thus affect their forecast revision behavior.

Finally, we control for trading volume. Prior research (e.g., Grossman and Stiglitz, 1976; Holden and Subrahmanyam, 1992) suggests that investors' expected profits from trading on analysts' information are related to the extent to which individual informed trades reveal the trader's information. The more thinly traded the firm's security is, the more likely the individual trades will reveal information to market participants. Assuming that the analysts' benefits from providing information are related to the investors' expected benefits from acting on that information, analysts have greater incentives to revise their forecasts for those firms whose shares are more heavily traded. We use a firm's relative trading volume (i.e., percentage trading volume) to proxy for this effect.

3.3 Empirical models

We employ the following model to test our hypothesis:

$$\mathrm{PREV} = \alpha_0 + \alpha_1{}^{*}\mathrm{DRD} + \alpha_2{}^{*}\mathrm{VOL} + \alpha_3{}^{*}\mathrm{SIZE} + \alpha_4{}^{*}\mathrm{ABUE} + \alpha_5{}^{*}\mathrm{SIGN} + e_1 \tag{1}$$

where PREV is the measure of revision activity, computed as the percentage of analysts who revise their annual earnings forecasts during a 21-day period after a quarterly earnings announcement. Specifically, PREV is the number of revisers divided by the number of analysts. The revisers are analysts who revise their forecast of annual earnings per share between day 0 and +20 after a quarterly earnings announcement, where day 0 is the earnings announcement date. Each analyst following a particular firm who has provided a least one forecast of annual earnings during the fiscal year of the announcement is included in the number of analysts.

DRD is the annual research and development expense reported in the income statement, deflated by total operating expenses.[2] According to our earlier discussion regarding the relationship between analysts' forecast revision activity and a firm's R&D expenses, the association between DRD and PREV could be either positive or negative.

VOL is the relative trading volume, calculated as the annual trading volume divided by the total number of shares outstanding. As discussed above, prior studies suggest that analysts are likely to have stronger incentives to revise their forecasts for a firm if the firm's shares are more heavily traded. Therefore, we expect that VOL is positively associated with PREV.

SIZE is the logarithm of market value of equity, measured at the beginning of the year. To the extent that firm size is a proxy for investor interest, analysts are likely to have more incentives to revise the forecasts of larger firms. Conversely, if larger firms have greater amount of other information available, and therefore investors rely less on analysts for information, then firm size would be negatively associated with revision activity.

ABUE is the absolute value of percentage forecast errors (i.e., unexpected earnings) associated with a quarterly earnings announcement. Specifically, ABUE = |(AEPS−FEPS)/AEPS|. AEPS is actual quarterly earnings per share from the I/B/E/S database. FEPS is the consensus one-quarter-ahead earnings forecasts reported by I/B/E/S in the most recent month prior to the quarterly earnings announcement date. Based on the empirical evidence provided by Stickel (1989), we predict that ABUE will be positively associated with PREV.

SIGN is an indicator variable that has value of 0 if the forecast error is positive or zero (i.e., actual EPS is greater than or equal to forecasted EPS), and its value is 1 if the forecast error is negative (i.e., actual EPS is less than forecasted EPS). Given prior research findings of Stickel (1989) and others, we expect that SIGN will be positively associated with PREV.

4 Sample, data and descriptive statistics

4.1 Sample selection and data description

This study uses the Institutional Brokers Estimate System (I/B/E/S) Detail database as the source of individual analysts' one-year-ahead forecasts of annual earnings per share. The I/B/E/S Summary database also provides the number of analysts, summary forecast measures, quarterly earnings forecasts, and firms' actual earnings per share. Earnings announcement dates are obtained from the Compustat Quarterly PST and Industrial files. The Compustat database also provides R&D expenses, total operating

[2] We use total operating expenses as the deflator to be consistent with Barth et al. (2001) and Barron et al. (2002). Alternatively, we employ sales as the deflator and the pattern of results is unaltered. Following Barth et al. (2001), we also use an industry-adjusted R&D ratio to measure a firm's R&D expense. Specifically, the industry-adjusted R&D ratio for a firm is calculated as the ratio of R&D expenses to total expenses for the firm, less the respective industry median ratio. The results based on this alternative measure of R&D expense are essentially the same as those reported in this study.

Table 1 Sample distribution

N	First quarter	Second quarter	Third quarter	Total
1990	296	331	319	946
1991	308	338	344	990
1992	367	375	379	1,121
1993	416	426	442	1,284
1994	486	498	514	1,498
1995	553	567	575	1,695
1996	666	689	678	2,033
1997	793	802	804	2,399
1998	855	839	835	2,529
1999	792	808	796	2,396
Total	5,532	5,673	5,686	16,891

expenses, trading volume, number of shares outstanding and market capitalization. To be included in the sample, a firm must have December 31 fiscal-year end. We exclude from the final sample firm-quarters missing any of the above data. The final sample includes 1,438 firms and 16,891 firm-quarter observations.[3] Table 1 lists the distribution of firm-quarter observations by year and fiscal quarter.

The industry composition of our 1,438 sample firms is presented in Table 2. The sample contains firms from 50 different two-digit SIC codes, with concentrations in business services including software companies (SIC 73, 273 firms, 18.98% of our sample), instruments (SIC 38, 181 firms, 12.59%), industrial machinery (SIC 35, 174 firms, 12.10%), electronic equipment (SIC 36, 161 firms, 11.20%), and chemicals and allied products (SIC 28, 153 firms, 10.64%). Similar to Barron et al. (2002), utilities and financial institutions are not included in the sample.

4.2 Descriptive statistics

Table 3 presents the descriptive statistics for our observations. The mean (median) of PREV is 0.398 (0.381), indicating that, on average (at the median), 40 (38) percent of analysts revise their annual earnings forecasts over the $[+0, +20]$ period following a quarterly earnings announcement. The mean of DRD indicates that, for the average firm in our sample, the R&D expenses constitute about 20.10% of total operating expenses. The median DRD is 16.90% and is smaller than the mean DRD, which is consistent with the concentration of R&D spending in certain firms.

Table 3 also shows that the median firm has a logarithm market value of equity of \$6.03, which is equivalent to market value of \$416 million. For the median firm, the annual trading volume is equal to 96.80% of its total number of shares outstanding at the beginning of the year, and the absolute value of unexpected earnings in quarterly earnings announcements is 10.50% of the actual earnings.

[3] This study's main purpose is to examine analysts' revisions of annual earnings forecasts in response to quarterly earnings information. Because 4th quarter earnings and annual earnings are usually released simultaneously, we exclude them from our sample.

Table 2 Industry composition of sample firms

Industry	2-digit SIC	No. of firms	Industry	2-digit SIC	No. of firms
Agricultural Production Crops	01	3	Instruments	38	181
Agricultural Services	07	1	Misc. Manufacturing	39	15
Metal Mining	10	1	Transportation Services	47	1
Oil and Gas Extraction	13	11	Communications	48	18
Minerals	14	4	Durable Goods	50	34
Building Constructions	15	2	Wholesale Trade—Non-Durables	51	16
Heavy Constructions	16	1	Building Materials	52	5
Construction-Special Trade	17	2	General Merchandise Stores	53	6
Food	20	18	Food Retail	54	9
Tobacco Products	21	3	Automotive Dealers	55	5
Textile Mill Products	22	2	Apparel Retail	56	8
Lumber& Wood	24	4	Furniture & Home Furnishings	57	4
Furniture& Fixtures	25	8	Eating & Drinking Places	58	38
Paper& Allied Products	26	18	Miscellaneous Retail	59	31
Printing, Publishing & Allied	27	5	Hotels	70	8
Chemicals& Allied Prod.	28	153	Miscellaneous Services	72	1
Petroleum & Coal	29	14	Business Services (including Software)	73	273
Rubber& Plastics	30	20	Automotive Repair, Services and Parking	75	3
Leather Products	31	2	Entertainment Services	78	3
Stone, Clay, Glass & Concrete Products	32	12	Amusement & Recreation	79	19
Primary& Metal Industries	33	23	Health Services	80	30
Fabricated Metal Products	34	27	Educational Services	82	2
Industrial Machinery	35	174	Social Services	83	3
Electronic Equipment	36	161	Engineering, Accounting, Research and Management	87	16
Transport Equipment	37	36	Others	99	4
Total number of firms in the sample					**1,438**

5 Empirical results

5.1 Bivariate evidence: pairwise correlation analysis

Table 4 presents both Spearman and Pearson correlations among the variables included in the empirical analyses. It reveals a significantly positive Spearman (Pearson) correlation of 0.12 (0.12) between DRD and PREV, suggesting that analysts' earnings forecasts revision activity increases with R&D expenses. We also find a significantly positive correlation between VOL and PREV, which is consistent with the notion that analysts have greater incentives to revise their forecasts for firms whose shares are relatively more heavily traded because investors' benefits from acting on private information in such firms are expected to be higher. The correlation between SIZE

Table 3 Descriptive statistics for the variables used in the regression Eq. (1) ($N = 16{,}891$, 1990–1999)

Variable	Mean	Standard deviation	25th percentile	Median	75th percentile
PREV	.398	.256	.200	.381	.571
DRD	.201	.181	.058	.169	.293
VOL	1.452	1.473	.564	.968	1.797
SIZE	6.259	1.797	4.929	6.030	7.371
ABUE	.239	.310	.030	.105	.300
SIGN	.363	.481	0	0	1

PREV: the measure of revision activity, which is computed as the percentage of analysts who make revisions during the 21-day period following a quarterly earnings announcement (days 0 through +20, inclusive, where day 0 is the Compustat earnings announcement date), DRD: research & development expenses deflated by total operating expenses, VOL: annual trading volume deflated by number of shares outstanding at beginning of the year, SIZE: logarithm of market value of equity at beginning of the year, ABUE: absolute value of actual EPS minus forecasted EPS divided by actual EPS, SIGN: an indicator variable, whose value is one (zero) if actual EPS is less than (greater than or equal to) forecasted EPS.

and PREV is significantly positive, indicating that analysts of larger firms are more likely to revise their forecasts after an earnings release. We also find a positive correlation between the magnitude of unexpected earnings (ABUE) and the percentage of analysts revising their forecasts (PREV), indicating that earnings releases trigger more revisions when the earnings surprise is larger. The correlation between SIGN and PREV is negative, although not significant at any conventional level.

5.2 Multivariate evidence: multiple regression analysis

Table 5 contains the multiple regression results for testing our hypothesis. The regression equation is estimated in two ways. First, in the pooled analysis, the regression coefficients are estimated by pooling all firm-quarter observations. Second, we conduct our tests using the Fama-MacBeth (hereafter FM) technique which estimates regression coefficients separately for each of the 30 quarters (3 quarters for each of 10 years). A *t*-test is then performed on the average of the 30 regression coefficients. The FM test addresses cross-sectional correlations and related statistical problems observed by Bernard (1987).

In columns (1) and (2) of Table 5, we report the FM test and pooled regression results for the entire sample (i.e., including all firm-quarter observations). As shown

Table 4 Correlation analysis for the variables used in regression equation (1) ($N = 16{,}891$, 1990–1999)

Variable	PREV	DRD	VOL	SIZE	ABUE	SIGN
PREV		.12 (< .01)	.17 (< .01)	.08 (< .01)	.16 (< .01)	−.01 (.93)
DRD	.12 (< .01)		.27 (< .01)	−.04 (< .01)	.09 (< .01)	−.01 (.21)
VOL	.17 (< .01)	.29 (< .01)		−.20 (< .01)	.11 (< .01)	−.03 (< .01)
SIZE	.06 (< .01)	−.05 (< .01)	−.11 (< .01)		−.27 (< .01)	−.06 (< .01)
ABUE	.08 (< .01)	.09 (< .01)	.11 (< .01)	−.26 (< .01)		.43 (< .01)
SIGN	−.00 (.73)	−.01 (.24)	−.01 (.07)	−.06 (< .01)	.41 (< .01)	

Numbers above (below) the diagonal represent Spearman rank (Pearson) correlations. See Table 3 for the definitions of all variables.

Table 5 Results on multiple regression analysis for the association between forecast revision activity and R&D expenses over the [+0, +20] window

Model : PREV $=\alpha_0+\alpha_1{}^*$DRD $+\alpha_2{}^*$VOL $+\alpha_3{}^*$SIZE $+\alpha_4{}^*$ABUE $+\alpha_5{}^*$SIGN $+ e_1$

		FM test all quarters (1)	Pooled Regression all quarters (2)	FM test first quarter (3)	Pooled Regression first quarter (4)	FM test second quarter (5)	Pooled regression second quarter (6)	FM test third quarter (7)	Pooled Regression third quarter (8)
Variable	Predicted Sign	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)
Intercept	+/−	.230 (17.80)***	.234 (28.19)***	.189 (7.72)***	.201 (14.32)***	.218 (16.30)***	.213 (14.98)***	.283 (15.95)***	.283 (19.45)***
DRD	+/−	.088 (7.88)***	.107 (9.58)***	.090 (4.33)***	.104 (5.54)***	.114 (5.67)***	.125 (6.50)***	.061 (4.10)***	.090 (4.61)***
VOL	+	.022 (11.50)***	.026 (18.80)***	.028 (9.48)***	.031 (13.51)***	.019 (6.36)***	.027 (11.23)***	.018 (5.79)***	.020 (8.37)***
SIZE	+/−	.013 (11.49)***	.015 (13.19)***	.012 (7.40)***	.013 (7.09)***	.013 (6.56)***	.016 (8.26)***	.014 (5.80)***	.016 (8.09)***
ABUE	+	.086 (8.73)***	.080 (11.21)***	.108 (6.69)***	.099 (8.52)***	.098 (5.14)***	.093 (7.30)***	.052 (4.83)***	.057 (4.64)***
SIGN	+	−.004 (−.50)	−.018 (−4.11)***	−.016 (−1.75)	−.031 (−4.16)***	.012 (1.04)	−.006 (−.77)	−.007 (−.43)	−.028 (−3.59)***
Adj. R^2		.048	.048	.061	.066	.056	.056	.027	.034

Note: This table reports the multiple regression results for the association between revision activity (i.e., the percentage of analysts who revise their annual forecasts after quarterly earnings announcements) and R&D expenses. PREV is percentage of analysts who make revisions during the 21-day period following a quarterly earnings announcement (days 0 through +20, inclusive, where day 0 is the Compustat earnings announcement date). All other variables are defined in the endnotes of Table 3.

Columns (1) and (2) show the results for the entire sample including all firm-quarter observations. The multiple regression analyses are conducted in two ways. In the pooled regressions, the regression coefficients are estimated by pooling all firm-quarter observations. In the FM (Fama-MacBeth) tests, the regression is estimated separately for each of the 30 quarters (3 quarters for each of 10 years, 1990–1999). The reported coefficient estimates and significance levels in the mean tests are based on the average of the 30 regressions. Columns (3) through (8) show the results for each interim quarter.

***Significant at the 1% level for a two-tailed test.

in column (2), the coefficient on DRD in the pooled regression analysis is positive and significant at the 1% level using a two-tailed test, indicating that the percentage of analysts who revise their annual forecasts following quarterly announcements is higher for firms with larger amounts of R&D expenses, after controlling for other factors likely associated with analysts' revision activity.

Regarding the control variables in the pooled regression, the coefficients on both VOL and SIZE are significantly positive at the 1% level, suggesting that analysts' revision activity following earnings announcements is higher for larger firms and those with more intensive trading. The positive coefficients on VOL and SIZE are consistent with the idea that large firms and those with more active trading—both indicators of investor interest—produce a greater investor demand for enhanced forecast precision from analysts as R&D expenses increase. Also, the lack of reported negative SIZE coefficients suggests that relatively large amounts of information available for large firms is insufficient to offset the demand for additional information searches as R&D expenses in quarterly earnings increase.

The coefficient on ABUE is also significantly positive at the 1% level, as predicted, indicating a positive association between analysts' revision activity and the magnitude of earnings surprise contained in quarterly announcements. This result for ABUE confirms previous research (e.g., Stickel, 1989) and suggests a positive response across analysts to a greater demand for forecast precision as the unexpected component of revealed quarterly information increases.

Contrary to our prediction for a positive relation, Table 5 shows mixed results across the SIGN coefficients. Three of the four pooled regressions show significant negative coefficients while all four SIGN coefficients in the FM tests show no significance. The negative coefficients on SIGN suggest that analysts' forecast revisions are less likely to occur if forecast errors are negative. A possible explanation for this result is that analysts, on average, may initially decline to engage in further information searches when a firm fails to meet the previous earnings forecast because the search costs exceed expected benefits for these firms. However, the overall mixed results are perhaps more consistent with the notion that the SIGN variable has little effect on revision activity. Importantly, our results for the remaining variables (not reported) remain qualitatively similar in sensitivity tests excluding the SIGN variable from our regressions.[4]

As shown in column (1) of Table 5, the findings from the FM test generally corroborate the pooled regression results. The coefficient on DRD is positive and significant at the 1% level, providing further support for the argument that the percentage of analysts' revising their forecasts soon after quarterly announcements is positively associated with the degree of a firm's R&D expenses. This is consistent with the notion that analysts have more incentives to acquire information and make forecast revisions for firms with intensive R&D because these firms have higher uncertainty with future earnings. The signs of the coefficients on VOL, SIZE, and ABUE are all significantly positive at the 1% level.

[4] Stickel (1989) reports a positive relation between analyst forecast revision activity and the sign of unexpected earnings. However, our sample differs from Stickel's by time period (Stickel 1982–1985, ours 1990–1999) and database (Stickel used 1,251 firms from Zachs with 7,526 total earnings announcements and we used 1,438 firms with 16,891 earnings announcements listed on I/B/E/S)

We also repeat the multiple regression analysis for each interim quarter separately to see if our results depend on the identity of the interim quarter. The results are presented in columns (3) through (8) of Table 5. The positive association between revision activity and R&D expense does not vary across interim quarters. For all three interim quarters examined, the coefficient on DRD is significantly positive at the 1% level in both the pooled regressions and FM tests. The signs of the coefficients on control variables are also consistent across interim quarters.[5]

Overall, the results point to a rejection of the null hypothesis of no association between analysts' annual earnings forecast revision activity for a firm and the current level of the firm's quarterly R&D expenses. Moreover, the positive coefficients on DRD provide evidence that R&D is associated with an increase in analysts' forecast revisions. This positive association suggests that analysts find utility in collecting additional information and revising forecasts for firms that report current R&D expenses. The results show no support for the alternative hypothesis in the negative direction, i.e., R&D reduces forecast revision activity. Because current R&D can produce higher uncertainty in the earnings generation process and less informative current earnings, analysts must weigh the costs and benefits of additional information search to improve forecast precision. If such costs are excessive, we would expect analysts forecast revision activity to decline as R&D expenses increase. However, the lack of a negative association between revision activity and R&D is inconsistent with the notion that the additional search costs induced by R&D exceed the benefits.

5.3 Additional analyses

5.3.1 Are the results sensitive to the length of the window after the announcement?

Our study tests the association between R&D expense and analysts' forecast revision activity following quarterly earnings announcements. To examine the sensitivity of our results to the choice of window after the announcement, we repeat all our analyses using the shorter, $[+0, +5]$ window. Consistent with the longer $[+0, +20]$ window Table 6 shows that PREV is positively and significantly associated with DRD at the 1% level for both the pooled regressions and FM tests. In addition, the results are fairly consistent across three interim quarters. We also use the $[+0, +10]$ window to check the sensitivity of our results. Again, the results are nearly identical and therefore not tabulated for brevity. Thus, our inferences do not appear sensitive to the length of the window used in our study.[6]

[5] We use the Belsley et al. (1980) approach to assess the degree of collinearity among independent variables. The maximum condition index in all analyses is 11.38. Belsley et al. (1980) suggest that mild collinearity is diagnosed if the maximum condition index is between 5 and 10 and severe collinearity exists for an index over 30. Although there is some degree of collinearity in our multiple regression analyses, it does not appear to be a severe problem.

[6] We also examine the forecast revision activity during the 10-day period before the earnings announcement and its association with R&D expense. Since we focus on the period prior to the announcement, both ABUE and SIGN are not relevant and we simply include DRD, SIZE, and VOL in the regressions. The results show that the coefficient on DRD is positive but not significant at the conventional level. A plausible explanation is that analysts tend to delay their forecast revisions until earnings information is released,

Table 6 Results on multiple regression analysis for the association between forecast revision activity and R&D expenses over the [+0, +5] window

Model: $PREV = \alpha_0 + \alpha_1 * DRD + \alpha_2 * VOL + \alpha_3 * SIZE + \alpha_4 * ABUE + \alpha_5 * SIGN + e_1$

		FM test all quarters (1)	Pooled regression all quarters (2)	FM test first quarter (3)	Pooled regression first quarter (4)	FM test second quarter (5)	Pooled regression second quarter (6)	FM test third quarter (7)	Pooled regression third quarter (8)
Variable	Predicted sign	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)
Intercept	+/−	.071 (5.99)***	.062 (8.33)***	.059 (3.53)***	.052 (4.19)***	.068 (3.32)***	.056 (4.37)***	.086 (3.46)***	.075 (5.63)***
DRD	+/−	.064 (6.92)***	.121 (12.13)***	.065 (3.21)***	.117 (7.03)***	.063 (4.98)***	.121 (7.00)***	.063 (3.99)***	.125 (7.02)***
VOL	+	.015 (7.81)***	.029 (23.24)***	.018 (5.49)***	.031 (15.47)***	.015 (3.82)***	.030 (14.02)***	.012 (4.24)***	.025 (11.33)***
SIZE	+/−	.014 (9.95)***	.018 (17.84)***	.011 (5.35)***	.015 (8.79)***	.014 (5.37)***	.018 (10.46)***	.017 (6.71)***	.022 (12.07)***
ABUE	+	.038 (6.85)***	.034 (5.39)***	.049 (4.10)***	.047 (4.50)***	.039 (4.03)***	.037 (3.21)***	.027 (4.24)***	.027 (2.45)**
SIGN	+	−.013 (−2.42)**	−.036 (−9.13)***	−.021 (−2.38)**	−.046 (−6.95)***	−.005 (−.55)	−.027 (−3.89)***	−.014 (−1.25)	−.043 (−6.18)***
Adj. R^2		.042	.069	.047	.081	.041	.070	.039	.067

Note: This table reports the multiple regression results for the association between revision activity (i.e., the percentage of analysts who revise their annual forecasts after quarterly earnings announcements) and R&D expenses. PREV is percentage of analysts who make revisions during the 6-day period following a quarterly earnings announcement (days 0 through +5, inclusive, where day 0 is the Compustat earnings announcement date). All other variables are defined in the endnotes Table 3.

Columns (1) and (2) show the results for the entire sample including all firm-quarter observations. The multiple regression analyses are conducted in two ways. In the pooled regressions, the regression coefficients are estimated by pooling all firm-quarter observations. In the FM (Fama-MacBeth) tests, the regression is estimated separately for each of the 30 quarters (3 quarters for each of 10 years, 1990–1999). The reported coefficient estimates and significance levels in the mean tests are based on the average of the 30 regressions. Columns (3) through (8) show the results for each interim quarter.

***Significant at the 1% level for a two-tailed test.

**Significant at the 5% level for a two-tailed test.

5.3.2 Are the results driven by certain R&D-intensive, high-technology industries?

To examine whether our results are primarily driven by certain R&D-intensive, high-technology firms, we repeat our analyses for a sample of firms outside the high-technology industries. Following Amir et al. (1996) and Barron et al. (2002), we identify high-technology industries using the following three-digit SIC codes: 283 (Drugs); 284 (Chemicals); 357 (Computer and Office Equipment); 366 (Communications Equipment); 367 (Electronics); 371 (Motor Vehicles); 382 (Measurement and Control Devices); 384 (Medical Instruments); and 737 (Software). This sub-sample includes 669 firms and 8,800 firm-quarter observations.

The regression results are presented in Table 7. As shown in columns (1) and (2), the coefficient on DRD is positive and significant at the 10% (5%) level for the pooled regression (FM test) over the [+0, +20] window, indicating that analysts' forecast revision activity is still positively associated with R&D expense for the set of firms that are not within the high-technology industries. The results for the [+0, +5] window are weaker but qualitatively similar. Untabulated statistics also show that the positive association between revision activity and R&D expense is robust across all three interim quarters for this set of firms. Although the results for this sub-sample are somewhat weaker than those of the total sample, the overall pattern remains the same. Our results therefore do not appear to be solely attributable to the effect of high-technology firms.

5.3.3 The association between the magnitude of forecast revisions and R&D expenses

We next examine the association between the magnitude of analysts' forecast revisions following earnings announcements and the level of R&D expenses. Because R&D-intensive firms have a more uncertain earnings generation process, the distribution of analysts' earnings forecasts (prior to earnings announcements) for these firms is likely to be more dispersed. Earnings surprises are therefore likely to have a greater impact on analysts' belief revision process, and thus a larger magnitude of revision. We use regression model (2) to test this conjecture:

$$\text{MAGI} = b_0 + b_1^*\text{DRD} + b_2^*\text{VOL} + b_3^*\text{SIZE} + b_4^*\text{ABUE} + b_5^*\text{SIGN} + e_2 \qquad (2)$$

where MAGI is the magnitude of analysts' forecast revisions made during the [+0, +20] period after a quarterly earnings announcement. Specifically, MAGI = |(AREV–BREV)/BREV|. AREV is the average of the revised forecasts of annual earnings per share across individual analysts who make a revision during the [+0, +20] period after a quarterly earnings announcement. BREV is the consensus annual earnings per share forecast reported by I/B/E/S in the most recent month prior to the quarterly earnings announcement. All other variables in Eq. (2) are as previously defined.

making it less likely to find a significant association between R&D expense and revision activity before earnings announcements.

Table 7 Results on multiple regression analysis for the association between forecast revision activity and R&D expenses for a sample excluding high-technology firms

Model1: $PREV = \alpha_0 + \alpha_1{}^*DRD + \alpha_2{}^*VOL + \alpha_3{}^*SIZE + \alpha_4{}^*ABUE + \alpha_5{}^*SIGN + e_1$

		FM test all quarters [+0, +20] window (1)	Pooled regression all quarters [+0, +20] window (2)	FM test all quarters [+0, +5] window (3)	Pooled regression all quarters [+0, +5] window (4)
Variable	Predicted sign	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)
Intercept	+/−	.224 (15.76)***	.227 (20.05)***	.079 (5.71)***	.072 (7.18)***
DRD	+/−	.045 (2.55)**	.040 (1.92)*	.039 (2.29)**	.027 (1.47)
VOL	+	.023 (7.29)***	.031 (12.34)***	.014 (6.08)***	.035 (15.45)***
SIZE	+/−	.014 (11.39)***	.016 (10.48)***	.013 (8.46)***	.017 (12.86)***
ABUE	+	.088 (6.93)***	.074 (7.63)***	.037 (4.70)***	.012 (1.40)
SIGN	+	.003 (.36)	−.007 (−1.23)	−.007 (−1.27)	−.026 (−5.23)***
Adj. R^2		.032	.031	.029	.043

Note: This table reports the regression results for the association between revision activity (i.e., the percentage of analysts who revise their annual forecasts) and R&D expenses over the [+0, +5] and [+0, +20] windows following quarterly earnings announcements for a sample of firms that are not within high-technology industries. The high-technology industries are defined as the industries with the following three-digit SIC codes: 283 (Drugs); 284 (Chemicals); 357 (Computer and Office Equipment); 366 (Communications Equipment); 367 (Electronics); 371 (Motor Vehicles); 382 (Measurement and Control Devices); 384 (Medical Instruments); and 737 (Software). See Table 3 for the definitions of all variables.

***Significant at the 1% level for a two-tailed test.

**Significant at the 5% level for a two-tailed test.

The regression results for Eq. (2) are contained in Table 8. As shown, the coefficients on DRD in both the pooled and FM tests are significantly positive, indicating that the magnitude of forecast revisions is higher for firms with higher amounts of R&D expenses. These results are fairly consistent across all three interim quarters.

For the control variables, Table 8 shows that the coefficient on VOL is significantly positive, suggesting that the magnitude of forecast revisions is higher for firms whose shares are more heavily traded in the market. The negative coefficient on SIZE is consistent with the view that larger firms are associated with more pre-disclosure information and therefore the information content of earnings announcements is lower for larger firms. Lower information content is expected to trigger lower magnitude of forecast revisions. In contrast to the mixed results for our SIGN variable reported in Tables (5–7), we report consistently significant positive coefficients for the SIGN variable in Table 8. These results indicate that the magnitude of forecast revisions tends to be higher when there is a large earnings surprise and when the earnings surprise is negative. Thus, for our sample, the sign of unexpected earnings variable appears to be an important factor in explaining the magnitude of analysts' forecast revisions, but not overall forecast revision activity.

Table 8 Results on multiple regression analysis for the association between forecast revision magnitude and R&D expenses over the [+0, +20] window

Model: $PREV = b_0 + b_1{}^*DRD + b_2{}^*VOL + b_3{}^*SIZE + b_4{}^*ABUE + b_5{}^*SIGN + e_2$

		FM test all quarters (1)	Pooled regression all quarters (2)	FM test first quarter (3)	Pooled regression first quarter (4)	FM test second quarter (5)	Pooled regression second quarter (6)	FM test third quarter (7)	Pooled regression third quarter (8)
Variable	Predicted sign	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)	Coefficient (*t*-statistic)
Intercept	+/−	.030 (4.69)***	.035 (5.71)***	.035 (2.89)**	.043 (3.78)***	.023 (2.78)**	.028 (2.66)***	.033 (2.46)**	.035 (3.38)***
DRD	+/−	.089 (6.01)***	.091 (10.89)***	.141 (5.03)***	.131 (8.65)***	.087 (6.63)***	.091 (6.38)***	.038 (1.60)	.050 (3.58)***
VOL	+	.019 (7.30)***	.013 (12.47)***	.019 (6.05)***	.014 (7.87)***	.023 (4.96)***	.016 (8.94)***	.014 (2.69)**	.008 (4.58)***
SIZE	+/−	−.006 (−6.56)***	−.007 (−8.08)***	−.007 (−3.56)***	−.008 (−5.37)***	−.006 (−4.49)***	−.006 (−4.29)***	−.005 (−3.41)***	−.006 (−4.04)**
ABUE	+	.338 (23.61)***	.347 (65.19)***	.282 (15.71)***	.290 (30.80)***	.374 (17.38)***	.385 (41.00)***	.359 (13.89)***	.372 (42.32)***
SIGN	+	.035 (6.59)***	.039 (11.72)***	.034 (2.53)**	.040 (6.72)***	.038 (4.98)***	.041 (7.14)***	.032 (6.40)***	.031 (5.67)***
Adj. R^2		.309	.314	.251	.258	.345	.354	.330	.342

Note: MAGI: magnitude of analysts' forecast revisions made during the [+0, +20] window following a quarterly earnings announcement, defined as the absolute value of average revised forecast after the announcement minus the consensus forecast before the announcement divided by the consensus forecast before the announcement.

Other variables are defined in the endnotes of Table 3.

***Significant at the 1% level for a two-tailed test.

**Significant at the 5% level for a two-tailed.

Similar to the results of revision activity, our untabulated statistics show that the positive association between revision magnitude and R&D expense is robust to the length of window after earnings announcements. In addition, the results are basically similar for the set of firms not included in high-technology industries, providing evidence that the results are not solely driven by those high-tech firms.

6 Summary and concluding remarks

Our empirical analysis finds that analysts' annual earnings forecast revision activity is positively and significantly associated with a firm's level of R&D expenses reported in quarterly earnings. We measure revision activity as the percentage of financial analysts who revise their annual earnings forecasts following a quarterly earnings announcement. Our results are consistent with the following argument. By its very nature, current R&D implies only uncertain future benefits. This uncertainty reduces the forecast relevance of current earnings and consequently creates demand for additional information. Moreover, to the extent that the R&D has future value, the requirement to expense R&D expenditures as incurred also reduces the forecast relevance of currently reported earnings. To maintain forecast accuracy, analysts therefore have an incentive to collect further information when earnings contain R&D expense, which, in turn, triggers additional forecast revisions. Although we also expect that information search costs are greater for firms with extensive R&D, our results suggest that the benefits from forecast revisions exceed the associated costs.

We also find that the magnitude of analysts' forecast revisions following quarterly announcements is positively and significantly associated with the level of R&D spending. With the higher earnings uncertainty for firms with larger amounts of R&D expenses, analysts' prior distributions of earnings are likely to be more disperse. With more dispersed priors, earnings surprises are likely to have a greater impact on the analyst's belief revision process, resulting in a larger magnitude of revision. Our results are consistent with this view.

Additional analyses show that the positive association between analysts' revision activity and R&D expenses does not vary across interim quarters. Further sensitivity analysis indicates the length of the window following quarterly earnings announcements does not affect our results. For three different windows following earnings announcements, we document a significantly positive association between the activity and magnitude of forecast revisions and the level of R&D spending.

Overall, our analyses provide evidence that R&D expense is an important determinant of analysts' revisions of annual earnings forecasts. By focusing on forecast revision activity, this study extends Barth et al., 2001) and Barron et al. (2002) and further contributes to our knowledge and understanding of the role of financial analysts as information intermediaries for firms with high levels of R&D expenses versus other firms in the economy.

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