Another R&D Anomaly?

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ABSTRACT

In this paper, we investigate the relation between stock returns and R&D spending under different market conditions. Our empirical evidence suggests that investors' response to R&D activities varies according to stock market status.

Following the conventional definitions of markets, we first categorize the market into four different states: slightly up (up by 0-20%), bull (up by more than 20%), slightly down (down by 0-20%), and bear (down by more than 20%). Using firms in high-tech industries from 1992 to 2009 as our sample, we show that investors value R&D spending consistently positively only when the market (proxied by the S&P 500) is up. R&D is valued less in the downward market and R&D response coefficients even turn negative during bear markets. However, earnings response coefficients are consistently positive regardless of market status. The results remain unchanged after we control for beta, bankruptcy risk, size, and different measuring windows. Our findings cannot be explained by risk-based hypothesis.

The study advances our understanding of the relation between stock returns and R&D activities by empirically documenting its variations in market valuation across different market states; particularly, we found empirical evidence that R&D response coefficients in the down markets are negative. The study also provides additional input to the ongoing debate on finding the appropriate accounting treatment for intangible assets.

Keywords: R&D; Market Anomaly; Market Valuation; Market States; Risk

1. INTRODUCTION

The extant literature has provided extensive empirical evidence on the relationship between research and development (R&D) expenditures and future abnormal returns. As noted, both the level of R&D and the change of R&D activities are followed by positive risk-adjusted returns in subsequent periods. While some studies find that a delayed positive response to R&D activities is prevalent across industries (e.g., Hall, 1993, Sougiannis, 1994, Lev & Sougiannis, 1996), others show the delayed positive price reaction to R&D only exists in certain industries, especially in R&D-intensive sectors (e.g., Chan et al., 2001). Nevertheless, it is still puzzling as to *why* and *how* R&D activities will be followed by abnormal returns.

Two competing hypothesis exists to explain the price response to R&D activities. One strand of studies argues that investors have difficulties in understating the nature of R&D expenditures, resulting in a delay in incorporating the information in stock price efficiently. The underpricing is particularly severe for technology-based firms, since their intangible assets count a large percentage of total assets and their market capitalization depends heavily on R&D-based growth potential. Such delay also presents a challenge to accounting policymakers in contemplating whether R&D should be capitalized like most other major capital investments. If R&Ds can be capitalized, which usually requires more detailed disclosure compared to expensing, the capitalized R&D value and enhanced disclosure could facilitate a better understanding of R&D and allow for more timely incorporation of new information. Thus, the subsequent abnormal returns to R&D may be alleviated and the well-documented underpricing of R&D could disappear. The other strand of studies posits that the delayed R&D-return relation could be explained by extra risks. Kothari et al. (2002) show that the uncertainty of R&D outcomes contributes greatly to the volatility of operational results. Chambers, Jennings, and Thompson (2002) argue and provide empirical evidence that these R&D related risks are compensated with future returns. They interpret their results that R&D-return relation could not be directly attributed to reporting manner and suggest that amending current accounting procedure to capitalize R&D may have no effects on improving price efficiency.

In this study, we re-examine this relation in a different framework to further understand the dynamic between R&D activities and subsequent returns. Specifically, we investigate whether R&D expenditures are priced in the same fashion under different market conditions. If returns are to compensate for unexplained firm-specific risks, we should not expect the coefficients between abnormal returns and R&D activities to vary under different market conditions. On the other hand, based upon the market anomaly assumption, return-R&D relation will follow a random pattern regardless of the general trend of market. As shown in recent literature that many other market anomalies seem to relate to market sentiment (Stambaugh, Yu, & Yuan, 2012), we conjecture if future abnormal returns will respond more (less) to R&D intensity differently as market goes up (down).

Our results are in supportive of the anomaly hypothesis. Abnormal returns only trail R&D activities when the market is in an upward trend. We first segment the market states into slightly up (0-20% increase), bull (more than 20% increase), slightly down (0-20% decrease), and bear (more than 20% decrease). Using firm-year observations of the high-tech industries from 1992 to 2009, we find that investors appear to price reported R&D expenditures positively only when markets are up between 0-20%. R&Ds are valued less in slightly down markets and much less in bear markets. To rule out other risk-based explanations for the R&D pricing differentials, we added two risk measures – beta and solvency risk (Altman-z) - to proxy market risk and financial distress risk at the firm level. Our results remain unchanged.

We also test if our results are driven by variations of earnings rather than R&Ds. Prior literature has found that investment in R&D contributes more to subsequent earnings variability than investment in capital expenditures (Kothari, Laguerre, & Leone, 2002; Amir, Guan, & Livne, 2007). The different patterns of mispricing could have come from the misunderstanding of earnings rather than R&Ds. Interestingly; our findings show that earnings (excluding R&Ds) are priced consistently regardless of market status. Overall, our findings are in supportive of the view of market anomaly (mispricing). These findings shed some lights for policymakers that changing accounting policy to capitalize R&D expenditures may have help improve market efficiency especially during the economy booms.

In the following sections, we first review the relevant literature and develop hypotheses in Section 2. We then describe the research methodology and data in Section 3. The empirical findings are presented in Section 4, and the concluding remarks are provided in the final section.

2. LITERATURE BACKGROUND AND HYPOTHESIS

Research and development (R&D) activities are generally regarded as the primary driving force of recent economic developments in many parts of the world including the United States. However, how capital market values R&D expenditures still remains puzzling to researchers. Empirical evidence shows that R&D is not efficiently priced by investors. Instead, it is associated with subsequent positive stock returns. Using estimated firm-specific R&D capital, Lev and Sougiannis (1996) show that R&D capital is positively related to future stock returns. However, the evidence in Chan et al. (2001) suggests that such anomaly is not prevailing among all firms. They find that only a subset of companies with a high ratio of R&D to market value of equity appear to earn abnormal future returns. In addition to the association between the level R&D spending and future abnormal returns, anomaly is found in valuing the changes of R&D spending as well. For example, Lev et al. (2005) show a positive relation between the R&D growth rate and future abnormal returns. Penman and Zhang (2002) find similar relation between excess returns and the ratio of change in R&D to net operating assets. Lastly, Eberhart et al. (2004) demonstrate that firms with large increases in R&D expenditures have higher subsequent abnormal returns. Taken together, R&D activities seem to be undervalued contemporaneously and followed by positive abnormal returns. Such mispricing anomaly is especially pronounced among firms that show high R&D intensity based on various metrics.

In the literature, two different hypotheses are developed to study the contemporaneous undervaluation of R&D. The first is known as market anomaly assumption due to investors' fixation. R&D expenditure is not capitalized under current United States GAAP standards. Therefore, it is argued that the current accounting practice of expensing R&D significantly lowers the reported earnings of R&D-intensive companies. Such practice contributes to investor's inability to adequately capture the real benefits of R&D activities in a timely fashion. Instead, we observe that, as information and benefits of R&D are gradually comprehended by market, positive returns follow. Such mismatch between reported accounting numbers and market reaction also prompt the accounting policy makers to ponder whether the current accounting treatment of R&D impedes information efficiency in the capital market. If the anomaly is mainly caused by the way information is convened, capitalizing R&D, which demands more detailed disclosures, may promote investors ability to comprehend financial reports and help investors grasp the true underlying economic value of R&D activities in a more timely and efficient fashion. The second explanation builds its argument on the embedded risk of R&D. It is argued that the relation between current R&D spending and future abnormal stock returns is due to the elevated risks inherent to R&D activities. For instance, using the firm-year observations from 1972 to 1992, Kothari et al. (2002) find R&D increases earnings variability in subsequent periods significantly. As well, Shi (2003) shows that R&Ds also positively relate to bond default risks. Furthermore, empirical evidence in Chambers, Jennings, and Thompson (2002) confirm that the abnormal returns to R&D-related activities appear to be long lasting rather mean reverting. Dispersions of analyst forecast are also greater for R&D-intensive firms. These findings, taken together, are inconsistent with the investor fixation induced market anomaly hypothesis, but fit with the traditional risk-return trade-off argument. Investors are rewarded over time for taking extra risks because of R&D activities. Abnormal future returns are indeed to compensate for these specific risks.

We contribute to the market anomaly versus risk debate by examining the valuation of R&D across different market states. We argue that if abnormal returns reflect the risk inherent to R&D activities (risk hypothesis), we should not see differential pricing of R&D expenditures across different market states after controlling for systematic risk and size effects. On the other hand, market anomaly hypothesis suggests a random pattern of R&D-return relation regardless market status. Therefore, we hypothesize that, R&D-return relation should will remain relatively constant and positive regardless of different market conditions (Null hypothesis). Alternatively, investors will respond to R&D in a random pattern (Alternative hypothesis).

Moreover, a recent study by Stambaugh et al. (2012) find that many market anomalies are more pronounced when market sentiment is high. Given the similarity between R&D-return relation and other market anomalies, we expect to see lower (higher) valuation for R&D; i.e., more (less) mispricing, when the market is up (down) under our alternative hypothesis. As a robustness check, we examine how R&D adjusted earnings are priced under different market conditions. If the pricing efficiency is due to reasons other than R&D, we should not observe a similar pattern of our main results.

3. RESEARCH METHODOLOGY

3.1 Sample Selection

The sample used in this study is selected from COMPUSTAT firms from 1992 to 2009, subject to data availability of the following variables: (1) At least two years of the monthly stock price to calculate returns; (2) at least two years of earnings per share to calculate change; (3) at least three years of R&D spending to satisfy the requirement of the lagged R&D variable used in the model; (4) industry R&D intensity; and (5) data for computing the debt to equity ratio. To eliminate the influence of extreme observations, cases with values falling below 1 percentile or above 99 percentile in total assets, net sales, R&D spending, and earnings per share are excluded.

Firms are defined as high-tech companies according to the metrics used by Francis and Schipper (1999).[1] The S&P 500 composite index was selected as the market proxy. To identify the market status, we divide general market conditions into the following four states:

(1) BEAR: when the annual market (S&P 500) return is down at least 20%;
(2) SLIGHTLY DOWN: when annual market return is negative but less than 20%;

[1] Francis and Schipper (1999) define high-tech firms as firms whose SIC codes are 2800s, 3500s, 3600s, 3700s, 3800s, 4810s, 7370s, and 8730s.

(3) SLIGHTLY UP: when annual market return is between 0 and 20%;
(4) BULL: when annual market return is more than 20%.

In our empirical testing, each firm-year observation's annual return is calculated from nine months before to three months after its fiscal year end. The following example explains how we classify each observation's market state. Suppose that a firm-year observation has a fiscal year ending in December 2001; and we calculate its annual return from April 2001 to March 2002. The corresponding annual market return, proxied by S&P 500 index, will be calculated over the same period (from April 2001 to March 2002). For this specific case, since the annual market return was -1.1% which falls between -20% and 0%, we denote "down" market state to this firm-year observation.

3.2 Model Estimated

We adopt a simultaneous equation model to estimate the market valuation of R&D across different market states. We choose the simultaneous equation model to better control for the potential endogeneity between stock returns and R&D spending. Our system of equations is specified as:

$$RET_t = \alpha_0 + \beta_1(RD_t) + \beta_2(\Delta RD_t) + \beta_3(RD_{t-2}) + \beta_4(E_t) + \beta_5(\Delta E_t) + \beta_6(SIZE_t) + \beta_7(DE_t) + \beta_8(BETA_t) + \beta_9(Z_t) \quad (1)$$

$$RD_t = \gamma_0 + \gamma_1(RET_t) + \gamma_2(RET_{t-1}) + \gamma_3(IRD_{t-1}) + \gamma_4(FCF_t) \quad (2)$$

where, RET = annual stock returns accumulated from nine months before to three months after the fiscal year end;
RD_t = annual R&D spending in year t;
E_t = earnings before R&D expense for year t;
$SIZE_t$ = natural log of firm's market value at the beginning of year t;
DE_t = debt to equity ratio of year t;
IRD_{t-1} = the R&D intensity of the industry (four-digit SIC) where the firm is located
FCF_t = free cash flow in year t;
$BETA_t$ = stock beta, calculated using rates of returns 60 months prior to year t;
Z_t = Altman Z-score for year t;
Δ represents change (the first difference);

and both RD and E are scaled by sales.

We run the system of equations for each market state separately. Based on the null hypothesis, the coefficient for R&D spending, β_1, is expected to remain constant regardless of market states. The first seven independent variables in Equation (1) are typically included in the current literature to empirically examine the market valuation of R&D investments. To rule out the potential influence of other financial risks, especially during down markets, we include two risk measures as additional control variables –Beta and Altman Z-score. Beta captures the systematic risks associated with market volatility, and the Altman Z-score measures the financial distress risk and is often used predict bankruptcy. We expect the Altman Z-score to play a significant role in explaining returns, especially in down market states, when the market is more concerned about the risk of bankruptcy in bearish markets. In our empirical tests, we first run the basic model. Then, we repeat each regression by adding beta and Altman Z-score separately and combine both together.

The literature has shown that, managers may (and often) curtail or increase R&D spending to manipulate investors' perceptions of firm performance (See Dechow & Sloan, 1991; Darrough & Rangan, 2005) due to its discretionary nature. It is difficult to argue that, in any given year, management's determination of the level of R&D spending is made independently of firm equity value change. Therefore, to capture managers' tendency to over-invest (under-invest) in R&D due to stock price appreciation (depreciation), we include both the contemporaneous returns and the previous year's returns as determinants of R&D in Equation (2). In addition, we add industry R&D intensity of the firm-year observation to control for common macro economic factors that may affect R&D spending within the same industry. Last, free cash flow is added to control for the availability of funding for R&D activities (Dewan et al., 1998).

Because our primary focus is the response coefficient to R&D, we design our methodology to accommodate heterogeneous pricing of both earnings and R&D across different market states. To test the differential valuation of R&D across the four market states in the same equation while keeping the earnings response coefficient constant, we run another set of tests by modifying Equation (1) into (1B) as follows:

$$\begin{aligned} RET_t &= \alpha_0 + \beta_{01}(BULL) + \beta_{02}(DOWN) + \beta_{03}(BEAR) \\ &+ \beta_{11}(RD_t) + \beta_{12}(RD_t * BULL) + \beta_{13}(RD_t * DOWN) + \beta_{14}(RD_t * BEAR) \\ &+ \beta_2(\Delta RD_t) + \beta_3(RD_{t-2}) + \beta_4(E_t) + \beta_5(\Delta E_t) + \beta_6(SIZE_t) + \beta_7(DE_t) + \beta_8(BETA_t) + \beta_9(Z_t) \end{aligned} \tag{1B}$$

where: *BULL* = 1 if the annual S&P 500 return is equal to or greater than 20%, and 0 otherwise;
SLIGHTLY DOWN = 1 if the annual S&P 500 return is less than 0 but greater than -20%, and 0 otherwise;
BEAR =1 if the annual S&P 500 return is equal to or less than -20%, and 0 otherwise;
All other variables are as defined earlier.

In this alternative model, market value of R&D spending during the SLIGHTLY UP market (increase between 0-20%) is captured by the coefficient β_{11}. The incremental market value of R&D during the BULL market, the SLIGHTL DOWN, and the BEAR market are then revealed by β_{12}, β_{13}, and β_{14}, respectively. A positive β_{11} would imply that R&D is valued higher in the BULL markets. A statistically significant negative β_{13}, and β_{14} will indicate that the market value of R&D is lower in down markets.

As to the other variables, β_4 and β_5 are earnings (level and change) response coefficients. Based on the extant accounting literature, we expect them to be positive (e.g., Easton & Harris, 1991, Ali & Zarowin, 1992). β_6 and β_7, the coefficients on firm size and debt to equity ratio, respectively, are expected to be negative (e.g., Collins, Kothari, & Rayburn, 1987; Smith & Watts, 1992).

4. EMPIRICAL RESULTS

4.1 Summary Statistics

Table 1 provides the number of observations included in our sample in each high-tech industry and the distribution of the market states by industry. Our initial sample contains a total of 41, 512 firm observations based on criteria described in Section 3.

As Table 1 shows, the largest number of observations (firm years) are from SIC 2800 (Chemicals and Allied Products), SIC 3600 (Electronic and other Electric Equipment), 3500 (Industrial Machinery and Equipment), 3800 (Measurement Instruments, Photographic Goods, and Watches), and SIC 7300 (Business Services). Table 1 also demonstrates the independence of industry classifications and market states. There is no noticeable correlation between industry specifications and market states.

Table 1: The Distribution of Industry against Market States

S&P 500 Annual returns (Sample period: 1992-2009) **2-digit SIC code (Industry Name)**	*<=-20%* **Bear**	*-19.99%-0* **Slight Dn**	*0-19.99%* **Slight Up**	*>=20%* **Bull**	**Total Obs.**	**% of Sample**
28 Chemicals and Allied Products	912	436	3011	1255	5614	13.52%
30	63	21	240	139	463	1.12%
33	71	11	247	131	460	1.11%
34	68	18	282	137	505	1.22%
35 Industrial Machinery and Equipment	675	398	2474	1398	4945	11.91%
36 Electronic and Other Electric Equipments	924	605	3122	1678	6329	15.25%
37 Transportation Equipments	178	100	622	334	1234	2.97%
38 Measurement Instruments, Photographic Goods, Watches	809	439	2845	1447	5540	13.35%
48	75	28	285	124	512	1.23%
50	93	58	414	279	844	2.03%
51	62	25	205	168	460	1.11%
56	13	122	179	195	509	1.23%
58	112	49	382	272	815	1.96%
59	87	113	348	281	829	2.00%
73 Business Services	1129	594	3224	1684	6631	15.97%
80	108	18	278	208	612	1.47%
87	100	34	287	138	559	1.35%
All other industries; each represents less than 1% of the observations used in the empirical tests	526	293	2346	1486	4651	11.20%
Total	6005 (14.47%)	3362 (8.10%)	20791 (50.08%)	11354 (27.35%)	41512 (100%)	100%

Table 2 presents summary statistics of the sample firms. On average, firm invested 42% of its sales in R&D during the sample period, while the medium of sales to R&D is about 5%. The market capitalization ranges from $1.129 million to $58,688 million, with an average of $154 million.

Table 2: Summary Statistics of the Sample (n = 41,512)

	Mean	Median	Standard Deviation	Minimum	Maximum
Market Capitalization (MM$)	154.467	134.137	8.457	1.129	58,688.554
Total Assets (MM$)	1,634.258	102.873	7,593	0.036	304,012
Net Sales (MM$)	1,490.907	96.206	6,270	0.004	200,087.635
R&D spending (MM$)	63.931	4.700	316.930	0.000	9,694.394
R&D intensity (R&D/NetSales)	0.422	0.054	1.930	0.000	34.19
EPS excluding extraordinary items	0.160	0.160	10.082	-2015.4	28.43
Net Income before R&D to Sales	- 0.102	0.075	1.102	-25.910	0.779
Raw annual returns	0.567	-0.022	3.396	-0.965	60.767
Excess annual returns	0.466	-0.110	3.384	-1.463	60.580
Debt to Equity	1.080	0.611	1.681	0.000	20.342
Beta (n = 37,464)	-15.169	1.016	1297	-13186	2212.16
Altman Z (n = 29,143)	290.127	3.511	14483	-829.90	887389

Table 3 reports the identification of market states during the sample period for each cumulative annual returns ending month from 1992-2009. As shown, almost every sample year contains at least two different market states in the 12-month period. Table 4 tabulates the frequency of market states by each sample year from 1992 to 2009 for all observations that meet our selection criteria. As shown in Table 3 and Table 4, market returns based on the S&P 500 during 1992-1999 are all in the positive zone and the market turned completely down in 2001 and 2002. Similar pattern repeated in the period of 2004-2007 (positive) and 2008-2009 (negative). About 45% of the firm-year observations saw S&P 500 having positive returns between 0 and 19.99%.

Table 3A: The Identification of Market States Based on S&P 500 Annual Returns During the Sample Period from 1992-1997

	1992	1993	1994	1995	1996	1997
January	18.9% Slightly Up	7.3% Slightly Up	9.8% Slightly Up	-2.3% Slightly Down	35.2% Bull	23.6% Bull
February	12.4% Slightly Up	7.4% Slightly Up	5.4% Slightly Up	4.3% Slightly Up	31.4% Bull	23.5% Bull
March	7.6% Slightly Up	11.9% Slightly Up	-1.3% Slightly Down	12.3% Slightly Up	28.9% Bull	17.3% Slightly Up
April	10.6% Slightly Up	6.1% Slightly Up	2.4% Slightly Up	14.1% Slightly Up	27.1% Bull	22.5% Bull
May	6.5% Slightly Up	8.4% Slightly Up	1.4% Slightly Up	16.8% Slightly Up	25.4% Bull	26.8% Bull
June	10.0% Slightly Up	10.4% Slightly Up	-1.4% Slightly Down	22.6% Bull	23.1% Bull	32.0% Bull
July	9.4% Slightly Up	5.6% Slightly Up	2.3% Slightly Up	22.7% Bull	13.9% Slightly Up	49.1% Bull
August	4.7% Slightly Up	12.0% Slightly Up	2.6% Slightly Up	18.2% Slightly Up	16.0% Slightly Up	38.0% Bull
September	7.7% Slightly Up	9.8% Slightly Up	0.8% Slightly Up	26.3% Bull	17.6% Slightly Up	37.8% Bull
October	6.7% Slightly Up	11.7% Slightly Up	1.0% Slightly Up	23.1% Bull	21.3% Bull	29.7% Bull
November	15.0% Slightly Up	7.1% Slightly Up	-1.8% Slightly Down	33.4% Bull	25.1% Bull	26.2% Bull
December	4.5% Slightly Up	7.1% Slightly Up	-1.5% Slightly Down	34.1% Bull	20.3% Bull	31.0% Bull
year	1992	1993	1994	1995	1996	1997

Table 3B: Identification of Market States Based on S&P 500 Annual Returns During the Sample Period from 1998-2003

	1998	1999	2000	2001	2002	2003
January	24.7% Bull	30.5% Bull	9.0% Slightly Up	-2.0% Slightly Down	-17.3% Slightly Down	-24.3% Bear
February	32.7% Bull	18.0% Slightly Up	10.3% Slightly Up	-9.3% Slightly Down	-10.7% Slightly Down	-24.0% Bear
March	45.5% Bull	16.8% Slightly Up	16.5% Slightly Up	-22.6% Bear	-1.1% Slightly Down	-26.1% Bear
April	38.7% Bull	20.1% Bull	8.8% Slightly Up	-14.0% Slightly Down	-13.8% Slightly Down	-14.9% Slightly Down
May	28.6% Bull	19.3% Slightly Up	9.1% Slightly Up	-11.6% Slightly Down	-15.0% Slightly Down	-9.7% Slightly Down
June	28.1% Bull	21.1% Bull	6.0% Slightly Up	-15.8% Slightly Down	-19.2% Slightly Down	-1.5% Slightly Down
July	17.4% Slightly Up	18.6% Slightly Up	7.7% Slightly Up	-15.3% Slightly Down	-24.7% Bear	8.6% Slightly Up
August	6.4% Slightly Up	37.9% Bull	14.9% Slightly Up	-25.3% Bear	-19.2% Slightly Down	10.0% Slightly Up
September	7.4% Slightly Up	26.1% Bull	12.0% Slightly Up	-27.5% Bear	-21.7% Bear	22.2% Bull
October	20.1% Bull	24.1% Bull	4.9% Slightly Up	-25.9% Bear	-16.4% Slightly Down	18.6% Slightly Up
November	21.8% Bull	19.4% Slightly Up	-5.3% Slightly Down	-13.3% Slightly Down	-17.8% Slightly Down	13.0% Slightly Up
December	26.7% Bull	19.5% Slightly Up	-10.1% Slightly Down	-13.0% Slightly Down	-23.4% Bear	26.4% Bull
year	1998	1999	2000	2001	2002	2003

Table 3C: Identification of Market States Based on S&P 500 Annual Returns During the Sample Period from 2004-2009

	2004	2005	2006	2007	2008	2009
January	32.2% Bull	4.4% Slightly Up	8.4% Slightly Up	12.4% Slightly Up	-4.2% Slightly Down	-40.1% Bear
February	36.1% Bull	5.1% Slightly Up	6.4% Slightly Up	9.9% Slightly Up	-5.4% Slightly Down	-44.8% Bear
March	32.8% Bull	4.8% Slightly Up	9.7% Slightly Up	9.7% Slightly Up	-6.9% Slightly Down	-39.7% Bear
April	20.8% Bull	4.5% Slightly Up	13.3% Slightly Up	13.7% Slightly Up	-6.5% Slightly Down	-37.0% Bear
May	16.3% Slightly Up	6.3% Slightly Up	6.6% Slightly Up	20.5% Bull	-8.5% Slightly Down	-34.4% Bear
June	17.1% Slightly Up	4.4% Slightly Up	6.6% Slightly Up	18.4% Slightly Up	-14.9% Slightly Down	-28.2% Bear
July	11.3% Slightly Up	12.0% Slightly Up	3.4% Slightly Up	14.0% Slightly Up	-12.9% Slightly Down	-22.1% Bear
August	9.5% Slightly Up	10.5% Slightly Up	6.8% Slightly Up	13.1% Slightly Up	-13.0 Slightly Down	-20.4% Bear
September	11.9% Slightly Up	10.2% Slightly Up	8.7% Slightly Up	14.3% Slightly Up	-23.7% Bear	-9.2% Slightly Down
October	7.6%% Slightly Up	6.8% Slightly Up	14.2% Slightly Up	12.4% Slightly Up	-37.5% Bear	7.0% Slightly Up
November	10.9% Slightly Up	6.4% Slightly Up	12.1% Slightly Up	5.7% Slightly Up	-39.5% Bear	22.2% Bull
December	9.0% Slightly Up	3.0% Slightly Up	13.6% Slightly Up	3.5% Slightly Up	-38.5% Bear	23.5% Bull
year	2004	2005	2006	2007	2008	2009

Table 4: Market States Frequency by Year

Market State* (firm-year observations)	Bull (>=20%)	Slightly Up (0% to 19.99%)	Slightly Down (-19.99% to 0)	Bear (< =-20%)	total
1992	0	304	0	0	304 (0.7%)
1993	0	1589	0	0	1589 (3.8%)
1994	0	2449	0	0	2449 (5.9%)
1995	1041	1634	0	0	2675 (6.4%)
1996	2792	111	0	0	2903 (7.0%)
1997	1453	1747	0	0	3200 (7.7%)
1998	2933	419	0	0	3352 (8.1%)
1999	1291	1907	0	0	3198 (7.7%)
2000	0	2803	262	0	3065 (7.4%)
2001	0	0	807	2183	2990 (7.2%)
2002	0	0	2556	496	3052 (7.4%)
2003	315	185	184	1835	2519 (6.1%)
2004	1258	566	0	0	1824 (4.4%)
2005	0	1822	0	0	1822 (4.4%)
2006	0	1762	0	0	1762 (4.2%)
2007	147	1542	0	0	1689 (4.1%)
2008	0	0	1361	266	1627 (3.9%)
2009	124	22	121	1225	1492 (3.6%)
total	11354 (27.4%)	18862 (45.4%)	5291 (12.7%)	6005 (14.5%)	41512 (100%)

* Market state is determined by S&P 500 annual returns

4.2 Regression Results

4.2.1 Justification for Regression Models Used

In Section 3, we argue that a two-stage simultaneous equation model should be considered to test the hypotheses because R&D spending is discretionary, may possibly be dependent on the movement of the stock price. To provide statistical guidance on the choice of equation models in empirical testing, we perform Hausman's (1978) Test of Specification on Equations (1) and (1B). Four methods are compared: ordinary least square (OLS), two-stage least square (2SLS), three-stage least square (3SLS) and seemingly unrelated regression (SUR) methodologies. The resulting statistics, not presented here, show that 2SLS is preferred over all the other models at a significance level of less than 1% for Equation (1), and that OLS is preferred over al other models for Equation (1B) at a significance level of less than 1%. Consequently, in the following sections, we present the outcome of our empirical testing using the regression models as suggested by these Hausman Tests.

4.2.2 Regression Results

Table 5 Panel A show the results when markets go up, and Panel B summarizes results when market goes down. All rows are numbered. Each market state starts with the results of the basic model, followed by the addition of the control variables BETA, and Z, separately and then jointly.

In our hypothesis, we predict that if risk can explain the R&D return premium, market valuation of R&D will not vary across different market states once we control for risk. Focusing first on the coefficients for RD (level) across both panels, we can see the sign changes from positive in upward market states to negative in downward market states. Specifically, the RD coefficient goes from about 0.3 in BULL markets, to a little less than 0.1 in SLIGHTLY UP markets, and changes to -0.2 in SLIGHTLY DOWN markets and about -0.1 in BEAR markets. Except for row (12), all R&D level coefficients are statistically significant. Overall, the empirical results do not support the risk explanation for R&D valuation. The coefficients for the lagged variables, ΔRD_t and $RD_{t-2,}$ show no significance, either statistically or in terms of magnitude.

The earnings level variable, E, is consistently statistically positive across all market states and remains around 0.02 to 0.06 across different market conditions, in line with the empirical results of the current literature. The coefficient on firm size is consistently negative across different market conditions, as expected. Debt to equity ratio (DE) does not appear to explain the sample high-tech firms' excess returns except during the UP markets. Beta risk variable is positive in UP markets and negative in DOWN markets, a result consistent with recent finance research findings (e.g., Pettengill, Sundaram, & Mathur, 1995). The Altman Z-score does not show any significance except for row (12) when the market is DOWN.

There is an apparent shift in the magnitude of the earnings response coefficient and R&D response coefficient across market states. The R&D response coefficient is higher than the earnings response coefficient in all of the BULL market regressions (rows 1 to 4). This result implies that in BULL markets, investors of high-tech companies focus much more on the firm value contributed by R&D than on reported earnings, which reflects firm's past performance. However, the coefficient on earnings level gradually increased as the market turns towards BEAR, which suggest that investors appear to be more conservative and rely more on earnings as the overall market is not as optimistic or even pessimistic.

The regression results of Equation (2), not provided here, are discussed in this paragraph. The coefficient of *IRD*, industry level R&D spending, is around 1 across different market conditions, indicating that firms in the same industry have similar R&D spending. There appears to be no relationship between contemporary returns or the previous year's returns with current R&D spending. Contrary to intuition, the amount of free cash flow is inversely related to the amount of R&D spending after the other variables are controlled for.

Table 5: Results of 2-Stage Least Square (2SLS) Regressions

Market state	Intercept	RD_t	ΔRD_t	RD_{t-2}	E_t	ΔE_t	$SIZE_t$	DE_t	*Beta*	*Altman Z*	Adj. R^2
Panel A: When Stock Market is UP (with 1% and 99% extreme measures deleted)											
Dependent variable = XRET											
BULL (row 1)	0.59***	0.336***	-0.000	0.001**	0.021*	0.000	-0.081***	0.012			3.60% (n=5859)
(row 2)	0.59***	0.335***	-0.000	0.001**	0.021*	0.000	-0.081***	0.012	0.005**		3.68% (n=5852)
(row 3)	0.59***	0.285***	0.006	0.002***	0.016*	0.005	-0.080***	0.029*		0.000	3.42% (n=4023)
(row 4)	0.59***	0.285***	0.006	0.001***	0.016	0.005	-0.081***	0.029*	0.002	0.000	3.43% (n=4016)
SLIGHTLY UP	0.48***	0.133***	0.000	0.000	0.018***	-0.000	-0.058***	-0.037***			1.54% (n=10384)
(row 6)	0.48***	0.135***	0.000	0.000	0.017***	-0.000	-0.058***	-0.037***	0.000		1.54% (n=10311)
(row 7)	0.47***	0.087***	-0.000	0.000	0.017**	-0.000	-0.055***	-0.031***		0.000	1.27% (n=8162)
(row 8)	0.47***	0.089***	-0.000	0.000	0.016**	-0.000	-0.055***	-0.031***	0.000	0.000	1.25% (n=8091)
Panel B: When Stock Market is DOWN (with 1% and 99% extreme measures deleted)											
Dependent variable = XRET											
Market state	**Intercept**	RD_t	ΔRD_t	RD_{t-2}	E_t	ΔE_t	$SIZE_t$	DE_t	***Beta***	***AltmanZ***	**Adj. R^2**
SLIGHTLY DOWN	0.32***	-0.227**	-0.002	-0.001	0.033***	-0.002	-0.019***	-0.015*			2.20% (n=2624)
(row 10)	0.51***	-0.272***	-0.039	-0.001	0.055***	-0.010**	-0.033	-0.036**	-0.000		2.45% (n=1479)
(row 11)	0.18***	-0.102***	-0.003	-0.001	0.028***	-0.003*	-0.012*	-0.008*		0.000	1.20% (n=1967)
(row 12)	0.39***	-0.063	-0.07***	0.006	0.061***	-0.03***	-0.047***	-0.007	0.000	0.015***	6.70% (n=839)
BEAR	0.21**	-0.092***	0.001	-0.000	0.032***	-0.000	-0.024***	-0.003			1.49% (n=4567)
(row 14)	0.23***	-0.093***	0.001	-0.000	0.032***	-0.000	-0.026***	-0.003	-0.000		1.54% (n=4311)
(row 15)	0.09***	-0.053***	0.003	0.000	0.026***	-0.000	-0.013***	0.005		0.000	1.05% (n=3397)
(row 16)	0.12***	-0.055***	0.003	0.000	0.026***	-0.001	-0.016***	0.006	-0.000	0.000	1.07% (n=3143)

Significance levels: * 10%, **5%, ***1%

As discussed in Section 3, we also test our hypothesis using a modified model (1B) where the incremental market value of R&D at each market state relative to the SLIGHTLY UP market can be shown in one equation. The results of the modified model are provided in Table 6.

In Table 6, we first look at the market valuation of R&D for the base (SLIGHTLY UP) market. The coefficients for RD are around 0.01. Next, we examine the market valuation of R&D at other market states relative to the base state by looking into the interaction term between different market states and R&D spending. Looking across all interaction terms, we observe that coefficient on (RD*BULL) is significantly positive in all regressions, adding 4% more to abnormal returns, while (RD*DOWN and RD*BEAR) are statistically significantly negative in most cases, revealing a price penalty for having R&D activities when market condition turns south; stated differently, the results imply that R&D may be perceived as expense instead of asset in the down markets. In summary, the results from regression model (1B) are, again, inconsistent with the risk explanation.

The other variables have the same size and similar magnitude as the results presented earlier. Therefore, the same conclusions and interpretations still apply.

Table 6: Results of Ordinary Least Square (OLS)[2] Regressions (with 1% and 99% extreme measures deleted)

	Dependent variable = XRET			
	Regression 1	**Regression 2**	**Regression 3**	**Regression 4**
Intercept	0.43***	0.45***	0.42***	0.45***
$Bull_t$	0.016	0.013	0.026*	0.021
$Down_t$	-0.026	0.044	-0.096***	-0.031
$Bear_t$	-0.116***	-0.111***	-0.158***	-0.153***
RD_t	0.011**	0.010**	0.006	0.005
$RD*Bull_t$	0.043***	0.043***	0.043***	0.043***
$RD*Down_t$	-0.038***	0.002	-0.026**	0.028
$RD*Bear_t$	-0.015**	-0.016*	-0.006	-0.006***
ΔRD_t	-0.000	-0.001	0.000	-0.001
RD_{t-2}	0.001***	0.001***	0.001***	0.001***
E_t	0.033***	0.034***	0.028***	0.029***
ΔE_t	-0.000	-0.000	-0.000	-0.000
$SIZE_t$	-0.049***	-0.052***	-0.046***	-0.050***
DE_t	-0.025***	-0.027***	-0.017**	-0.019**
Beta		0.000		0.000
Altman Z			0.000	0.000
Adjusted R2 N	1.53% (n=33788)	1.55% (n=32081)	1.67% (n=24056)	1.64% (n=22382)

Significance levels: * 10%, **5%, ***1%. Variable Definitions: *Bull* =1 if the annual S&P 500 return is equal to or greater than 20%, and 0 otherwise; *Down* = 1 if the annual S&P 500 return is less than 0 but greater than -20%, and 0 otherwise; *Bear* = 1 if the annual S&P 500 return is equal to or less than -20%, and 0 otherwise; All other variables are as defined earlier.

[2] As discussed in Section 3, Hausman's Specification Test results suggest that OLS is preferred over all other models for testing this equation. Robustness test using 2SLS to test this equation yields similar results.

4.3 Robustness Checks

4.3.1 Regression Results using Other Model Specifications

As demonstrated earlier, the Hausman Test of Specification suggests that the two-stage least square method is statistically more efficient than the ordinary least square and three-stage least square methods when all sample firms are used in regressions. To check for the robustness of our results, we also conduct regression analyses using ordinary least square and three-stage least squares for both Equations (1) and (1B). The detailed regression results are not provided in table format here; however, a comparison between OLS and 2SLS shows that the absolute value of the R&D response coefficient is slightly smaller in the OLS regressions than in 2SLS. The other variables all have similar coefficients. The results, using three-stage least squares, also not reported here in table form, are generally consistent with the results obtained when two-stage least squares are used. So the same interpretation applies.

4.3.2 Check on Outliers

Next, we test for the robustness of the results against extreme observations. We run the same regressions by removing extreme observations that fall below the 5% or above the 95% level for the key variables. We also perform the same regressions without removing any extreme observations. Both results, not presented here, are qualitatively similar. Thus, the previous conclusions are robust to the deletion of outliers.

4.3.3 Defining "Market States" Using Different Window

As market price is believed to incorporate forward-looking information, it is likely that investors may price current accounting information based on the *anticipated* market returns in the near future, instead of the current market state they are in. For this reason, we conduct more regressions by changing the "market states" definition to those based on 1-month-ahead, 1-quarter-ahead, and half-year-ahead S&P returns. The resulting statistics are qualitatively similar to what are being reported here.

4.3.4 Using Alternative Variables in the Simultaneous Equation

We also conduct regressions to find out whether replacing the change variable, R&D increment, with the lagged variable – last year's R&D – would change the results. We find similar results. To find out the robustness of the results against an alternative specification in the endogenous variable, we replace the lagged industry R&D with the contemporaneous industry R&D and also find similar results.

In summary, our results are robust against different simultaneous equation models, the deletion of outliers, different definitions of market states using different windows, as well as the use of alternative variables for R&D change and lagged industry R&D spending. The results that R&D is priced negatively during down markets cannot be explained by beta risk and Altman-Z bankruptcy risk.

5. CONCLUSIONS

The aim of this study is examining whether investors price R&D consistently across market states to understand the well-documented R&D-return relation. We collect stock and accounting variables of high-tech firms from 1992 to 2009 and divide the sample into four market states – BULL (more than 20% returns on S&P 500), SLIGHTLY UP (0% to 20% returns), SLIGHTLY DOWN (-20% to 0% returns), and BEAR (less than -20% returns). We examine the relation between stock returns and R&D spending across these four states after controlling for earnings, firm size, financial structure, beta risk, and bankruptcy risk.

The empirical results show that market valuations of R&D are heterogeneous across market states. We find that while earnings consistently contribute to returns in a positive manner under all market states, investors value R&D positively when market goes up and negatively when the overall market is down after controlling for other risks. The results appear to be inconsistent with the risk explanation for the association between R&D spending and subsequent future abnormal stock returns, but more in line with the anomaly hypothesis. Our results are also robust to the use of different simultaneous equation models, lagged variable, and alternative endogenous variable specifications.

Our research is the first study in the literature to document a differential valuation to R&D across different market states. These findings shed light on the continuing discussions in accounting treatment in intangible assets and contribute to the continuing debate of risk versus anomaly in accounting and finance research.

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NOTES