Market underestimation of the implications of R&D increases for future earnings: the U.S. evidence

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April 2011

Abstract: Prior studies document that firms that increase research and development (R&D) expenditures experience positive abnormal returns in future years. The reasons for this association are unclear, however. This result may reflect an unidentified R&D correlated risk factor and/or it may reflect a systematic underestimation by market participants of future benefits from current increase in R&D. We show that future abnormal returns to R&D increases are concentrated around subsequent earnings announcements. We further show that market expectations, implied from stock prices, underestimate the future earnings benefits of increase in R&D. Finally, we document that in their forecasts of future earnings, security analysts also underestimate the effect of increase in R&D spending. These results suggest that future abnormal returns following R&D increases are at least in part due to the market's underestimation of the earnings benefits of R&D increases. The finding in this study contributes to the longstanding debate in accounting on whether the U.S GAAP requirement to expense R&D costs when incurred causes investors to underestimate the benefits of R&D.

Keywords: R&D increases, mispricing, underestimation of future earnings, analysts' forecasts.

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We gratefully acknowledge the comments of the seminar participants, especially Jim Ohlson and Paul Zarowin, the discussant, at the American Accounting Association's Financial Accounting and Reporting Section Conference.

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1. Introduction

Recent studies document that firms with R&D increases experience positive abnormal returns in future years (Penman and Zhang 2002; Eberhart, Maxwell, and Siddique 2004; and Lev, Sougiannis, and Sarath 2005). The reasons for this association are unclear, however. It may reflect an unidentified R&D or R&D correlated risk factor and/or it may reflect a systematic underestimation by market participants of future benefits from current R&D increases. The underestimation of future benefits perspective is that investors are mislead by the U.S. GAAP requirement to expense all R&D costs when incurred. That is, consistent with GAAP-based reporting, investors overly discount the future benefits of R&D.[1] The alternative R&D risk factor perspective argues that increase in R&D investment increases the fundamental riskiness of the firm and investors demand higher returns as compensation for bearing this risk. Common to both perspectives is the presence of a positive association between R&D increases and subsequent returns.

Eberhart et al. (2004) claim that they provide evidence consistent with the mispricing explanation. They show that firms with R&D increases exhibit greater future operating performance than other firms. They argue that the market is slow to recognize these benefits and hence undervalues firms with R&D increases. However, their evidence does

[1] We acknowledge that stock price under-reaction to R&D increase can also be due to other reasons put forward in the literature. Specifically, Barberis, Shleifer, and Vishny (1998) argue that the reason for under-reaction by the market is related to a phenomenon documented in psychology called conservatism, defined as slow updating of models in the face of new evidence. Hong and Stein (1999) argue that prices under-react in the short run because information diffuses gradually across the population.

not rule out the possibility that the market is efficient at recognizing properly the future benefits from R&D increases. The observed association between future abnormal returns and R&D increases may be due to errors in their long window abnormal return measures, arising from improper control for risk factors related to R&D increases. Eberhart et al. (2004) control for the standard risk factors, namely beta, market to book, size, and momentum. However, these factors are unlikely to control for risks associated with increase in R&D spending. This is an important concern given that Kothari, Laguerre, and Leone (2002) show that R&D increases are related to significantly higher variability in future earnings. Furthermore, Berk, Green, and Naik (2004) propose that R&D investments have systematic component which should be priced by the market and that book to market and firm size may not suffice. Since the Eberhart et al. (2004) research design does not explicitly control for systematic risk related to increase in R&D spending, one cannot rule out the omitted risk factor explanation for firms with large R&D increases exhibiting large positive values of their abnormal return measures for future years. Our goal here is to provide direct evidence on whether the stock market fails to fully recognize future earnings implications of R&D increases.

We follow the Eberhart et al. (2004) approach to identify firms-years with economically significant increases in R&D (we define this in detail below). Consistent with their finding, we show that firms with large R&D increases experience positive future abnormal returns. We further show that future abnormal returns associated with R&D increases are concentrated at earnings announcements. This evidence suggests that these abnormal returns are at least partially attributable to mispricing since risk effects should not be heavily concentrated at earnings announcement dates. That is, asset-pricing models do not predict significant shifts in expected returns over short windows (Bernard and Thomas 1989, 1990: Bernard, Thomas, and Whalen 1997).[2] Moreover concentration of abnormal returns at subsequent earnings announcements reflects the correction of the mispricing on these announcement dates when disproportionately large amounts of information about firm performance reaches the market. Thus, we conclude that some of the abnormal returns associated with R&D increases are attributable to the market's failure to fully recognize R&D's future implications on a timely basis.[3]

To more directly examine whether it is future earnings benefit of an R&D increase to which the market is underreacting, we use the following procedure. We first estimate the relation between R&D increases and future earnings using an earnings prediction model. The regression coefficient on the R&D measure in this model reflects the benefits of R&D in terms of future earnings. This coefficient is significantly positive, suggesting that future earnings benefits are greater for firms with R&D increases. Next, using a returns model, we estimate the relation between R&D increases and future earnings that are implicit in market prices. Specifically, we regress contemporaneous returns against unexpected earnings, where earnings expectations are specified in terms of prior period's earnings and R&D increases. Coefficients from this model provide an estimate of the

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[2] Bernard, Thomas, and Whalen (1997) argue that for a strategy that predicts future returns, a mispricing explanation is likely if the returns are concentrated around subsequent earnings announcements and if the returns are consistent in sign and magnitude with predictable changes in earnings being announced on those dates. We show that both of the results obtain in the context of large R&D increases. We show that future returns associated with R&D increases are concentrated around earnings announcement dates and R&D increases predict future earnings.

[3] It is also possible that R&D increases increase the information risk associated with subsequent earnings disclosures. Ball and Kothari (1992) propose that information risk may account for the increase in unconditional average return at earnings announcement dates. The return portion of our analysis cannot rule out large R&D increase driven information risk effects as a source of the announcement period return effects it documents. However, our analysis also finds that analyst forecasts do not fully reflect the implications of R&D increases for future earnings. Such a forecast bias is consistent with market underestimation of the future earnings impacts of R&D increases, but is not something expected to happen due to increased announcement period information risk.

market's perception of future earnings benefits of R&D increases. We find that the regression coefficient on R&D increases from the earnings prediction model is significantly greater than the corresponding coefficient on the R&D variable implied from the returns model. This result suggests that the market underestimates the effect of R&D increases on future earnings. This finding corroborates our result that future abnormal returns associated with R&D increases are concentrated at earnings announcements. Together, these results suggest that the market underestimates the future earnings benefits of R&D and is surprised at the time of future earnings announcements when future earnings turn out to be greater than what it had expected.

Next, we examine whether security analysts, who are considered to be sophisticated market participants, also underestimate the future earnings implications of R&D increases. It is more straightforward to test for a bias in analysts' estimates of future earnings, because unlike the market's estimate of future earnings analysts' estimates are observable in the form of their forecasts. We find that analysts' forecasts of next year's earnings are understated to a greater extent for firms with R&D increases. To the extent that analysts' forecasts of earnings influence or represent stock market's expectations of earnings, this evidence supports the view that future abnormal returns following R&D increase are at least in part due to the market's underestimation of earnings benefits of R&D increases.

In sum, our study contributes to the literature by examining why firms with R&D increases experience positive future abnormal returns. Our results are consistent with the market systematically underestimating future earnings benefits from current R&D increases. Thus, an omitted R&D correlated risk factor explanation, if valid, is unlikely to be the sole reason for the association between R&D increases and future abnormal returns.

The rest of the paper is organized as follows. Section 2 discusses the related literature. Section 3 describes data sources and the sample selection procedure. Section 4 documents for our sample the previously established relation between R&D increases and future abnormal returns. Section 5 documents the concentration of these abnormal returns at earnings announcements. Section 6 presents results on whether the market correctly estimates the implications of R&D increases on future earnings. Section 7 documents whether analysts correctly incorporate the effect of R&D increases in their earnings forecasts. Section 8 summarizes the paper and discusses the implications of our results for the debate over the current requirement in the U.S. GAAP to expense all R&D expenditures in the period incurred.

2. Background Literature

Several recent studies examine the relation between R&D expenditures and future abnormal returns. These studies fall into two groups. The first group considers *level* of R&D investments. Lev and Sougiannis (1996) show that estimated R&D assets deflated by the market value of equity is positively related to future abnormal returns.[4] Chan et al. (2001) document that R&D expenditures deflated by the market value of equity is also positively associated with future abnormal returns. However, Chan et al. (2001) argue that their results are driven by the market value of equity deflator. They show that when sales are used as the deflator the relation with future abnormal returns becomes

[4] R&D assets are computed using the Lev and Sougiannis (1996) model that estimate the impact of current and past R&D expenditures on earnings. This model enables measurement of the proportion of past spending that is still productive, and thereby provides an estimate of the value of R&D assets.

insignificant. Further, Chambers et al. (2002) show that any association of future returns with estimated R&D assets deflated by the market value of equity is likely to be due to an inadequate control for risk in the measurement of abnormal returns.

The second group of studies examines the association between *changes* in R&D investments and future abnormal returns. Lev et al. (2005) show that R&D growth is positively related to future abnormal returns. Penman and Zhang (2002) document that change in the ratio of estimated R&D assets to net operating assets is positively associated with future abnormal returns. Finally, Eberhart et al. (2004) document that firms with large R&D increases experience positive future abnormal returns. These studies conjecture that US GAAP's requirement to expense R&D expenditures when incurred misleads the market participants, causing them to underestimate the effect of increase in R&D investments on future profitability.[5]

Consistent with the above studies, Chambers et al. provide evidence that contemporaneous market returns are lower when firms report increases in R&D spending.[6] That is, the market appears to penalize firms when they ramp up their R&D spending, consistent with the notion that future R&D benefits are undervalued. Similarly, Lev et al. (2005) and Penman and Zhang (2002) also show that stocks are undervalued when R&D investments grow. They argue that their evidence is consistent with investor fixation on reported profitability measures, which decrease when R&D investments grow

[5] It is also possible that the R&D increase is signaling a substantive shift in firm strategy and that the subsequent earnings increases are more directly attributable to this strategic move. From this perspective our analysis should be viewed as examining whether the market underestimates the earnings impacts of the firm strategy shift signaled by the R&D increase.

[6] Specifically, Chamber et al. (2002, p. 151) regress excess returns in year t+1 on $G\Delta RDA_{t+1}$ and two other explanatory variables, where $G\Delta RDA_{t+1}$ is a rank variable *decreasing* in ΔRDA_{t+1}, defined as change in R&D assets for year t+1 (see footnote 2 for the definition of R&D assets). They obtain a positive coefficient on $G\Delta RDA_{t+1}$, suggesting a negative association between increase in R&D spending and contemporaneous market returns.

and the R&D expenditures are treated as expense in the year in which they are incurred. However, Chambers et al. (2002) emphasize that one cannot rule out the risk explanation for these results. If R&D spending signals risk then prices of firms experiencing risk increases due to R&D spending increases are properly discounted more than prices of firms not experiencing such increases (see also Berk, Green, and Naik, 2004). This discounting effect would lead to a negative relation between R&D increases and contemporaneous returns.

Eberhart et al. (2004) is of particular interest for our study in that like our own analysis it focuses on sizable increases in R&D spending. They show that firms with large R&D increases exhibit positive abnormal returns and positive abnormal operating performances in subsequent periods. They conclude that these results are consistent with market underestimating the future earnings benefits of R&D. However, it is possible that market efficiently estimates the benefits of R&D increases, but improper control for R&D related risk factors in the measurement of long window abnormal returns drives their results. The notion of omitted or mismeasured risk factors is an inherent issue in long window abnormal returns. Their analysis controls for market-to-book, size, momentum, and beta risk factors estimated over historical rolling five year (60 month) intervals. However, these factors are unlikely to completely control for all risk factors, especially for firms with R&D increases. For example, Kothari, Laguerre, and Leone (2002) show that future benefits associated with R&D investments are far more uncertain than those associates with property, plant, and equipment investments. Furthermore, Berk, Green, and Naik (2004) propose that the risk associates with cash flows generated by R&D investments have systematic component which should be priced by the market.

Eberhart et al. design does not explicitly control for systematic risk related to R&D spending increases. Thus, one cannot rule out omitted risk factor as the explanation for Eberhart et al.'s finding that large R&D increases are positively related to their abnormal return measures.[7]

In sum, there is no conclusive evidence in the literature that the observed long-run future abnormal returns associated with R&D increases are truly abnormal. In other words, it is not clear that the effect of omitted risk factors correlated with R&D increases has been properly controlled for in prior studies. In the absence of a reliable fully risk-adjusted long-run abnormal return measure drawing reliable inferences about R&D mispricing effects based on long-run returns is not possible. In this study, we address this problem by using tests that do not rely on long-run abnormal returns. In one set of tests, we examine whether R&D increase are related to future short-window returns around earnings announcements. Omission of risk factors is unlikely to be a problem over short-windows because expected returns are likely to be relatively small (Bernard and Thomas 1990). We also examine whether future returns associated with R&D increase are more concentrated in the earnings announcement periods as compared to the non-announcement periods. Greater concentration of returns around earnings announcements would suggest that a relatively large amount of price correction occurs at that time because disproportionately large amounts of information about firm performance reaches the market at that time. Our second set of tests uses a methodology similar to that in Mishkin (1983). Specifically, market's expectations of earnings are inferred from stock

[7] Eberhart et al. (2004) also propose that their rolling portfolio approach in which the portfolio risk parameters are estimated using the 60 immediate prior months of data addresses the notion that R&D spending increases risk. This approach has a problem. If a risk parameter increases at t due to the R&D spending event, then it can only be estimated with data from month t+1 and beyond. That is, only a model estimated over months t+1 to t+60 or later would properly capture this risk impact.

prices, and then we test whether these implied expectations properly incorporate implications of R&D increases for future earnings. Our final set of tests examine whether security analysts underestimate the future earnings implications of R&D increases. Collectively, these tests shed new light on whether future abnormal returns following R&D increases are at least in part due to the market's underestimation of the earnings benefits of R&D increase.

3. Data

We obtain data from the 2007 Compustat and CRSP files. Our sample contains NYSE, AMEX, and Nasdaq firms with non-zero R&D expenditure and covers the period 1975 to 2002. The sample period starts from 1975 because starting from October 1974 (SFAS No.2) GAAP requires expensing of R&D expenditures in the period incurred. The last year of our sample period is 2002 because for some of the analyses in the paper we need four-year-ahead earnings and returns. We also require that a firm-year observation have data for the four quarterly earnings announcement dates. We delete firms with sales revenue of less than 5 million, to avoid small denominator problem when measuring R&D intensity. The resulting sample consists of 36,200 firm-year observations. For the tests related to analysts' forecasts of earnings, we obtain forecast data from IBES. Our sample for this test consists of 17,132 firm-year observation for the period 1979 to 2002.

4. R&D Increases and Future Abnormal Returns

We first document for our sample that firms with large R&D increases exhibit positive future abnormal returns. Following Eberhart et al. (2004), we define large R&D

increase as an indicator variable, *R&DIncrease*, which takes the value of one if the firm has an R&D intensity (i.e., the ratios of R&D to assets and R&D to sales at the beginning of their R&D increase year) of at least 5 percent, increases its annual dollar R&D spending by at least 5 percent, and increases the ratio of R&D to assets by at least 5 percent. [8] For our sample, 12.37% of the observations are classified as having a large increase in R&D expenditures. Eberhart et al. argue that the *R&DIncrease* variable signals an explicit management decision to ramp up R&D investment. For firms with large R&D increases, when we regress change in annual R&D spending in t+1 on change in R&D spending in t, the slope coefficient is indistinguishable from 0 (average coefficient is .0505). That is, for these firms, the year t R&D spending increases are on average maintained in year t+1.

We use size-adjusted abnormal returns.[9] Specifically, each firm in the sample is assigned to a companion portfolio based on its decile ranking by size. Size is defined as the market value of equity at the end of December of previous year. The size decile breakpoints are determined by classifying the NYSE companies into ten equal groups. The monthly risk-adjusted abnormal returns are then computed as the difference in the firm's monthly return minus the companion portfolio's value-weighted monthly return. The annual abnormal returns are obtained by cumulating the monthly abnormal returns

[8] Chambers et al. (2002) use change in estimated R&D assets deflated by the market value of equity as a measure of change in R&D investments. We do not consider this measure because the deflator, market value of equity, may be responsible for the association with future returns. Chan et al. (2001) show that the association between R&D expense over market value of equity and future returns is driven by the deflator market value of equity. Penman and Zhang (2002) consider a different measure of change in R&D investments, defined as the average of the change in the ratio of estimated R&D assets to net operating assets and the deviation of this ratio from its industry median. Since it is difficult to interpret results for this measure because of its composite nature, we decided against using it in the paper.

[9] We repeat all of the analyses in the paper after replacing size-adjusted abnormal returns with raw returns and then with size and book-to-market adjusted abnormal returns. Our conclusions remain the same. Note that the main tests in the paper are based on short-window (three days around earnings announcements) returns. Thus, the omission of any risk factors is unlikely to be important because expected returns are likely to be relatively small over short windows.

from four months after the end of a fiscal year to four months after the end of the next fiscal year. If a firm is delisted, we follow Chan et al. (2001) and put delisting return for the month the firm is delisted and value-weighted market return for the following months.

Table 1 reports annual abnormal returns for the year of and the three years after portfolio formation date for firms with large increase in R&D investments (*R&DIncrease*=1) and firms without large increase in R&D investments (*R&DIncrease*=0). In the year of the R&D increase the R&D increase firm returns are indistinguishable (t=-1.29) from those of other R&D firms. In the years after the increase, however, the abnormal returns are significantly greater for firms with large increase in R&D in the first two years, 8.20% (t= 2.39), and 6.46% (t=2.07), but not in the third year. Overall, these results are consistent with those of Eberhart et al. (2004) and suggest that firms with large R&D increases experience positive future abnormal returns.[10]

Donelson and Resutek (2008) suggest that growth in R&D, measured as percentage increase in R&D, is not associated with future returns. They claim that prior studies' observation of positive association between increase in R&D spending, deflated by a scaling variable such as total assets, and future returns is driven by other measures of firm growth such as growth in assets. However, a substantive difference between Donelson and Resutek analysis and Eberhart et al. (2004) and our analysis is that we explore future excess returns to economically large increases. Donelson and Resutek do not employ such an "economically large" filter which means that their high % R&D growth portfolio includes both economically significant and insignificant R&D growth

[10] Chan, Lin, and Wang (2010) report evidence that large cuts in R&D spending are also associated with higher future returns which it attributes to strategy change driven reductions in cost of capital. The results reported in this paper are robust to the exclusion of large decrease firms from the comparison group of non-large-increase R&D firms.

firms. For example a firm with 0.1% R&D to asset will be considered as high R&D growth when it has 0.05% increase in R&D (it will translate into 50% increase in %R&D growth). However, this growth would not be an economically significant increase. The Donelson and Resutek analysis does point out that growth in total assets is an important correlated omitted variable in examining the association between a deflated measure of increase in R&D spending and future returns. To examine the robustness of the relation between large R&D increases and future abnormal returns to the inclusion of the growth in total assets variable, we estimate the following regression model:

$$ARET_{t+n} = \alpha_0 + \alpha_1 \, R\&DIncrease_t + \alpha_2 \, \Delta ASSET_t + \alpha_3 \, RDAS_{t-1} + \varepsilon_{t+n} \qquad (1)$$

where $\Delta ASSET_t$, defined as percentage change in total assets of a firm from time $t - 1$ to t. The second control variable, $RDAS_{t-1}$ is motivated by the definition of $R\&DIncrease_t$. For $R\&DIncrease_t$ to take a value of one, the observation must have the beginning of the period R&D to assets and R&D to sales ratios that are at least 5 percent. Thus, the observations that we classify as having large R&D increase also have high R&D intensity, in terms of R&D to assets and R&D to sales ratios. Chambers et al. (2002) document a positive relation between R&D intensity and future returns, and attributes this association to omitted risk factors. In order to control for the effect of R&D intensity on the relation between $R\&DIncrease_t$ and $ARET_{t+n}$, we use $RDAS_{t-1}$, defined as the ratio of R&D expense to total assets at the beginning of period t as an additional control variable.

Table 2 reports the regression results of three models based on equation (1). The dependent variables for the three models are $ARET_{t+1}$, $ARET_{t+2}$, and $ARET_{t+3}$, respectively. For the $ARET_{t+1}$ model, the coefficient on $\Delta ASSET_t$ is negative and significant, consistent with the results of prior studies (see e.g., Fairfield, Whisenant, and Yohn, 2003). The coefficient on $RDAS_{t-1}$ is positive and significant consistent with the finding of Chambers et al. (2002). The coefficient on our variable of interest, $R\&DIncrease_t$ remains positive and significant. The coefficient value is 0.0581, which suggests that the one-year abnormal returns of firm-years with large R&D increase is 5.81% greater than that of firm-years without large R&D increase. The equivalent univariate amount is 8.20% (see Table 1). For the $ARET_{t+2}$ model, the coefficient on $R\&DIncrease_t$ also remains significantly positive at 4.13%, but for the $ARET_{t+3}$ model, the coefficient on $R\&DIncrease_t$ is insignificant. These results are consistent with the notion that the market undervaluation of R&D increases in year t are corrected by a greater amount in years t+1 and t+2, than in year t+3. The results also suggest that the coefficients on $R\&DIncrease_t$ for the $ARET_{t+1}$ and $ARET_{t+2}$ models are smaller in magnitude than the corresponding amounts based on the univariate analysis (see Table 1). Thus, in the remaining analysis in the paper, we check the robustness of our results to the inclusion of $\Delta ASSETt$ and $RDAS_{t-1}$ as control variables in the abnormal returns model.

5. R&D Increases and Future Earnings Announcement Returns

If future abnormal returns associated with R&D increases are only due to omitted risk factors, then these abnormal returns should not be concentrated at future earnings announcements. Table 3 reports future abnormal returns at earnings announcements for the portfolio of firms with and without large increases in R&D.[11] We measure earnings announcement returns for the period day -2 to day 0, where day 0 is the earnings announcement date. For the year of and for each of the three years after the portfolio formation date, we report the sum of the abnormal returns of the four quarterly earnings announcements. Abnormal returns are positive for both portfolios in all four years examined. This finding is consistent with Ball and Kothari (1991) who show that abnormal returns around earnings announcement periods are on average positive. In the year of the increase the average announcement period return for the large increase firms, however, is smaller (t=-1.88) than the average return for other R&D firms. In subsequent years this relation is reversed as the differences in earnings announcement returns between firms with large R&D increases and those without are significantly positive for each of the three years after the portfolio formation date. The differences for years 1, 2, and 3 are 0.0146, 0.0174, and 0.070, respectively.[12]

The corresponding differences for the full year (earnings announcement and non-announcement periods combined), as reported in table 1, are 0.082, 0.0646 and 0.0304, for years 1, 2 and 3, respectively. Thus, the differences in earnings announcement period

[11] Since bad news tends to be delayed, the market may anticipate and react to the bad news before the earnings announcement date. Thus, returns on the earnings announcement date of bad news may understate the bad news. On the other hand, good news tends to be announced early. Thus, returns on the earnings announcement date of good news may correctly reflect the good news. Furthermore, firms with large R&D increases are more likely to provide good news to the market than those without large increases. Thus, the difference in returns on future earnings announcement dates for firms with and without large R&D increases are likely to be understated. Also, note that these earnings announcement returns do not reflect returns from a trading strategy, because to earn these returns investors will have to know the exact dates of earnings announcements (Cohen et al. (2007) and Thomas and Zhang (2008)).

[12] Amir et al. (2007) find that the R&D variability effects documented in Kothari et al. (2002) are largely restricted to firms in industries where R&D is high relative to physical capital while Eberhart et al. (2004) evaluate whether the future long run R&D return effects are present across high-tech, low-tech, high-growth, and low-growth sample partitions. Consistent with the robust across sub-group findings in Eberhart et al. we find that at future announcement dates large increase firms generate larger announcement returns compared to other R&D firms for low-tech, high-tech, low growth and high growth sample partitions. The difference in return, however is greatest for high growth firms and smallest for low growth firms.

abnormal returns between firms with and without large R&D increases are 17.80% (=0.0146/0.0820) and 26.94% (=0.0174/0.0646) of the corresponding returns for the full year period for years 1 and 2. We do not consider year 3 concentration measure because the long window return difference for year 3 is not statistically significant (see Table 1). Given that earnings announcement period constitutes only 5% of the total trading days, our results suggest that future abnormal returns associated with R&D increases are highly concentrated at earnings announcements.[13] Thus, the association between R&D increases and future abnormal returns is unlikely to be due to R&D related omitted risk factors alone. The market seems to underestimate the future benefits of R&D increases, and large price corrections occur during future earnings announcements when significant information about firms' performance is released.

To check the robustness of the univariate results, we estimate the following equation, which is similar to equation (1), except that the dependent variable is EA_ARET_{t+n} , which is the sum of the three day (-2, 0) earnings announcement abnormal returns of the four quarters of year t+n.

$$EA\_ARET_{t+n} = \alpha_0 + \alpha_1\, R\&DIncrease_t + \alpha_2\, \Delta ASSET_t + \alpha_3\, RDAS_{t-1} + \varepsilon_{t+n} \quad (2)$$

The regression results of equation (2) are reported in Table 4. The coefficient on $R\&DIncrease_t$ is positive and significant for years t + 1 and t + 2, (0.0069, t = 2.29 and

[13] Bernard et al. (1997, table 3) document a similar level of concentration of future returns in the three-day earnings announcement window for the post-earnings-announcement-drift (PEAD) strategy. Specifically, they show that out of a total of 5.9% drift in the first quarter 1.33% (=5.90-4.57) belong to the earnings announcement window. Thus, 22.5% (1.33/5.90) of the drift is concentrated in the earnings announcement window. Bernard et al. (1997) also not that for the mispricing explanation to be valid the strategy should also predict future earnings. We show in the next section that a large R&D increase predicts high future earnings. This supports the interpretation that the concentration of abnormal returns around future earnings announcement windows that we document reflects mispricing.

0.0055, t = 1.91, both significant at better than 5% level), but is not significant for year t + 3. These results are consistent a significant amount of future price correction associated with increase in R&D spending in year t happens during the earnings announcement windows. This result is consistent with the mispricing explanation. The corresponding coefficients on *R&DIncrease*$_t$ for the full year, as reported in Table 2, are 0.0581 and 0.0413 for years t+1 and t+2, respectively. Thus, the earnings announcement period abnormal returns for observations with large R&D increases are 12% (=0.0069/0.0581) and 13% (=0.0055/0.0413) of the corresponding returns for the full year period for years t+1 and t+2. Given, the earnings announcement period constitutes only 5% of total trading days, our results suggest that future returns associated with large R&D increases are concentrated at earnings announcements. We estimate a regression similar to equation (2), after replacing the dependent variable earnings announcement window returns with the returns during the non-announcement period. Untabulated results show that the resulting coefficients on *R&DIncrease*$_t$ have lower significance levels (t = 1.76, and 1.27 for years t + 1 and t + 2, respectively) than in the case of earnings announcement window returns (t = 2.29 and 1.91 for years t + 1, and t + 2, respectively). These results further underscore the point that future returns around earnings announcements is an important driver of the significant relationship between *R&DIncrease*$_t$ and future periods' long window returns.

6. The Market's Estimate of the Implications of R&D Increases for Future Earnings

Methodology

Our results in Tables 3 and 4 suggest that future abnormal returns associated with R&D increases are in part due to the market's underestimation of future implications of R&D increases. To examine whether it is the future earnings benefits of R&D increases to which the market is underreacting, we use the following procedure. First, we estimate the association between R&D increases and future earnings. Next, we estimate the association between R&D increases and future earnings implicit in stock returns. Finally, we compare the estimated coefficients from the first two steps to conclude whether the market underestimates the effect of R&D increases on future earnings.

We use the following equation to estimate the relation between R&D increases and future earnings.

$$E_{t+1} = b_0 + b_1 E_t + b_2 R\&DIncrease_t + \varepsilon_{t+1} \quad (3)$$

where E_t is operating income before depreciation and R&D expense for fiscal year t divided by the market value of equity at the beginning of year t. Our definition of E_t is consistent with that of Lev and Sougiannis (1996). They argue that operating income is an appropriate measure of R&D's benefits, since consequences of R&D investments are largely unrelated to non-operating items such as interest expense. Depreciation is excluded from operating income since it represents ad hoc write offs of tangible and intangible assets. R&D expenses are excluded because we are interested in examining the benefits of R&D, and consider R&D increases as a separate explanatory variable in the model. $R\&DIncrease_t$ stands for increase in R&D investments. As defined earlier, it is an indicator variable that takes the value of one if the firm has an R&D intensity (i.e., the ratios of R&D to assets and R&D to sales) of at least 5 percent, increases its dollar R&D of at least 5 percent, and increases the ratio of R&D to assets of at least 5 percent.

We estimate the relation between R&D increases and future earnings that is implicit in market price by using the following model:

$$EA\_ARET_{t+1} = a_0 + a_1\, UE_{\,t+1} + \varepsilon_{\,t+1} \qquad (4)$$

where, EA_ARET_{t+1} is size-adjusted abnormal returns summed over the four earnings announcement periods in year t+1, $UE_{\,t+1}$ is unexpected earnings and is defined as,

$$UE_{\,t+1} = E_{\,t+1} - \text{Expectation at t of } E_{t+1} \qquad (5)$$

Combining equations (3), (4), and (5), yields the following model:

$$EA\_ARET_{t+1} = a_0 + a_1\, (E_{\,t+1} - (b_0{*} + b_1{*}E_t + b_2{*}R\&DIncrease_t)) + \varepsilon_{t+1} \qquad (6)$$

where b_1*and b_2* in equation (6) reflect the association of E_t and $R\&DIncrease_t$ with future earnings as implied by market price. Prior studies have used non-linear estimation procedures on pooled data to estimate the pricing equations (see, e.g., Sloan 1996 and Kraft et al. 2007). However, we estimate the following linear cross-sectional equation to obtain estimates of b_1* and b_2*:

$$EA\_RET_{t+1} = \lambda_{\,0} + a_1\, E_{t+1} + \lambda_1 E_t + \lambda_2\, R\&DIncrease_t + \varepsilon_{t+1} \qquad (7)$$

Then, $b_1* = - \lambda_1 / a_1$ and $b_2* = - \lambda_2 / a_1$. These estimates are calculated annually and the mean value of the estimates and the t-statistics of the mean are obtained from the distribution of the annual estimates, consistent with the Fama-MacBeth approach. This procedure addresses a concern raised by Kraft et al. (2007) with regards to the use of a system of non-linear equations, as its estimation requires iterative procedures which can be unreliable. They also note that it is difficult to control for cross-sectional correlations in the regression residuals when estimating a non-linear equation.

If the market appropriately incorporates R&D increases into its expectations of future earnings then b_2* would equal b_2, which is obtained from estimating (3). If the market underestimates the future earnings implications of R&D increases, then b_2* would be smaller than b_2. Similarly, a comparison of b_1* and b_1 would indicate if the market properly estimates the relation between current and future profitability, and will be a useful benchmark for interpreting any difference we observe between b_2* and b_2.

Our methodology is similar to that in Ball and Bartov (1996). They estimate the market's assessment of the serial correlation in seasonally differenced quarterly earnings using stock returns at earnings announcements. They compare the market's estimate with the estimate of actual serial correlation in seasonally differenced quarterly earnings and conclude from that the extent to which the market underestimates the serial correlation. Sloan (1996) also uses a similar methodology to examine whether the market overestimates the effect of accruals on future earnings. However, unlike Ball and Bartov (1996), he uses total returns over both the earnings announcement and non-announcement periods and also uses a non-linear estimation method with the pooled cross-sectional and time-series data, as suggested by Mishkin (1983).

Kraft et el. (2007) discusses several problems associated with using the Mishkin test and one of these concerns apply to the Ball and Bartov approach as well. Below, we address this concern. They argue that correlated omitted variables from the forecasting and pricing equations may lead to incorrect conclusions about efficient pricing of accounting variables, if the omitted variables are not rationally priced. To address this concern, we repeat our analyses after including in our forecasting and pricing equations all the control variables that prior accounting research suggests or finds to be correlated with future returns or earnings. Specifically, we use all the control variables that Kraft et al. (2007) consider.

Our approach is distinguishable from Kraft et al. (2007) in that we, like Ball and Bartov (1996), examine short window announcement period returns. Sloan (1996) and Kraft et al. (2007) use returns over a twelve month period. The benefit of using short window returns is that omission of any risk factors in the pricing equation is unlikely to bias the coefficients on the included variables by much, because expected returns associated with the omitted risk factors is likely to be small over short windows (Bernard and Thomas, 1989, 1990 and Bernard et al. 1997, Kothari, 2001). Specifically, we estimate the following models:

$$E_{t+1} = b_0 + b_1 E_t + b_2 R\&DIncrease_t + b_3 R_t + b_4 SALES_t + b_5 \Delta SALES_t + b_6 CAPEX_t + b_7 \Delta CAPEX_t + b_8 NOAR_t + b_9 E_{t-1} + b_{10} R\&DIncrease_{t-1} + b_{11} \Delta ASSET_t + b_{12} RDAS_{t-1} + \varepsilon_{t+1} \quad (8)$$

$$EA\_ARET_{t+1} = \lambda_0 + a_1 E_{t+1} + \lambda_1 E_t + \lambda_2 R\&DIncrease_t + \lambda_3 R_t + \lambda_4 SALES_t + \lambda_5 \Delta SALES_t$$
$$+ \lambda_6 CAPEX_t + \lambda_7 \Delta CAPEX_t + \lambda_8 NOAR_t + \lambda_9 E_{t-1} + \lambda_{10} R\&DIncrease_{t-1}$$
$$+ \lambda_{11} \Delta ASSET_t + \lambda_{12} RDAS_{t-1} + \varepsilon_{t+1} \qquad (9)$$

where, R_t is lagged annual return, $Sales_t$ and $\Delta Sales_t$ are the level and changes in sales deflated by total assets, $CAPEX_t$ and $\Delta CAPEX_t$ are the level and changes in capital expenditures scaled by total assets, and $NOAR_t$ is net operating assets ratio. These variables are defined as in Kraft et al. (2007). We also include lagged values of E_t and lagged values of R&D increase, namely, $R\&DIncrease_{t-1}$. These lagged variables further control for any correlated omitted variables effects (Mishkin 1983 and Kraft et al. 2007). Finally, as in sections 4 and 5, we include $\Delta ASSET_t$, defined as percentage change in total assets, and $RDAS_{t-1}$, defined as R&D expense over total assets, as additional control variables.

Finally, Kraft et al. (2007) suggest estimating only equation (7) and argues that the coefficient on $R\&DIncrease_t$, if significantly positive, would suggest that the market undervalues the future implication of R&D. However, we cannot infer from this result that there is a relation between R&D and future earnings and more importantly, whether the market underestimates the future earnings benefits of R&D increases. Specifically, by estimating both equations (8) and (9) separately, we will be able to estimate b_2, the actual relation between R&D increases and future earnings, and b_2^*, the relation between R&D increases and future earnings implicit in market price. The estimates of b_2 and b_2* will then enable us to infer whether the market underestimates the future earnings benefits of R&D.

Results

One-Year-Ahead Earnings and Returns Models

Table 5 presents results from estimating equations (8) and (9). For brevity, we do not report the coefficient estimates of the control variables. The results of the earnings prediction model suggests that b_1, the slope coefficient on E_t, is positive, 0.6469 (t-statistic=27.62) and b_2, the slope coefficient on $R\&DIncrease_t$, is also positive, 0.0121 (t-statistic=2.61). The results of the returns model, which reflects the market's perception, suggest that b_1^*, the slope coefficient on E_t, is significantly positive, 0.6724 (t-statistic=23.65), and b_2^*, the slope coefficient on $R\&DIncrease_t$, is insignificant, -0.0174 (t-statistic=-1.29). Furthermore, the slope coefficients on E_t from the earnings prediction model and the returns model, namely, b_1 and b_1^*, are not significantly different (t-statistic=-0.81), suggesting that the market does not seem to be biased in estimating the implication of current earnings for future earnings. However, b_2, the slope coefficient on $R\&DIncrease_t$ from the earnings prediction model is significantly greater than b_2^*, the slope coefficient on $R\&DIncrease_t$ implied from the returns model (t-statistic=2.64). These results suggest that the market underestimates the effect of R&D increases on future earnings benefits.

Two-Year-Ahead Earnings and Returns Models

The results in Table 5 uses EA_ARET_{t+1}, earnings announcement window returns of year t+1, as the dependent variable in the returns model (equation 9). Since Table 4 shows that EA_ARET_{t+2} is also significantly associated to $R\&DIncrease_t$, we repeat the analysis in Table 5, after replacing the dependent variable EA_ARET_{t+1} with $EA\_ARET_{t+1,t+2}$, which is the average earnings announcement window returns of years t+1 and t+2. Correspondingly, we replace E_{t+1} with $E_{t+1},_{t+2,}$ which is the average earnings over years t+1 and t+2. We report the results for these models in Table 6. The results are consistent with those reported in Table 5. Specifically, b_1, the slope coefficient on E_t from the earnings prediction model, and b_1^*, the slope coefficient on E_t implied from the returns model, are both positive and not significantly different (t-statistic= -0.26), suggesting that the market does not seem to be biased in estimating the implication of current earnings for future earnings. Table 6 also reports that b_2, the slope coefficient on $R\&DIncrease_t$ in the earnings prediction model, is significantly positive (t-statistic=2.61), suggesting that R&D increases lead to higher future earnings. However, b_2^*, the slope coefficient on $R\&DIncrease_t$ implied from the returns model, is insignificant, -0.0214 (t-statistic= -1.21). Moreover, the two slope coefficients are significantly different (t-statistic=2.69). These results once again suggest that the market underestimates the effect of R&D increases on future earnings.

We subject our results in sections 5 and 6 to the following sensitivity checks and the results continue to support out conclusions. First, we re-estimate the returns model (equation (9) in Tables 5 and 6) after replacing the dependent variable earnings announcement abnormal returns with annual abnormal returns, which is the sum of returns over both the earnings announcement and non-announcement periods. The use of long-window returns as the dependent variable is likely to reduce measurement error in the explanatory variable, the unexpected component of earnings, because not all information about earnings is received by the market on the earnings announcement dates. Using long-window returns is also likely to reduce the concern about the market anticipating bad news before the earnings announcement date, because earnings announcements with bad news tend to be delayed (see footnote 7). The results from this analysis lead to the same conclusions as before. Finally, we repeat our analysis after excluding the Kraft et al. (2007) suggested control variables in equations (8) and (9). The results in all the cases remain consistent with those reported in tables 5 and 6.

7. Analysts' Estimate of the Implications of R&D Increases on Future Earnings

Finally, we examine whether security analysts, whose future earnings estimates are directly observable (unlike market expectations of earnings, which have to be inferred from stock prices), also underestimate the future earnings implications of R&D increases. If so, the difference in future period earnings forecast errors between firms with R&D increases as compared to those without R&D increases should be positive. Analysts' forecasts data are obtained from IBES database, which starts coverage from 1979. A sample of 18,283 observations meets the data requirements for our analysis. We define forecast error as the actual earnings per share for fiscal year t+1 minus analysts' one-year-ahead earnings forecast for fiscal year t+1 seven month before the fiscal year end, divided by share price at the end of fiscal year t. The analysts' forecast measure we use is consensus (median) analysts' forecasts from IBES Summary files and actual earnings are also from IBES Summary Files.

Column one Table 7 reports the mean values of forecast errors of one-year-ahead forecasts. The mean value of the forecast errors are negative both for firms with and without large R&D increases. This result is consistent with the general optimistic bias in analysts' annual forecasts. More importantly, analysts' annual forecasts of firms with large R&D increases exhibit less negative forecast errors than that of firms without large R&D increases; the difference is 0.0048 (t=3.07). This result suggests that analysts' forecasts underestimate future earning of firms with large R&D increases.

One concern with the above result is that the consensus forecast measure may be influenced by stale forecasts of analysts who have not yet revised their forecasts after the disclosure of information on R&D increases for period t. Thus, it is possible that the analysts' who have not yet revised their forecasts know that R&D increases would lead to higher earnings but their beliefs are not reflected in the consensus forecast measure. The above result is based on consensus forecast measures computed seven months before the end of the fiscal year for which the forecast is made. We repeat our analyses after reducing the forecast horizon to four months and then to one month. It is very unlikely that by then analysts would not have updated their forecasts to reflect their estimate of the effect of R&D increases of the previous fiscal year.

Columns 2 and 3 of Table 7 report the mean values of the forecast errors of the forecasts with horizons of four months and one month, respectively. As expected, the magnitude of the forecast error reduces with forecast horizon. However, for both forecast horizons, analysts' annual forecasts of firms with large R&D increases exhibit less negative forecast errors than that of firms without large R&D increases; the differences are 0.0035 (t=2.63) and 0.0026 (t=2.32), respectively. These results further suggest that analysts' forecasts underestimate future earnings of firms with large R&D increases.

Prior studies have shown that the market value of equity and the book-to-market ratio are correlated with analysts' forecast errors (Core et al. 2006). To the extent that these two determinants of forecast errors are correlated with R&D increases, our univariate result in Panel A may not be reliable. We use a regression procedure to address this issue.

$$FE_{t+1} = d_0 + d_1 R\&DIncrease_t + d_2 logBM_t + d_3 logMV_t + d_4 \Delta ASSET_t + d5RDAS_{t-1} + \varepsilon_{t+1} \quad (10)$$

where FE_{t+1} is the IBES year t+1 forecast error deflated by lagged price; logBM_t is the log of the book value of equity divided by the market value of equity at time t; and logMV_t is the log of the market value of equity at time t. As before, we add $\Delta ASSET_t$ and $RDAS_{t-1}$ as additional explanatory variables to capture the effects of growth in assets and R&D intensity on forecast errors.

The Fama-MacBeth regression results of equation (10) are reported in Table 8. For forecasts with seven month horizon, the coefficient on $R\&DIncrease_t$ is positive and significant, 0.0046 (t-statistic=2.42). This result suggests that the forecast errors of analysts' one-year-ahead forecasts are greater for firms with large R&D increases as compared to that for firms without large R&D increases. In other words, this result is consistent with analysts' underestimating the future earnings of firms with large R&D increases. The coefficients on $logBM_t$ and $logMV_t$ are significant with the signs consistent with that obtained by prior studies (Core et al. 2006). Moreover, the coefficients $\Delta ASSET_{i,t}$ is significantly negative, suggesting that analysts overestimate future earnings of firms with asset growth. Table 8 also shows that the results for forecasts with four-month and one-month horizons are consistent with those for forecasts with seven-month horizon.

Overall, the results in this section suggest that analysts, who are sophisticated market participants, also underestimate the future earnings implications of large R&D increases. These results corroborate our results in sections 5 and 6, which suggest that the market as a whole underestimates the future earnings implications of R&D increases.

8. Summary and Conclusions

Several recent studies document a positive association between increase in R&D spending and future abnormal returns. This result may be due to a measurement error in abnormal returns due to an R&D correlated omitted risk factor and/or it may reflect the stock market's underestimation of the effect of R&D increases on future earnings. Our study provides evidence that the market's failure to fully recognize future earnings implication of R&D increases is at least partly responsible for the positive association between R&D increases and future abnormal returns.

Specifically, we document that future abnormal returns associated with R&D increases are concentrated at earnings announcements. This result suggests that these abnormal returns are unlikely to be due to omitted risk factors alone and that some of the future abnormal returns associated with R&D increases are likely to be due to the market's underestimation of the implications of R&D increases. Given that a large amount of information about firm's performance reaches the market during earnings announcement periods, correction of the market's mispricing is concentrated around these announcements. Furthermore, using stock prices to infer market estimates, we show that the market significantly underestimates the future earnings benefits of R&D increases. Finally, we show using analysts' forecasts of earnings that analysts' also underestimate the future earnings benefits of R&D increases in their forecasts.

The results of this study have the potential to contribute to the longstanding debate over the current requirement in the U.S. GAAP to expense all R&D expenditures in the period they are incurred. Our analysis shows that market participants struggle with appropriately assessing the future profitability and return implications of R&D expenditures under the current US standard. Even security analysts, who are sophisticated investors get mislead by the expensing of R&D costs and as a consequence end up being predictably surprised by higher income realizations following large increases in R&D spending. Since a primary objective of accounting policy is to convey useful predictive information to external users then this evidence suggests current R&D reporting standards are not effective. The underestimation by investors of the benefits of R&D spending and the resulting undervaluation of stocks has another important implication. To avoid undervaluation of their stocks, firms may end up underinvesting in R&D. Such actions can be detrimental not only to the well-being of the firm, but to the economy as well. It is not clear though that allowing firms to capitalize R&D expenditures is a superior option, because it could introduce too much subjectivity on the reported numbers. Conducting an analysis similar to that of this study on countries where the accounting rules allow capitalization of R&D expenditures can help shed some light on the relative merits of the two alternative approaches to account for R&D. We leave such analysis for future research.

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Table 1
Annual Abnormal Returns of Firms with and without Large R&D Increases

$R\&DIncrease_t$	$ARET_t$	$ARET_{t+1}$	$ARET_{t+2}$	$ARET_{t+3}$
1	-0.0187	0.0859	0.0698	0.0699
0	0.0137	0.0039	0.0052	0.0095
Difference (1 - 0)	-0.0324	0.0820**	0.0646**	0.0304
(*t*-value)	(-1.29)	(2.39)	(2.07)	(1.22)

The sample contains 36,200 firm-year observations for the period 1975 to 2002. It includes all domestic NYSE, AMEX and Nasdaq firms covered in CRSP and COMPUSTAT with non-zero R&D expenditures. $ARET_{t+1}$ ($ARET_{t+2}$, $ARET_{t+3}$) is size-adjusted buy and hold abnormal returns over first (second, third) year after portfolio formation. $ARET_t$ is size-adjusted buy and hold abnormal returns over year t. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of annual R&D expense as well as increase in R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. For our sample, 12.37% of the observations fall into the $R\&DIncrease_t$ = 1 category. Significance levels are computed using the Fama-MacBeth approach. ***, **, * indicates significance at the 1%, 5%, and 10% level, respectively. *t*-values are in parenthesis.

Table 2
Regression of Long Run Future Returns on Large R&D Increases

	Dependent Variable $= ARET_{t+1}$	*Dependent Variable* $= ARET_{t+2}$	*Dependent Variable* $= ARET_{t+3}$
$R\&DIncrease_t$	0.0581**	0.0413*	0.0275
	(2.00)	(1.68)	(1.19)
$\Delta ASSET_t$	-0.1082***	-0.0636***	-0.0395**
	(-5.35)	(-3.49)	(-2.48)
$RDAS_{t-1}$	0.3380**	0.2207	0.0694
	(2.00)	(1.41)	(0.65)
Adjusted R^2	0.0218	0.0185	0.0147

The sample contains 36,200 firm-year observations for the period 1975 to 2002. It includes all domestic NYSE, AMEX and Nasdaq firms covered in CRSP and COMPUSTAT with non-zero R&D expenditures. $ARET_{t+1}$ ($ARET_{t+2}$, $ARET_{t+3}$) is size-adjusted buy and hold abnormal returns over first (second, third) year after portfolio formation. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of annual R&D expense as well as R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. $RDAS_{t-1}$ is the R&D expense to asset ratio in t-1. $\Delta ASSET_t$ is the change in total assets in year t from year t-1 scaled by total assets in year t-1. Significance levels are computed using the Fama-MacBeth approach. *, **, and *** denote significance at 0.10, 0.05 and 0.01 respectively. *t*-values are in parenthesis.

Table 3
Earnings Announcement Period Abnormal Returns of Firms with and without Large R&D Increases

$R\&DIncrease_t$	EA_ARET_t	EA_ARET_{t+1}	EA_ARET_{t+2}	EA_ARET_{t+3}
1	0.0090	0.0261	0.0307	0.0223
0	0.0169	0.0115	0.0133	0.0153
Difference (1 - 0)	-0.0079*	0.0146***	0.0174***	0.0070*
(*t*-value)	(-1.88)	(2.92)	(3.27)	(1.84)

The sample contains 36,200 firm-year observations for the period 1975 to 2002. It includes all domestic NYSE, AMEX and Nasdaq firms covered in CRSP and COMPUSTAT with non-zero R&D expenditures. EA_ARET_{t+1} (EA_RET_{t+2}, EA_ARET_{t+3}) is size-adjusted buy and hold returns over three-day window (-2,0) for the four quarterly earnings announcements in first (second, third) year after portfolio formation. EA_ARET_t is size-adjusted buy and hold returns over three-day window (-2,0) for the four quarterly earnings announcements in year t. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of annual R&D expense as well as R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. Significance levels are computed using the Fama-MacBeth approach. ***, **, * indicates significance at the 1%, 5%, and 10% level, respectively. *t*-values are in parenthesis.

Table 4
Regression of Earning Announcement Period Abnormal Returns on Large R&D Increases

	Dependent Variable = EA_ARET_{t+1}	*Dependent Variable* = EA_ARET_{t+2}	*Dependent Variable* = EA_ARET_{t+3}
$R\&DIncrease_t$	0.0069**	0.0055**	0.0002
	(2.29)	(1.91)	(0.11)
$\Delta ASSET_t$	-0.0256***	-0.0142***	-0.0072**
	(-5.95)	(-5.16)	(-2.17)
$RDAS_{t-1}$	0.0027	0.0231	0.0316*
	(0.17)	(0.98)	(1.60)
Adjusted R^2	0.0067	0.0047	0.0042
# of years out of 28 where $R\&DIncrease_t$ is positive	20	18	14

The sample contains 36,200 firm-year observations for the period 1975 to 2002. It includes all domestic NYSE, AMEX and Nasdaq firms covered in CRSP and COMPUSTAT with non-zero R&D expenditures. EA_ARET_{t+1} (EA_RET_{t+2}, EA_ARET_{t+3}) is size-adjusted buy and hold returns over three-day window (-2,0) for the four quarterly earnings announcements in first (second, third) year after portfolio formation. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of annual R&D expense as well as R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. $RDAS_{t-1}$ is the R&D expense to asset ratio in t-1. $\Delta ASSET_t$ is the change in total assets in year t from year t-1 scaled by total assets in year t-1. Significance levels are computed using the Fama-MacBeth approach. *, **, and *** denote significance at 0.10, 0.05 and 0.01 respectively. *t*-values are in parenthesis.

Table 5
Actual versus the Market's Assessment of the Association between Large R&D Increases and One-Year-Ahead Earnings

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Earnings Prediction Model:

$$E_{t+1} = b_0 + b_1 E_t + b_2 R\&DIncrease_t + b_3 R_t + b_4 SALES_t + b_5 \Delta SALES_t + b_6 CAPEX_t + b_7 \ \Delta CAPEX_t + b_8 NOAR_t + b_9 E_{t-1} + b_{10} R\&DIncrease_{t-1} + b_{11} \Delta ASSET_t + b_{12} RDAS_{t-1} + \varepsilon_{t+1} \quad (8)$$

Returns Model:

$$EA\_ARET_{t+1} = \lambda_0 + a_1 E_{t+1} + \lambda_1 E_t + \lambda_2 R\&DIncrease_t + \lambda_3 R_t + \lambda_4 SALES_t + \lambda_5 \Delta SALES_t + \lambda_6 CAPEX_t + \lambda_7 \ \Delta CAPEX_t + \lambda_8 NOAR_t + \lambda_9 E_{t-1} + \lambda_{10} R\&DIncrease_{t-1} + \lambda_{11} \Delta ASSET_t + \lambda_{12} RDAS_{t-1} + \varepsilon_{t+1} \quad (9)$$

	Earnings Prediction Model, b_i	Returns Model	$b_i^* = -\lambda_i / a_1$	Difference $b_i - b_i^*$
E_{t+1}		0.3003***		
		(21.21)		
E_t	0.6469***	-0.2045***	0.6724***	-0.0255
	(27.62)	(-16.64)	(23.65)	(-0.81)
$R\&DIncrease_t$	0.0121***	0.0061*	-0.0174	0.0295***
	(2.61)	(1.76)	(-1.29)	(2.64)
Adjusted R^2	0.5663	0.1197		

The sample contains 36,200 firm-year observations for the period 1975 to 2002. It includes all domestic NYSE, AMEX, and Nasdaq firms covered in CRSP and COMPUSTAT with non-zero R&D expenditures. EA_ARET_{t+1} is size-adjusted buy and hold returns over three-day window (-2,0) for the four quarterly earnings announcements in first year after portfolio formation. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of annual R&D expense as well as R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. E_t is operating income before depreciation and R&D expense for fiscal year t divided by the market value of equity at the beginning of the fiscal year. R_t is buy-and hold returns from May of year t to April of year $t+1$. $SALES_t$ is sales revenue scaled by total assets. $\Delta SALES_t$ is change in sales revenue scaled by total assets. $CAPEX_t$ is capital expenditures scaled by total assets. $\Delta CAPEX_t$ is change in capital expenditures scaled by total assets. $NOAR_t$ is net operating assets ratio defined as in Kraft et al (2007). $RDAS_{t-1}$ is the R&D to asset ratio in t-1. $\Delta ASSET_t$ is the change in total assets in year t from year t-1 scaled by total assets in year t-1. Significance levels are computed using the Fama-MacBeth approach. For brevity, the coefficient estimates of the control variables are not reported. Significance levels are computed using the Fama-MacBeth approach. *, **, and *** denote significance at 0.10, 0.05 and 0.01 respectively. *t*-values are in parenthesis.

Table 6
Actual versus the Market's Assessment of the Association between R&D Increases and Two-Year-Ahead Earnings

Earnings Prediction Model

$$E_{t+1,\,t+2} = b_0 + b_1 E_t + b_2\, R\&DIncrease_t + b_3 R_t + b_4\, SALES_t + b_5\, \Delta SALES_t + b_6\, CAPEX_t + b_7\, \Delta CAPEX_t + b_8\, NOAR_t + b_9 E_{t-1} + b_{10}\, R\&DIncrease_{t-1} + b_{11}\, \Delta ASSET_t + b_{12}\, RDAS_{t-1} + \varepsilon_{t+1,\,t+3} \quad (8)$$

Returns Model

$$EA\_ARET_{t+1,\,t+2} = \lambda_0 + a_1 E_{t+1,\,t+2} + \lambda_1 E_t + \lambda_2\, R\&DIncrease_t + \lambda_3 R_t + \lambda_4\, SALES_t + \lambda_5\, \Delta SALES_t + \lambda_6\, CAPEX_t + \lambda_7\, \Delta CAPEX_t + \lambda_8\, NOAR_t + \lambda_9 E_{t-1} + \lambda_{10}\, R\&DIncrease_{t-1} + \lambda_{11}\, \Delta ASSET_t + \lambda_{12}\, RDAS_{t-1} + \varepsilon_{t+1,\,t+2} \quad (9)$$

	Earnings Prediction Model, b_i	Returns Model	$b_i^* = -\lambda_i/a_1$	Difference $b_i - b_i^*$
$E_{t+1,\,t+2}$		0.2002*** (19.80)		
E_t	0.6191*** (23.04)	-0.1257*** (-14.27)	0.6288*** (19.65)	-0.0097 (-0.26)
$R\&DIncrease_t$	0.0178 (2.61)***	0.0059** (2.08)	-0.0214 (-1.21)	0.0392*** (2.69)
Adjusted R^2	0.5175	0.1093		

The sample contains 36,200 firm-year observations for the period 1975 to 2002. It includes all domestic NYSE, AMEX and Nasdaq firms covered in CRSP and COMPUSTAT with non-zero R&D expenditures. $EA\_ARET_{t+1,\,t+2}$ is size-adjusted buy and hold returns over three-day window (-2,0) for the four quarterly earnings announcements in the first and second years after portfolio formation. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of R&D expense as well as R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. E_t is operating income before depreciation and R&D expense for fiscal year *t* divided by the market value of equity at the beginning of the fiscal year. $E_{t+1,\,t+2}$ is operating income before depreciation and R&D expense averaged over fiscal year *t*+1 to t+2, divided by the market value of equity at the beginning of the fiscal year t. R_t is buy-and hold returns from May of year t to April of year *t+1*. $SALES_t$ is sales revenue scaled by total assets. $\Delta SALES_t$ is change in sales revenue scaled by total assets. $CAPEX_t$ is capital expenditures scaled by total assets. $\Delta CAPEX_t$ is change in capital expenditures scaled by total assets. $NOAR_t$ is net operating assets ratio defined as in Kraft et al (2007). Significance levels are computed using the Fama-MacBeth approach. For brevity, the coefficient estimates of the control variables are not reported. Significance levels are computed using the Fama-MacBeth approach. *, **, and *** denote significance at 0.10, 0.05 and 0.01 respectively. *t*-values are in parenthesis.

Table 7
Analysts' Earnings Forecast Errors for Firms with and without Large R&D Increases

	Forecast horizon		
$R\&DIncrease_t$	7 months	4 months	1 month
1	-0.0137	-0.0090	-0.0040
0	-0.0185	-0.0125	-0.0066
Difference (1-0)	0.0048***	0.0035***	0.0026**
(*t*-value)	(3.07)	(2.63)	(2.32)

The sample contains 18,283 firm-year observations for the period 1979 to 2002. It includes all domestic NYSE, AMEX, and Nasdaq firms covered in IBES, CRSP and COMPUSTAT with non-zero R&D expenditures. FE_{t+1} is the one-year-ahead forecast error, measured as actual earnings per share for year t+1 minus analysts' one-year-ahead earnings forecast divided by share price at the end of fiscal year t. Analysts' forecasts are consensus (median) forecast from IBES Summary Files and actual earnings is also from IBES Summary Files. Forecast horizon is the time between the forecast date and the fiscal year end date for the fiscal year to which the forecast corresponds. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of R&D expense as well as increase in R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. *, **, and *** denote significance at 0.10, 0.05 and 0.01 respectively. *t*-values are in parenthesis.

Table 8
Regressions of Analysts' Forecast Errors on Large R&D Increases

Dependent variable: Forecast error (FE_{t+1})

	Forecast Horizon		
	7 months	4 months	1 month
Intercept	-0.0520*** (-6.17)	-0.0381*** (-9.51)	-0.0345*** (-7.68)
$R\&DIncrease_t$	0.0046** (2.42)	0.0042*** (2.85)	0.0039*** (2.55)
$\log BM_t$	-0.0123*** (-4.62)	-0.0085*** (-5.10)	-0.0080*** (-4.71)
$\log MV_t$	0.0028*** (6.73)	0.0026*** (7.92)	0.0024*** (5.68)
$RDAS_{t-1}$	-0.0041 (-0.17)	-0.0103 (-0.57)	-0.0380 (-1.51)
$\Delta ASSET_t$	-0.0043** (-2.01)	-0.0022* (-1.69)	-0.0034** (-2.29)
Adjusted R^2	0.0662	0.0493	0.0438
# of years out of 24 where $R\&DIncrease_t$ is positive	17	18	16

The sample contains 18,283 firm-year observations for the period 1979 to 2002. It includes all domestic NYSE, AMEX, and Nasdaq firms covered in IBES, CRSP and COMPUSTAT with non-zero R&D expenditures. FE_{t+1} is the one-year-ahead forecast error, measured as actual earnings per share for year t+1 minus analysts' one-year-ahead earnings forecast divided by share price at the end of fiscal year t. Analysts' forecasts are consensus (median) forecast from IBES Summary Files and actual earnings is also from IBES Summary Files. Forecast horizon is the time between the forecast date and the fiscal year end date for the fiscal year to which the forecast corresponds. $R\&DIncrease_t$ is an indicator variable, which takes the value of one if increase in dollar value of R&D expense as well as increase in R&D to assets ratio are greater than 5% and R&D intensity is at least 5%, where R&D intensity is defined as R&D to asset and R&D to sales ratios. $\log BM_t$ is the log of the book value of equity divided by the market value of equity at time t; and $\log MV_t$ is the log of the market value of equity at time t. $RDAS_{t-1}$ is the R&D expense to asset ratio in t-1. $\Delta ASSET_t$ is the change in total assets in year t from year t-1 scaled by total assets in year t-1. Significance levels are computed using the Fama-MacBeth approach. *, **, and *** denote significance at 0.10, 0.05 and 0.01 respectively. t-values are in parenthesis.