Chapter 5

On the Informational Usefulness of R&D Capitalization and Amortization

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Introduction

Expenditures on research and development (R&D) are the major drivers of innovation and economic growth. The size of resources devoted to R&D by private-sector corporations, governments and universities is very large—currently about $250 billion annually in the U.S.—and constantly growing. In developed countries investment in R&D typically amounts to 3-4% of GDP. R&D is clearly the major driver of growth of corporations, national economies, and the standard of living of their citizens.

The accounting for R&D by private-sector companies is widely regarded as outdated. In the U.S., the accounting standard for R&D, FASB Statement No. 2, was issued 30 years ago (1974), before the emergence of key R&D-intensive sectors, such as software, biotech, and Internet. No wonder then that this accounting rule is outdated. The main directive of Statement No. 2 is the immediate expensing of all R&D (except for software development costs, under certain circumstances). Thus, despite the fact that R&D generates, on average, significant future benefits (sales increases, cost savings)—which is the main characteristic of an asset—R&D is *not* regarded an asset in corporate financial reports.[1] Rather, R&D is expensed in the period it is incurred, like salaries, interest, and insurance. The international Accounting Standard (IAS No. 38) takes a somewhat more modern view toward R&D, allowing capitalization under certain circumstances, but most public companies expense R&D nevertheless. One reason is managers' concern that financial analysts will consider capitalization as a means of earnings manipulation.

There has been considerable controversy about R&D expensing in the last 20 years. Some commentators argue that it is an outdated accounting technique and should be changed, while others counter that the uncertainty of the outcomes of R&D (new products, cost savings) precludes recognizing R&D as an asset (e.g., Kothari, Laguerre and Leone 2002). We join in this chapter the discussion about the preferred accounting and reporting for R&D, by showing empirically that the current accounting for R&D leads to a systematic *undervaluation* of R&D-intensive

1 Numerous studies have established the association between R&D and subsequent benefits, see Lev (2001).

companies in capital markets. Stated differently, by showing that the current procedure of expensing R&D causes investors to misprice securities—thereby adversely affecting resource allocation by corporations and in capital markets—we provide supporting evidence for a change in the accounting and reporting of R&D.

Under current U.S. GAAP (SFAS No. 2, FASB 1974), investments in research and development (R&D) are immediately expensed. This study investigates whether capitalization and subsequent amortization of R&D expenditures improve the information conveyed by earnings and equity book value about intrinsic equity value. To address this question, we adjust reported financial statements to reflect R&D capitalization, followed by straight-line amortization over assumed industry-specific lives, and examine the effect of these simple adjustments on the association of earnings and equity book value with 1) current stock price, 2) future earnings (excluding R&D), and 3) future stock returns.

Consistent with intuition and the results of prior research (e.g., Loudder and Behn 1995, Lev and Sougiannis 1996, Monahan 1999, and Chambers, Jennings and Thompson 2001a), we find that our adjustments increase the association in the first and second analyses. These results indicate that despite the simple nature of our adjustments, they capture partially the economic amortization of R&D investments reflected in contemporaneous stock prices and future earnings. The results of our third analysis, which along with the associated robustness tests represent our main contribution, suggest however that stock prices initially undervalue unamortized R&D, measured by our adjustments to book value, and then rise predictably over the next 20 months.

A more descriptive summary of our analyses follows. We identify seven R&D-intensive industries (based on two-digit SIC codes) and begin our contemporaneous stock price analysis by computing adjusted earnings and book value for different assumed R&D lives between one and eight years. For each assumed life, we capitalize the reported R&D investment and amortize it equally over that assumed life, and then contrast the association between price and adjusted earnings/book value for each industry with the corresponding association for reported earnings/book value. Although we find that the former association is increased for *any* assumed useful R&D life for all industries examined, there is considerable variation across industries. First, the improvement in association is not economically significant in two industries, suggesting that the benefits of capitalizing and amortizing R&D may be limited in some cases. Second, the optimal useful R&D life (assumed useful life generating the highest association) varies across the remaining industries, consistent with the competitive environment and characteristics of R&D undertaken (consider, for example, differences in gestation periods and longevity of benefits between pharmaceuticals and software firms). Third, even though there is some cross-industry variation in the relative contribution of adjusted book value versus adjusted earnings, the former is generally more important than the latter.

Our second analysis (association with future earnings) is designed to alleviate potential concerns caused by recent research that stock prices may not fully impound R&D information (e.g., Lev and Sougiannis 1996, and Chan, Lakonishok, and Sougiannis 2001). To provide a perspective that does not rely on market efficiency, we assume that the sum of realized pre-R&D earnings over the subsequent three years represents an unbiased proxy for current intrinsic values, and repeat the association analysis.[2] Our results for this second analysis are generally consistent with those from the first analysis, which confirms the validity of using the association with contemporaneous prices to study alternative accounting treatments of R&D investments.

Our third analysis (association with future returns) is potentially the most important as it offers policy implications regarding capitalizing and amortizing R&D. Since it is easy to generate the adjusted book values/earnings we use in the first two analyses, and the stock market is implicitly aware of those adjustments in the first analysis, there could be reasonable disagreement about the incremental benefits of requiring firms to capitalize and amortize R&D. There should, however, be no disagreement about the benefits of capitalization/amortization if as our results suggest those adjustments are related to future returns because they are not fully incorporated in contemporaneous stock prices. Our results also suggest that the link between R&D and future returns is less likely to be due to mismeasured risk (e.g., Chambers, Jennings, and Thompson 2001b) and more likely to be due to mispricing (e.g. Lev and Sougiannis 1996, Chan, Lakonishok, and Sougiannis 2001, Lev, Sarath, and Sougiannis 2000, and Penman and Zhang 2002).

When investigating subsequent stock returns, rather than rely on the approach used in the prior literature where firms are partitioned based on R&D intensity, we focus on differences between adjusted and reported book value/earnings, and use the insights from our first analysis when measuring these differences. Specifically, we use the optimal industry-specific lives indicated by our price association analysis when amortizing R&D, and multiply the earnings and book value adjustments by the corresponding industry-specific coefficients from the price association analysis to convert those adjustments into estimated impact on market value.[3] We find that our proxies for the value impact of differences between capitalized and reported book values are positively related to subsequent abnormal stock returns over the next 20 months.[4] After that point, although we continue to observe positive abnormal returns for firms with high book value adjustments, we believe those abnormal returns are unlikely to be due to correction of residual mispricing since they are concentrated in January.

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2 Using a simulation model, Healy, Myers and Howe (1999) also provide evidence that is not subject to the assumption of market efficiency. They find that capitalizing and subsequently amortizing successful R&D costs improve the relation between accounting information and economic values even when there is widespread earnings management.

3 As explained in Section 4, it is reasonable to use estimates from our first analysis (where prices are implicitly assumed to be efficient) to generate proxies for the extent of mispricing.

4 To ensure that our results for this third analysis are not contaminated by any "look-ahead" bias, we use parameters derived from historic data that were publicly available when creating the different portfolios. To confirm that the abnormal returns we observe are due to mispricing, rather than mismeasured risk, we conduct several robustness checks, including, controlling a variety of risk proxies, and examining industry-by-industry, year-by-year, and long-term returns. We also control R&D intensity to confirm that the abnormal returns are indeed due to the distortion caused by reported book value/earnings deviating from capitalized numbers.

These results suggest that requiring firms to capitalize and subsequently amortize R&D in a methodical way should improve the efficiency of market prices and resource allocation. Also, finding that future returns are related to adjusted book values, not adjusted earnings, suggests that market mispricing is related more to levels of R&D investments, rather than changes in those levels. Finally, finding that abnormal returns after 20 months are concentrated in January provides a potential explanation for the result in Chambers, Jennings and Thompson (2001b) that abnormal returns persist for up to 10 years. Our results suggest that the abnormal returns observed after the first two years are due to mismeasured risk and could simply reflect the higher risk of firms with higher levels of R&D.

The remainder of this study proceeds as follows: The variables and sample are first described. We then present the first and second analyses, investigating the association of R&D-adjusted earnings/book value with price and future earnings, and then we discuss the third analysis, examining the association with future stock returns. This is followed by robustness checks, and the conclusion of the study.

Data

Variable measurement

To examine the usefulness of R&D capitalization and amortization, we calculate pro-forma or adjusted earnings and book value under alternative R&D useful lives (T), ranging between one and eight years. In all cases, we assume R&D expenditures are made at the middle of the fiscal year and have a salvage value of zero. The R&D adjustment to earnings involves: (1) adding back the current year R&D expense (COMPUSTAT #46) times (1-0.5/T), representing the full cost minus a half-year's straight-line amortization;[5] (2) deducting amortization of previous years' R&D, computed as 1/T times the total of R&D expense in the previous T-1 years plus 0.5/T times the R&D expense T years ago; and (3) adjusting the income tax expense by applying the statutory federal tax rate plus 2% average state tax rate to the previous two components of the R&D adjustment.[6] The R&D-adjusted book value is calculated by adding the sum of unamortized R&D expenditures over the last T years×(1- tax rate) to the reported book value. In effect, the adjustment to book value of equity adds the R&D asset, representing the pre-tax unamortized amount, with the corresponding deferred tax liability, representing the tax effect.

We measure reported earnings as income before extraordinary items (#18) minus after-tax special items (#17×(1- tax rate)), and reported book value of common equity as common equity (#60) plus preferred treasury stock (#227), minus preferred dividends in arrears (#242). Market value of equity is measured as the product of the number of shares outstanding (#25) and price per share at fiscal year end (#199).

5 We use #n as an abbreviation for COMPUSTAT data item n.

6 For all sample firms, we assume a U.S. federal tax rate of 48% for 1975-1978, 46% for 1979-1986, 40% for 1987, 34% for 1988-1992, and 35% for 1993-2000.

Sample selection

To construct the sample for the contemporaneous price association analysis, we apply the following criteria. First, data items #60, #18, and #6 (total assets) from COMPUSTAT's industrial, full coverage, and research files are available for the current year and for each of the previous eight years, and data items #199 and #25 (i.e., price and number of shares outstanding) are available for the current year. (Other required data items are set to zero when missing.) Second, the fiscal year is between 1983 and 2000. We drop years before 1983, since we need eight prior years of R&D data, and uniformity in R&D accounting is required only since 1975 (see FASB 1974). Third, to mitigate the effect of influential observations, we delete observations for which any of the variables we use in the price association regressions (see below), deflated by total assets at the end of the current year, lie outside the 1%-99% range of its sample distribution. Fourth, to focus on firms for which R&D is important, we include only those industries (based on 2 digit SIC code) with positive median R&D expense. Finally, we require that the selected industries have at least a thousand firm-year observations over the sample period 1983-2000. These selection criteria result in a sample of 20,503 firm-year observations, derived from seven industries. Panel A of Table 5.1 lists the seven industries and provides the number of observations per industry along with summary statistics for the ratio of R&D expense to market value.[7]

For the second analysis (association with future realized earnings), we use the same sample as in the first analysis, except that we exclude firm-year observations with missing pre-R&D earnings for any of the subsequent three years (which in effect excludes all observations from the years 1998 through 2000, as well as firms that did not survive for the three subsequent years). The resulting sample includes 13,852 observations.

For the market efficiency (association with future returns) analysis, we begin with the sample from the first analysis and require that the CRSP number of shares outstanding and closing share price be available as of the end of April in the subsequent calendar year. We also drop fiscal years 1999 and 2000.[8] These requirements result in a sample of 15,341 observations. Panel B of Table 5.1 provides the number of observations per year for each of the seven industries.[9]

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7 These industries correspond with those identified in prior research.

8 We cannot use fiscal years after 1998 for this third analysis, since the CRSP files we use contain data through December, 2000. Recall that we measure abnormal returns from the beginning of May of the subsequent year, and cumulate returns until April of the following year.

9 We reassign firms to years based on the calendar year in which the fiscal year ends, rather than use the COMPUSTAT year (which includes in the same year all fiscal year-ends between June of that year and May of the following year). Then we form our portfolios for this analysis in May of the subsequent year, to ensure that at least four months have passed since the fiscal year-end.

Table 5.1 Descriptive statistics for samples

Panel A: Distribution by industry of R&D intensity (R&D expense, scaled by end-of-year market value of equity) for price association analysis.

Industry (abbreviation; SIC)	*Obs.*	*Mean*	*SD*	*Median*
Chemicals and Pharmaceutics (Chem.; 28)	2,981	0.0423	0.0655	0.0272
Fabricated Metal (Fab.; 34)	1,431	0.0262	0.0653	0.0075
Machinery and Computer Hardware (Mach.; 35)	3,803	0.0929	0.2081	0.0423
Electrical and Electronics (Elec.; 36)	4,311	0.0836	0.1526	0.0411
Transportation Vehicles (Trans.; 37)	1,354	0.0454	0.0687	0.0203
Scientific Instruments (Scient.; 38)	3,400	0.0930	0.1405	0.0552
Business Services (Bus.; 73)	3,223	0.0659	0.1887	0.0013
Total	20,503	0.072	0.153	0.032

Panel B: Observations by industry and year for subsequent returns analysis

Year	*Chem.*	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*	*Total*
1983	119	79	152	172	68	119	83	792
1984	135	84	178	198	81	139	106	921
1985	126	81	173	185	76	138	104	883
1986	122	73	163	181	71	130	99	839
1987	116	72	169	183	69	128	98	835
1988	116	74	154	188	64	138	103	837
1989	114	71	157	178	62	138	108	828
1990	124	67	172	184	63	154	115	879
1991	135	66	179	197	67	166	134	944
1992	142	67	185	193	69	172	139	967
1993	160	75	190	202	68	178	171	1044
1994	170	72	194	223	70	190	183	1102
1995	173	68	194	232	71	183	184	1105
1996	179	65	197	242	74	188	192	1137
1997	180	62	195	242	69	190	187	1125
1998	185	61	184	228	66	192	187	1103
Total	2296	1137	2836	3228	1108	2543	2193	15341

Impact of Capitalizing and Amortizing R&D on the Association of Earnings and Book Value with Contemporaneous Stock Prices and Future Earnings

Association with stock prices

In this section we estimate the useful life of R&D (length of its benefits) in the main R&D-intensive industries. To do this, we employ a widely-used stock valuation model (Ohlson 1995) which relates the market value of a firm's equity (capitalization) to its book value of net assets and earnings. We use this model first for reported (i.e., R&D-expensed) book value and earnings. And alternatively, for various versions of book value and earnings under R&D capitalization. The model producing the best fit of market value with book value and earnings will indicate the optimal capitalization period of R&D, as perceived by investors. We calculate pro-forma (R&D-adjusted) earnings and book value assuming useful lives of R&D from T = 1 through T = 8 years. Then, for each T (including T = 0, corresponding to reported numbers), we estimate the following regression separately for each year T and industry:

$$P/A = \sum_{y=1983}^{2000} \beta_{1y} D_y + \beta_2\, 1/A + \beta_3\, B_T/A + \beta_4\, E_T/A + \beta_5\, DNE \times E_T/A + \beta_6\, DNE + \varepsilon \quad (1)$$

where P is market value of common equity at fiscal year-end; A is total assets; D_y is a dummy variables that equals one for year y; B_T and E_T are pro-forma book value and earnings, respectively, assuming a useful R&D life of T years; and DNE is a dummy variable that equals one when pre-R&D earnings are negative.[10]

The specification of equation (1) is based on evidence provided in prior studies that earnings and book value jointly explain cross-sectional variation in share prices (for a review, see Chambers, Jennings and Thompson 2001a). We allow for a different earnings coefficient for loss firms because a) losses are less permanent than positive earnings (see, e.g., Hayn 1995), and b) losses may proxy for the effects of conservative accounting.[11] The variables in equation (1) are deflated by the book value of total assets to mitigate the effect of heteroskedasticity, and the year dummy variables are included to mitigate the effect of autocorrelated regression errors. Note that the year dummies represent intercept dummies in the deflated equation. It is important to include an intercept in the deflated equation, which is equivalent to including total assets in the undeflated equation, to capture the average effect of omitted factors that are likely to be correlated with firm size.

Our choice of an eight-year maximum for T represents a compromise between two competing considerations. While increasing the number of years allows us to better identify the correct useful life of R&D when it is relatively long, it also requires us to delete firms without a relatively long history. The ex post experience

10 We measure pre-R&D earnings by adding the R&D expense times (1 – tax rate) to reported earnings.

11 We allow the loss dummy variable (DNE) to have both an intercept effect (β_6) as well as a slope effect on earnings (β_5) to mitigate potential biases due to differences between loss firms and positive earnings firms that are not captured by the earnings coefficient. Our inferences remain unchanged when we a) drop the intercept effect, or b) allow for the other regression coefficients to depend on DNE.

of such "surviving" firms may not be representative of the anticipated profile of R&D benefits captured in contemporaneous stock prices. To estimate the potential impact of limiting our choice of T to eight years, we repeated the analyses described above using values of T equal to 5 and 10 years, and observed qualitatively similar results.

To evaluate the change in the association of earnings and book value with price due to R&D capitalization and amortization over T years, we compare the R^2 of each of the eight pro-forma regressions (T =1 through 8) with that of the regression using the reported numbers (T = 0). These comparisons are valid because we use the same observations and dependent variable in all nine regressions.

We first report the benchmark regressions, using reported numbers. As shown in Panel A of Table 5.2, the coefficients on earnings (E_0/A) and book value (B_0/A) are positive and significant for all seven industries, and the earnings coefficient is always significantly smaller for loss firms, relative to that for firms with positive earnings (indicated by significant negative values for the coefficient on $DNE \times E_0/A$). However, there are substantial differences in the magnitudes of these coefficients across the industries. For example, the book value coefficient for the chemicals and pharmaceuticals industry is almost four times larger than that for the fabricated metal industry. The R^2s for the seven industries also vary widely, between 16.4 percent (scientific instruments) and 45.8 percent (transportation vehicles).

Panel B of Table 5.2 presents the percentage increase in R^2 from using adjusted earnings and book value, over those presented in Panel A (based on reported numbers). It is evident that in all cases (i.e., for all seven industries and for all useful lives between 1 and 8 years), capitalization and subsequent amortization of R&D expenditures result in an improved association with price. However, the magnitude of improvement and the R&D useful life that yields the best fit (indicated by the bold value in each column) vary significantly across industries. The largest improvement is observed for chemicals and pharmaceutical firms. For this industry, it appears that the benefits of R&D investments are spread, on average, over at least eight years, as the price association is highest for T = 8. On the other hand, for the two industries with the highest R&D intensity (machinery and computer hardware, and scientific instruments), the price association is highest when the assumed useful life is four years.

The smallest improvement in R^2 is observed for the transportation vehicles and fabricated metal industries (values are less than 5 percent for all values of T). This finding is not surprising since most firms in these industries are relatively mature with low and stable levels of R&D. Consequently, the R&D adjustments are relatively small, especially the earnings adjustment (for mature firms with low growth in R&D, earnings based on immediate expensing is similar to earnings based on R&D capitalization). Indeed, the R^2 from the reported numbers regressions in Panel A are substantially higher for these industries, relative to those for other industries.

Differences in firm maturity and the level of R&D are not the only factors that potentially explain the differences we find across industries. The economics and managerial literature on R&D suggests additional explanations.[12] The value and

12 For a recent survey, see Lev (2001, Ch. 3).

useful life of R&D projects depend, among other things, on the ability of firms to *appropriate* the benefits of R&D. Appropriation, in turn, depends on the ability to enforce intellectual property rights, namely the legal protection afforded by patents and trademarks. The most effective enforcement of property rights (maximum appropriation of benefits) exists in the chemical and pharmaceutical (including biotech) sectors, since the new inventions resulting from R&D are clearly defined in terms of chemical formulas, and are easiest to defend in courts against infringement. This is consistent with our findings (Panel B of Table 5.2) showing the highest improvement in R^2 and longest life of R&D for this industry group.

At the other extreme is the business services sector (which includes software), where most patents are of the controversial "business process" type, and are notoriously difficult to defend against infringement ("inventing around the patent"), given the imprecise, non-scientific nature of the patents.[13] Accordingly, the ability of firms to appropriate the benefits of such R&D is relatively low. Indeed, the results in Panel B indicate relatively low improvement in R^2 and short R&D life for the business services industry. In between these two extremes are industries with intermediate levels for the ability of firms to appropriate benefits, such as the electrical and electronics and machinery industries, and consequently intermediate useful lives for R&D.

The improvement in R^2 in Panel B ranges between 3.6 percent and 32.3 percent. The average improvement (measured as the mean percentage change in R^2 across the seven industries) is 13.6 percent. Although this measure is quite large, it likely understates the improvement due to R&D capitalization since the regressions include additional variables besides earnings and book value (the year dummies and total assets), which increase the benchmark R^2. That is, the percentage increase in the explanatory power of earnings and book value due to the R&D-adjustments is larger than the increase in R^2 reported in Panel B.

Panel C of Table 5.2 presents statistics for tests of the null hypothesis that the improvement in R^2 (between those reported in Panel B for adjusted book values/ earnings over those presented in Panel A for reported numbers) is zero. These statistics are calculated as $(N^{5} \times \text{mean}[r_0^2 - r_T^2]) / \text{std}[r_0^2 - r_T^2]$, where N is the number of observations, r_0 is the residual from the reported numbers regression, r_T is the residual from the pro-forma numbers regression, and std is the standard deviation. Invoking the central limit theorem, these statistics have a standard normal distribution in the limit.

In Panel D of Table 5.2 we report coefficients from estimating regression (1) for T^*, the "optimal" R&D life; i.e. the value of T that yields the largest improvement in R^2 in Panel B for each industry. Comparison of these results with the estimates in Panel A (based on reported numbers) suggests that the improvement in R^2 is generally due to both the book value adjustment and the earnings adjustment, as both t-statistics are larger in Panel D than in Panel A. However, for some industries the improvement

13 Consider, for example, Amazon's attempt to patent "one click" ordering. While requirements for prior years' data cause us to exclude from our sample Amazon and other firms that mushroomed during the Internet boom, we believe they illustrate the inherent difficulty associated with appropriating rents in this industry.

Table 5.2 Analysis of the impact of capitalizing and amortizing R&D on the association of earnings and book value with stock price

Panel A: Statistics from the reported numbers regression (T = 0)

$$P/A = \sum_{y=1983}^{2000} \beta_{1y} D_y + \beta_2\, 1/A + \beta_3\, B_0/A + \beta_4\, E_0/A + \beta_5\, DNE \times E_0/A + \beta_6\, DNE + \varepsilon$$

	Chem.	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*
1/A	0.090	1.583	1.071	0.022	0.070	0.440	0.968
	0.330	9.222	6.929	0.132	0.183	2.285	5.399
B_0/A	2.056	0.568	1.168	1.130	0.963	1.389	1.309
	17.303	7.546	16.358	14.669	12.540	14.667	14.160
E_0/A	8.789	7.341	6.304	7.708	8.661	4.581	10.688
	15.271	15.289	16.410	20.504	20.024	10.350	19.870
$DNE \times E_0/A$	-13.918	-11.630	-8.634	-10.071	-9.976	-7.534	-13.623
	-22.056	-21.249	-21.041	-24.621	-18.749	-15.108	-24.083
DNE	0.002	-0.223	-0.063	0.054	0.092	0.094	0.037
	0.017	-3.899	-1.134	0.904	1.561	1.091	0.453
R^2	0.268	0.418	0.226	0.250	0.458	0.164	0.284
N	2981	1431	3803	4311	1354	3400	3223

Panel B: Percentage increase in R^2 relative to reported numbers (T = 0)

T	*Chem.*	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*
1	7.950	1.198	4.457	3.983	1.169	11.743	4.087
2	14.921	2.175	7.433	7.393	2.175	18.130	5.895
3	19.621	2.823	9.408	9.637	2.839	20.441	6.891
4	23.392	3.377	**10.205**	11.730	3.289	**20.910**	7.656
5	26.283	**3.803**	9.808	13.764	3.531	20.584	**7.715**
6	28.659	3.749	9.186	15.239	**3.594**	19.638	7.074
7	30.590	3.474	8.552	16.185	3.496	18.505	6.004
8	**32.283**	3.346	8.123	**16.706**	3.168	17.351	4.803

Panel C: Test statistic (standard normal) for the change in R^2, reported in Panel B

T	*Chem.*	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*
1	7.322	1.597	4.223	4.316	2.689	2.435	3.309
2	7.948	1.695	4.272	5.797	2.902	2.544	3.210
3	8.035	1.738	4.247	6.224	2.823	2.615	3.155
4	8.209	1.747	3.960	5.918	2.725	2.560	3.171
5	8.169	1.619	3.471	5.062	2.583	2.447	2.977
6	8.086	1.500	3.061	4.361	2.432	2.288	2.563
7	7.965	1.432	2.651	3.902	2.244	2.116	2.051
8	7.838	1.333	2.294	3.564	1.941	1.949	1.558

Table 5.2 *continued*

Panel D: Statistics from the "optimal" regression for each industry (T with the highest R^2)

$$P/A = \sum_{y=1983}^{2000} \beta_{1y} D_y + \beta_2 1/A + \beta_3 B_T/A + \beta_4 E_T/A + \beta_5 DNE \times E_T/A + \beta_6 DNE + \varepsilon$$

	Chem.	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*
1/A	0.233	1.541	1.057	-0.031	0.253	0.441	1.111
	0.905	9.095	6.933	-0.198	0.673	2.338	6.285
B_{T*}/A	2.220	0.643	1.117	1.028	0.970	1.384	1.227
	24.023	8.575	17.525	16.903	12.845	15.761	14.904
E_{T*}/A	10.459	7.087	6.743	8.760	8.402	6.918	11.061
	19.549	15.066	18.825	26.113	20.592	15.247	22.588
$DNE \times E_{T*}/A$	-13.581	-11.308	-8.671	-10.379	-9.522	-9.356	-13.404
	-22.300	-21.049	-22.341	-27.519	-18.699	-18.383	-25.532
DNE	0.480	-0.218	0.030	0.272	0.136	0.367	0.208
	4.808	-3.868	0.555	4.645	2.350	4.277	2.578
R^2	0.355	0.434	0.249	0.292	0.475	0.198	0.306
N	2981	1431	3803	4311	1354	3400	3223

Panel E: Mean (first row) and standard deviation (second row) of the "optimal" book value and earnings adjustments

	Chem.	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*
$B_{T*}/A - B_0/A$	0.1246	0.0189	0.0729	0.1329	0.0408	0.0954	0.0892
	0.1692	0.0323	0.0847	0.1574	0.0493	0.0868	0.1444
$E_{T*}/A - E_0/A$	0.0111	0.0002	0.0031	0.0082	0.0026	0.0058	0.0052
	0.0334	0.0083	0.0232	0.0296	0.0107	0.0332	0.0345

Notes:

P is market value of common equity, A is total assets, D_y is a dummy variable that equals one for year y, B_T (E_T) is pro-forma book value (earnings) assuming R&D useful life is T years. T = 0 corresponds to reported book-value and earnings. DNE is a dummy variable that equals one when pre-R&D earnings are negative. Panel B reports the percentage change in R^2 (relative to the benchmark T = 0 regression) from using earnings and book value that have been adjusted to reflect R&D capitalization and amortization over the subsequent T years. The test statistics in Panel C are calculated as ($N^{.5} \times$ mean$[r_0^2 - r_T^2]$) / std$[r_0^2 - r_T^2]$, where N is the number of observations, r_0 is the residual from the benchmark regressions, and r_T is the residual from the adjusted earnings and book value regression. The test statistics have a standard normal distribution in the limit. T* denotes the value of T that maximizes the percentage change in R^2 (identified in panel B using bold font).

is mostly due to the book value adjustment (chemicals and pharmaceuticals), while for others it is primarily due to the earnings adjustment (electrical and electronics, and scientific instruments).[14]

Finally, in Panel E of Table 5.2, we report the mean and standard deviation of the R&D adjustments to earnings and book value for the optimal R&D life in each industry. As expected, the magnitude of the adjustments varies substantially across industries. The average earnings adjustment is relatively small, but its standard deviation is quite large (it is the standard deviation, not the mean, that indicates the potential improvement in explanatory power). For the book value adjustment, both the mean and standard deviation are generally large. The implied percentage increase in total assets due to R&D capitalization can be calculated by dividing the book value adjustment by (1–tax rate). Thus, for example, in the chemicals and pharmaceuticals industry, total assets are on average understated by more than 20 percent (assuming an average tax rate of 40 percent).

Association with future earnings

To alleviate potential concerns about stock prices failing to fully reflect information about earnings/book value adjusted for R&D capitalization and amortization, we re-estimate equation (1) after replacing stock prices with the sum of observed pre R&D earnings over the next three years. This methodology has remained relatively unexplored in the prior literature, and represents a valuable approach when market prices are either not available or suspected to be inefficient. This way of studying the association between accounting numbers and intrinsic value is especially relevant for those who subscribe to the view that the primary role of financial statement items lies in predicting future earnings and cash flows.

Panel A of Table 5.3 reports the change in R^2 from using proforma earnings and book value based on capitalizing and amortizing R&D over assumed lives between 1 and 8 years, relative to the regression on reported earnings and book value, and Panel B reports the statistical significance of these R^2 changes. For all industries, R^2 increases as a result of capitalizing and subsequently amortizing R&D, and for five of the seven industries (fabricated metals and scientific instruments are the two exceptions) the improvement is statistically significant. In addition, for all seven industries, the R^2 is maximized for $T = 8$. This last result differs from the unique optimum lives observed for each industry in the price association analysis (Table 5.2, Panel B), and we are unable to reconcile these differences in estimated optimal lives. Comparison of the regression coefficient estimates (not reported here) for adjusted book values and earnings with those for reported numbers reveals that the adjustment causes (1) an increase in the significance of both the earnings and book value coefficients, (2) no change in the level of the earnings coefficient, and (3) an increase in the level of the book value coefficient.

14 The t-statistics measure the unique information in the corresponding variables. Therefore, the change in the common information in earnings and book value about price cannot be gauged from the t-statistics. However, the total change in the information is indicated by the change in R^2.

Table 5.3 The impact of capitalizing and amortizing R&D on the association of earnings and book value with future earnings (before R&D)

$$\sum_{y+1}^{y+3}(\text{preRD})/A = \sum_{y=1983}^{2000} \beta_{1y} D_y + \beta_2 1/A + \beta_3 B_T/A + \beta_4 E_T/A + \beta_5 \text{DNE} \times E_T/A + \beta_6 \text{DNE} + \varepsilon$$

Panel A: Percentage change in R^2, relative to benchmark regression using reported numbers (T=0)

T	*Chem.*	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*
1	2.660	0.089	2.262	0.605	2.771	3.015	1.964
2	4.083	0.119	4.199	1.506	5.787	1.982	2.830
3	4.758	0.245	5.789	2.821	8.083	1.833	3.536
4	5.300	0.269	6.906	4.192	9.897	2.372	4.330
5	5.936	0.204	7.935	5.448	11.404	3.195	5.274
6	6.677	0.225	8.901	6.459	12.538	3.901	5.886
7	7.389	0.414	9.651	7.177	13.470	4.395	6.031
8	8.036	0.570	10.547	7.828	14.343	4.821	6.039

Panel B: Test statistic (standard normal) for the change in R^2 in Panel A

T	*Chem.*	*Fab.*	*Mach.*	*Elec.*	*Trans.*	*Scient.*	*Bus.*
1	4.179	0.233	2.376	1.093	3.147	1.214	2.252
2	3.927	0.205	2.703	1.646	3.315	0.716	2.441
3	3.709	0.359	2.999	2.451	3.313	0.620	2.487
4	3.707	0.344	3.160	3.143	3.468	0.755	2.612
5	3.842	0.227	3.343	3.638	3.642	0.970	2.932
6	4.067	0.225	3.579	3.934	3.737	1.134	3.042
7	4.273	0.381	3.790	4.054	3.820	1.227	2.868
8	4.441	0.489	4.008	4.196	3.929	1.297	2.725

Notes:
The R^2s correspond to within-industry panel data regressions of pre-R&D earnings (preRD) over the subsequent three years on an intercept, total assets (A), book value (B) and earnings (E), allowing for a different coefficient when pre-R&D earnings are negative. The equations are deflated by total assets and include year dummies (Dy). The benchmark regressions use the reported earnings and book value (corresponding to T=0). Panel A reports the percentage change in R^2 (relative to the benchmark regressions) from using earnings and book value that have been adjusted to reflect R&D capitalization and amortization over the subsequent T years. The test statistics in Panel B are calculated as $(N^{.5} \times \text{mean}[r_0^2 - r_T^2]) / \text{std}[r_0^2 - r_T^2]$, where N is the number of observations, r_0 is the residual from the benchmark regressions, and r_T is the residual from the adjusted earnings and book value regression. The test statistics have a standard normal distribution in the limit.

In sum, the results of this section suggest that capitalization and subsequent amortization of R&D expenditures using the straight-line method improve the association of earnings and book value with intrinsic value, as represented by contemporaneous stock prices and future earnings. Our results also indicate that the magnitude of improvement, the driver of improvement (i.e., book value or earnings adjustment), and the useful life of R&D vary substantially across industries.

Analysis of Future Returns

The question we turn to next is whether these cross-sectional differences between reported and adjusted book value/earnings are fully incorporated in contemporaneous stock prices. To address this question, we examine the association between *future* abnormal stock returns and optimal R&D adjustments to earnings and book value. If investors do not fully incorporate in current stock prices the information contained in R&D capitalization, these R&D adjustments should be positively related to subsequent abnormal returns, as prices gravitate to fundamental or intrinsic values.

We elected not to use the parameters estimated in our second analysis to generate optimal R&D adjustments and measures of potential mispricing because those parameters may be less precise and potentially biased.[15] We rely instead on parameters estimated in our first (price-association) analysis and use the differences between reported earnings/book value and the R&D-adjusted earnings/book value for the value of T that maximizes the R^2 of the industry-specific regression described by equation (1).

Because the results in Panel D of Table 5.2 indicate that there is substantial variation across industries in the estimated earnings and book value coefficients, we multiply the R&D adjustments to earnings and book value by the corresponding industry coefficients. Specifically, for each combination of industry and year (t), and using data from the years 1983 (i.e., first sample year) through year t, we estimate equation (1) with reported earnings and book value, and with pro-forma earnings and book value assuming useful lives of R&D from T = 1 through T = 8 years. We then identify the optimal useful life (T*) that maximizes the regression R^2, and the coefficients (β_3, β_4, and β_5) from that regression. Finally, for each firm *i* and year *t*, we estimate the "distortion" effect on market value caused by the difference between B_{T*}, the adjusted book value for the optimal useful life T*, and B_0, the reported book value, as follows:

$$BVDIST_{it} = \beta_3 \left(B_{T*}/A - B_0/A\right)_{it} \qquad (2)$$

15 Precision could be decreased because observed future outcomes measure ex ante projections with error, and because we exclude earnings past the next three years, which are especially relevant under conservative accounting for long-lived R&D investments. Moreover, if near-future earnings reflect different proportions of the total benefits from past and recent R&D investments (due, for example, to conservative accounting), the estimates could be biased. Bias could also be created because of survivorship, to the extent that the firms we delete (because earnings over any of the next three years is missing) are systematically different from the firms that remain in our sample.

The distortion effect for earnings is computed as follows:

$$\text{EARDIST}_{it} = \beta_4\,(E_{T*}/A - E_0/A)_{it} + \beta_5\,\text{DNE}_{it} \times (E_{T*}/A - E_0/A)_{it} \quad (3)$$

where E_0 and E_{T*} are the reported earnings and adjusted earnings for the optimal useful life T^*, respectively, for that firm-year. Note that T^*, β_3, β_4, and β_5 are re-estimated for each industry-year combination using data that are available before the stock return holding period (which starts on May first of the subsequent year).[16]

It is not clear, *a priori*, whether multiplying the book value and earnings adjustments by industry-specific coefficients results in better estimates of BVDIST and improves the power of our inefficiency tests. If the same R&D adjustment has different value implications in different industries, incorporating the industry-specific coefficients will result in more powerful tests. On the other hand, differences in the level of market efficiency across industries causes the use of industry specific coefficients to result in weaker tests, since the industry coefficients capture differences in mispricing.[17] Empirically, we find that the abnormal returns are smaller (consistent with the results in Chambers, Jennings and Thompson 2001b) and insignificant when industry-specific coefficients are not incorporated (results not reported). In contrast, the abnormal returns are large and significant when industry-specific coefficients are used to calculate BVDIST (see results discussed below).

To assure robustness, in examining the association of BVDIST and EARDIST with subsequent abnormal stock returns, we use three alternative approaches to control for risk: buy-and-hold portfolio returns adjusted for size and book-to-market; Fama and MacBeth (1973) cross-sectional regressions; and Fama and French (1993) three-factor time-series portfolio regressions. To evaluate further the extent to which any documented abnormal returns are due to market mispricing or improper risk adjustment, we also examine industry-by-industry, year-by-year, and long-term stock returns.

Although the use of book value/earnings adjustments and pricing coefficients from the first analysis, which implicitly assumes efficient pricing, to generate measures of potential mispricing may appear inconsistent, we explain below why this approach is reasonable. This analysis explores the possibility that the market underestimates the magnitude of unamortized R&D and/or the valuation multiple, and the degree of underestimation does not vary systematically across firms or industries. To be sure, there are other possible structural ways in which the market might misprice R&D investments. However, given observable data and the simple procedure proposed

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16 Of the 112 industry-year combinations (16 years times 7 industries), the optimum useful life (T^*) is zero for only one combination. For the 68 observations in this industry-year combination (see Table 5.1), BVDIST and EARDIST equal zero.

17 Specifically, our results show that market prices on average underprice the proforma unamortized R&D asset, and the level of underpricing varies across industries. In effect, *ceteris paribus*, industries with greater underpricing will have lower values of β_3, relative to the case where market prices are efficient, and this will result in greater understatement of BVDIST.

to measure adjusted book value/earnings, we believe we are limited in the types of mispricing that we can investigate.[18]

Buy-and-hold portfolio returns

For each of the 16 calendar years between 1983 and 1998 (referred to as year t), we compute firm-specific BVDIST and EARDIST (representing the distortions in book value and earnings, respectively, due to immediate expensing of R&D). We then form quintiles based on the magnitudes of BVDIST and EARDIST. For each set of quintiles, we examine the annual return from May 1 of year t+1 through April 30 of year t+2. The results of this analysis for BVDIST and EARDIST are reported in Panels A and B of Table 5.4. For each quintile, we report the time-series mean of each year's cross-sectional mean for BVDIST, EARDIST, three measures of subsequent returns (raw returns, size-adjusted returns, and returns adjusted for both size and B/M), and five firm and return characteristics (SIZE, B/M, BETA, VOLAT and R&D/M). For the three return measures, we also report the t-statistics associated with the time-series distribution of the cross-sectional means.

The first measure of subsequent returns in Table 5.4 (Raw Returns) is the one-year ahead buy-and-hold return. The second measure (Size Adjusted Returns) is calculated by deducting the contemporaneous size-decile return from the firm's raw return. The third measure (Size & B/M Adjusted Returns) is calculated as the difference between the firm's return and the contemporaneous return on a matched portfolio based on size (five quintiles) and book-to-market (five quintiles). In effect, we construct 25 benchmark portfolios, and subtract the return of the corresponding benchmark portfolio from the firm's raw return.

The benchmark size and book-to-market returns are calculated using all firms with available data on CRSP, including firms from non-R&D-intensive industries. SIZE is measured as the log of the market value of equity at the end of April in year t+1. The book-to-market ratio (B/M) is calculated using the market and book values at the end of the fiscal year that ended during calendar year t. The returns include all distributions to shareholders. For securities that delist during the one-year holding period, proceeds from the issue are invested in the NYSE, AMEX, and NASDAQ value-weighted index until the end of the holding period.

The data in Panel A of Table 4 indicate that BVDIST exhibits a positive monotonic relation with one-year-ahead returns. For example, focusing on the size and book-to-market adjusted returns, the mean abnormal return for portfolio 5 (i.e., stocks with the highest value for BVDIST) is 12 percent (t-statistics of 2.2), the mean abnormal return for portfolio 4 is 5.8 percent (t-statistics of 1.5), and for the other three portfolios the mean abnormal returns range between –0.4 and 1.1,

18 Relatedly, we do not consider all possible ways to sharpen our measure of mispricing. For example, using finer industry partitions, allowing for time variation in the estimates of regression parameters from our first analysis, and allowing for firm-specific variation in tax rates might increase the degree of mispricing documented here. While our measures are potentially noisy, we are careful to reduce the likelihood that they may unintentionally suggest mispricing when that is not the case.

Table 5.4 Annual buy-and-hold portfolio returns and other characteristics for quintiles of BVDIST and EARDIST

				Adjusted Returns						
Port.	BVDIST	EARDIST	Raw Returns	SIZE	SIZE &B/M	SIZE	B/M	BETA	VOLAT	R&D/M
Panel A: Portfolios sorted by BVDIST										
1	0.000	0.000	0.155	0.006	-0.004	10.927	0.758	0.946	0.133	0.001
			3.868	0.493	-0.317					
2	0.015	0.009	0.152	0.005	-0.003	11.477	0.714	1.005	0.120	0.029
			3.996	0.291	-0.189					
3	0.050	0.035	0.171	0.019	0.011	11.475	0.694	1.096	0.127	0.063
			3.719	1.245	0.740					
4	0.109	0.072	0.214	0.061	0.058	11.601	0.623	1.191	0.133	0.101
			3.657	1.539	1.496					
5	0.317	0.099	0.270	0.113	0.120	11.819	0.518	1.186	0.137	0.136
			3.248	1.848	2.156					
Panel B: Portfolios sorted by EARDIST										
1	0.135	-0.077	0.215	0.071	0.065	10.792	0.703	1.109	0.150	0.096
			3.527	2.292	2.150					
2	0.007	0.000	0.156	0.006	-0.002	10.961	0.758	0.963	0.132	0.014
			3.774	0.455	-0.193					
3	0.055	0.011	0.163	0.009	0.003	11.648	0.716	1.010	0.118	0.053
			4.464	0.669	0.216					
4	0.103	0.054	0.206	0.051	0.048	11.902	0.619	1.085	0.119	0.070
			4.196	2.278	2.260					
5	0.195	0.228	0.221	0.067	0.069	12.039	0.512	1.264	0.131	0.101
			3.038	1.189	1.307					
All firms	0.098	0.043	0.192	0.041	0.037	11.460	0.662	1.086	0.130	0.066
			4.055	2.179	1.994					

Notes.
The numbers reported in each cell are the time-series mean of the cross sectional means of those variables for each quintile. For the three return measures, we also report the t-statistic associated with the time-series distribution of the cross-sectional means. The number of cross-sections (i.e., years) is 16, from 1983 through 1998. BVDIST (EARDIST) measures the valuation impact of the "optimal" R&D adjustment to book value (earnings) (see equations (2) and (3)). The annual returns are measured from May 1 of year t+1 through April 30 of year t+2. SIZE (log of market value of equity) is measured at the end of April in year t+1. BETA is estimated using monthly stock returns and the CRSP value-weighted returns including all distributions during the five years that end in April of year t+1 (at least 30 observations are required). VOLAT is the root mean squared error from the BETA regression. R&D/M is the ratio of R&D expense to the market value of equity in year t.

and are insignificant.[19] Note that the abnormal returns for all five quintiles of firms from the seven R&D-intensive industries are positive (3.7 percent), on average, and significant (t-stat of 1.99), as indicated in the bottom row of Table 5.4. This result, which is consistent with those of prior studies (e.g., Chambers, Jennings and Thompson 2001b), suggests an average undervaluation of R&D assets.[20]

Prior research has documented that R&D investments are on average more risky than other investments (e.g., Kothari, Laguerre and Leone 2002). Our results in Table 5.4, Panel A, however, indicate that high BVDIST firms are larger in size and have lower book-to-market, relative to low BVDIST firms. To the extent that risk is negatively related to size and positively related to book-to-market, our high BVDIST portfolios appear to be of lower risk than the low BVDIST portfolios, along these two dimensions. Also, observing similar differences between the high and low BVDIST portfolios (between 11 and 12 percent) for all three measures of returns in Table 5.4 (raw, size-adjusted, and size and B/M adjusted) indicates that mismeasurement of risk related to size and book-to-market is unlikely to induce a spurious positive relation between BVDIST and abnormal returns.

The three columns on the right of Table 5.4 report three additional characteristics that may be related to risk: BETA, VOLAT and R&D/M. BETA is estimated using monthly stock returns and the CRSP value-weighted returns (including all distributions) during the five years that end in April of year t+1 (at least 30 observations are required). VOLAT, which reflects idiosyncratic volatility, is the root mean squared error from the BETA regression. R&D/M is the ratio of R&D expense to the market value of equity. The relations between these characteristics and BVDIST, unlike those for SIZE and B/M, are consistent with the argument that high BVDIST firms are more risky than low BVDIST firms. In particular, BVDIST is positively related to BETA and to R&D/M (consistent with the argument in Chambers, Jennings and Thompson 2001b, that R&D intensity proxies for an omitted risk factor). In addition, the high BVDIST portfolios are characterized by higher volatility of returns. We show, however, in our Fama-MacBeth analysis that BVDIST is positively related to abnormal returns, even after controlling for all five potential risk factors. Furthermore, the evidence reported in Section 5 (in particular the year-by-year and long-term returns) is also consistent with BVDIST capturing market underpricing.

Panel B of Table 5.4 presents the results for portfolios sorted by EARDIST. Unlike the data in Panel A, which indicates a monotonic, positive relation between BVDIST and EARDIST, in Panel B the two extreme EARDIST portfolios have the largest values for BVDIST. This is not surprising since EARDIST will be larger in absolute value for firms with substantial R&D activity. Examination of the returns reveals a pattern that is monotonically related to the portfolios' BVDIST rather than

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19 We obtained similar results when controlling for size and book-to-market using 100 (=10×10) portfolios.

20 Chan, Lakonishok and Sougiannis (2001), however, report that the average historical stock returns of firms investing in R&D matches the return of firms without R&D. This difference in results is likely due to differences in the sample years (1975-1995 versus 1983-1998) and to our focus on a smaller group of R&D intensive industries.

EARDIST: the extreme portfolios (which have the largest value for BVDIST) earn the highest abnormal returns. Moreover, the highest magnitude of abnormal returns in Panel B is substantially smaller than that in Panel A (7 percent compared with 12 percent). This evidence suggests that distortion in book value due to immediate expensing of R&D (BVDIST) better captures mispricing than distortion in earnings (EARDIST), and any differences observed across EARDIST quintiles in Panel B are due to EARDIST proxying for BVDIST. This conjecture is confirmed by the results we report next.

Cross-sectional regressions

Using the Fama-MacBeth (1973) cross-sectional regression approach, each month we regress stock returns on BVDIST, EARDIST, and firm-characteristics that proxy for risk. The relation between abnormal returns and BVDIST or EARDIST is examined by testing the significance of the time-series mean of the coefficient of these variables. By including both BVDIST and EARDIST in the same regression, we are able to identify the separate effects of each measure of distortion due to R&D. Another advantage of the Fama-MacBeth approach is that it allows us to explicitly and simultaneously control for various factors that may be related to expected returns. These factors include risk characteristics that have commonly been considered, such as size and B/M, as well as other factors, such as R&D intensity, that could potentially proxy for omitted risk factors. Finally, since only firms from the seven R&D intensive industries (see Table 5.1) are included in the Fama-MacBeth regressions, the average positive abnormal return associated with these industries (see Table 5.4) does not affect the results (it is fully captured by the regression intercept).

Table 5.5 provides estimates from the Fama-MacBeth cross-sectional regressions of monthly stock returns on BVDIST, EARDIST, |EARDIST| (i.e., the absolute value of EARDIST), and five control variables that are potential risk factors: ln(B/M), SIZE, BETA, VOLAT and R&D/M. We report regressions using |EARDIST| in addition to EARDIST, since the pattern of abnormal returns in Panel B of Table 5.4 suggests that abnormal returns are related to the magnitude of EARDIST rather than its sign. Fama and French (1992) show that when SIZE and ln(B/M) are included in the regression, other factors that explain expected returns (such as BETA) become insignificant. However, because of our focus on R&D intensive industries and the evidence in Table 5.4 that BVDIST and EARDIST are correlated with BETA, VOLAT and R&D/M, we also control for these variables in the Fama-MacBeth regressions.

To mitigate the effects of outliers (see Knez and Ready 1997), we delete observations with values outside the 1%-99% range of the pooled empirical distribution of any of the explanatory variables. The resulting sample includes 154,184 monthly observations. The first two regressions in Table 5.5 correspond to Panels A and B in Table 5.4 (SIZE&B/M adjusted returns). Consistent with the results in Table 5.4, the coefficient on BVDIST (first regression) is positive and highly significant, even after controlling for SIZE and ln(B/M), while the coefficient on EARDIST (second regression) is insignificant. As expected, when substituting |EARDIST| for EARDIST (third regression), the coefficient becomes positive and significant. However, the fourth and fifth regressions demonstrate that neither

Table 5.5 Monthly cross-sectional Fama-MacBeth (1973) regressions of firm returns on BVDIST, EARDIST and risk factors

	Int.	*BVDIST*	*EARDIST*	*|EARDIST|*	*SIZE*	*ln(B/M)*	*BETA*	*VOLAT*	*R&D/M*	*R2*	*N*
Mean	0.016	0.036			0.000	0.004				0.021	803
t-stat	1.717	4.132			-0.190	4.129					
Mean	0.019		0.008		0.000	0.004				0.021	803
t-stat	1.866		1.087		-0.201	3.275					
Mean	0.017			0.025	0.000	0.004				0.022	803
t-stat	1.755			2.407	-0.134	3.840					
Mean	0.016	0.037	-0.004		0.000	0.004				0.024	803
t-stat	1.702	4.622	-0.566		-0.171	4.119					
Mean	0.016	0.031		0.007	0.000	0.004				0.024	803
t-stat	1.722	4.323		0.837	-0.198	4.277					
Mean	0.015	0.023			0.000	0.003	0.000	0.000	0.027	0.038	803
t-stat	2.045	3.471			-0.328	3.003	0.164	-0.002	2.180		

Notes:
The first row reports the time-series mean of each coefficient. The second row reports the t-statistic for the time series distribution of the coefficient (mean coefficient divided by its standard error). The number of regressions (i.e., months) is 192, from May 1984 through April 2000. The dependent variable in all regressions is the monthly stock return. BVDIST (EARDIST) measures the "optimal" R&D adjustment to book value (earnings) (see equations (2) and (3)), SIZE (log of market value of equity) is measured at the end of April in year t+1. BETA is estimated using monthly stock returns and the CRSP value-weighted returns including all distributions during the five years that end in April of year t+1 (at least 30 observations are required). VOLAT is the root mean squared error from the BETA regression. R&D/M is the ratio of R&D expense to the market value of equity in year t. in year t.

EARDIST nor |EARDIST| is significant when BVDIST is included. BVDIST, on the other hand, is highly significant in both cases. We therefore conclude that EARDIST does not contain information regarding future abnormal returns incremental to BVDIST, and focus on BVDIST in the remaining analyses.

The last regression in Table 5.5 includes BVDIST and all five control variables (SIZE, ln(B/M), BETA, VOLAT, and R&D/M). The Fama and French (1992) result that BETA is insignificant holds in our sample as well.[21] The coefficient on VOLAT is also insignificant, but the coefficient on R&D/M is positive and significant. As may be expected (given the correlation between BVDIST and R&D/M, see Table 5.4), the inclusion of R&D/M erodes the explanatory power of BVDIST. However, the BVDIST coefficient remains positive and highly significant (in fact, it is the most significant coefficient). This result deserves emphasis. Several recent studies (e.g., Chan, Lakonishok and Sougiannis 2001, and Chambers, Jennings and Thompson. 2001b) indicate that R&D intensity is associated with subsequent abnormal returns and may proxy for an unknown risk factor associated with R&D. The estimates reported in the bottom row of Table 5.5 show that even after controlling for R&D intensity (R&D/M), BVDIST is still incrementally associated with subsequent abnormal returns.

Time-series portfolio regressions

As discussed in Fama (1998), the buy-and-hold matching portfolio returns approach and the Fama-MacBeth cross-sectional regressions approach may lead to invalid inferences. As an alternative, we use the Fama and French (1993) method of estimating abnormal returns, where, the monthly excess portfolio return (ER), representing the raw portfolio return minus the risk-free return, is regressed on the following three factors[22]: (1) the overall excess market return (RMRF, or market return minus the risk-free return); (2) the performance of small stocks relative to large stocks (SMB, or the excess of returns for small capitalization over those for large capitalization firms), and (3) the performance of value stocks relative to growth stocks (HML, or the excess of returns for high B/M stocks over that for low B/M stocks). The specific relation estimated for each portfolio is:

$$ER_t = \gamma_1 + \gamma_2 RMRF_t + \gamma_3 SMB_t + \gamma_4 HML_t + e_t$$

Fama and French (1993) contend that these factors explain most of the cross-sectional variation in excess portfolio returns, and hence the intercept (γ_1) from such a three-factor regression is a reliable estimate of abnormal returns. Moreover, Fama and French (1996) report that most of the documented anomalies disappear when abnormal returns are measured using this three-factor model.

21 The insignificance of SIZE in all six regressions is consistent with the findings in Knez and Ready (1997).

22 Data for the three factors can be obtained from Ken French's web site (http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/)

Table 5.6 Time-series regressions of monthly excess returns for BVDIST portfolios on the three Fama and French (1993) factors (market return, size, and B/M)

Portfolio	*Inter.*	*RMRF*	*SMB*	*HML*	R^2
1 (low	0.000	0.949	0.800	0.429	0.858
BVDIST)	0.259	26.759	17.453	7.145	
2	0.000	1.028	0.676	0.498	0.842
	-0.078	27.232	13.836	7.790	
3	0.002	1.020	0.847	0.237	0.857
	1.287	25.236	16.204	3.459	
4	0.006	1.026	1.005	-0.002	0.864
	3.417	22.842	17.299	-0.025	
5 (high	0.010	0.943	1.046	-0.283	0.852
BVDIST)	5.289	18.900	16.220	-3.347	

Notes:

The number of observations (i.e., months) in each of the regressions is 192, from May 1984 through April 2000. The first row reports the coefficient and the second row reports the t-statistic. BVDIST measures the "optimal" R&D adjustment to book value (see equation (2)). Shares are assigned to the five portfolios at the end of April each year. The dependent variable in each regression is the monthly portfolio excess return over the risk free interest rate for the month. RMRF is the excess return on the value-weighted stock market portfolio. HML is the return on a zero-investment portfolio that is long on high book-to-market (B/M) stocks and short on low B/M stocks. Similarly, SMB is the return on is a zero-investment portfolio that is long on small capitalization stocks and short on large capitalization stocks.

The monthly returns for each of the five BVDIST portfolios are computed for each of the twelve months starting with May of t+1. These twelve monthly returns times the 16 sample years (1983-1998) yield 192 monthly returns for each of the five BVDIST portfolios. Table 5.6 reports the three-factor regression results for the five BVDIST portfolios. As shown, the intercept (abnormal return) increases monotonically with BVDIST, and is positive and highly significant for the two portfolios with the largest value for BVDIST (portfolios 4 and 5). The magnitudes of the abnormal returns are quite large. For example, for portfolio 5, the monthly abnormal return is 1 percent (t-statistic of 5.3), which translates to roughly 13 percent annual abnormal return. The three-factor tests are thus consistent with our previous results, indicating that the distortion in book value due to immediate expensing of R&D (BVDIST) is positively associated with risk-adjusted returns over the year after the R&D information is disclosed.

Robustness Tests

Industry analysis

We consider next the possibility that technology and science-based sectors may have experienced unexpected good fortune during our sample period (1983-1998). If so, the positive abnormal returns documented above for R&D intensive firms are not representative, and are not likely to recur in the future. To the extent that R&D intensity (as measured by the ratio of R&D expenditures to market value) proxies for the ex-post success of R&D intensive firms, the evidence in Table 5.5 mitigates this concern (BVDIST is significant even after controlling for R&D intensity). To further evaluate the validity of this concern, we re-estimate the Fama and French (1993) three-factor regression for the high BVDIST portfolio (top twenty percent of the observations) for each of the seven R&D-intensive industries we study. While it is possible that during our sample years (particularly the 1990s) R&D activities in certain industries were unusually successful, it is less likely that such success would be observed in all seven industries. Therefore, observing positive abnormal returns for the high BVDIST portfolios in every industry should mitigate concerns based on unrepresentative samples.

Table 5.7 provides the results of this investigation. In addition to the regression estimates, we report the time-series means of the portfolio values of BVDIST, SIZE, B/M, BETA, VOLAT and R&D/M. It is evident that in all seven industries, abnormal returns (as measured by the intercept) are positive and statistically significant, suggesting that the returns are not merely a reflection of ex-post success in a few sectors. The abnormal returns are as high as 2.1 percent monthly (about 28 percent annually) for the business services industry (mainly software companies), and are economically significant (0.5 percent monthly, or more than 6 percent annually) even for the industry with the lowest abnormal returns (transportation vehicles).

As expected, the mean industry returns are positively related to the portfolio values of BVDIST. For example, the two industries with the lowest mean BVDIST (fabricated metal and transportation vehicles) have the lowest abnormal returns. However, the relationship is not entirely monotonic. The chemicals and pharmaceuticals industry has by far the largest value for BVDIST, but its abnormal returns, although relatively high, are not the highest. Similarly, the business services industry has the highest returns, although its BVDIST is only slightly above the median. This difference in delayed appreciation of the BVDIST variable could be due to investors having more experience with R&D investments in the chemicals and pharmaceuticals industry, relative to other industries with more recent technological innovations. Accordingly, mispricing of pharmaceutical firms is less severe than that of firms in the business services sector, even though the magnitude of BVDIST is greatest for pharmaceutical firms.[23]

23 Another possible explanation is that public information regarding the success of R&D investments is more widely disseminated for firms in the chemical and pharmaceutical industry.

Table 5.7 Time-series regressions of monthly excess portfolio returns on the Fama and French (1993) factors

Each portfolio invests in the twenty percent of firms with the highest value for BVDIST within the corresponding industry

	Regression Results					Portfolio Characteristics					
Industry	*Inter.*	*RMRF*	*SMB*	*HML*	R_2	*BVDIST*	*SIZE*	*B/M*	*BETA*	*VOLAT*	*R&D/M*
Chem.	0.017	0.877	1.129	-0.545	0.583	0.710	12.776	0.312	1.211	0.127	0.073
	4.029	7.981	7.939	-2.926							
Fab.	0.007	1.050	0.813	0.456	0.504	0.059	11.832	0.580	1.068	0.119	0.083
	1.923	11.242	6.730	2.881							
Mach.	0.009	1.143	1.191	-0.239	0.672	0.191	11.110	0.572	1.423	0.161	0.189
	2.474	11.861	9.560	-1.465							
Elec.	0.016	1.035	1.228	-0.439	0.736	0.173	11.373	0.662	1.328	0.154	0.166
	4.812	12.328	11.317	-3.092							
Trans.	0.005	1.022	0.521	0.448	0.712	0.056	13.569	0.593	1.106	0.087	0.116
	2.446	18.702	7.516	4.805							
Scient.	0.014	0.896	1.531	-0.054	0.703	0.337	10.666	0.676	1.174	0.148	0.163
	4.111	10.391	13.734	-0.369							
Bus.	0.021	1.066	1.182	-0.264	0.611	0.193	10.597	0.599	1.291	0.178	0.180
	5.082	10.009	8.583	-1.464							

Notes:

The number of observations (i.e., months) in each of the regressions is 192, from May 1984 through April 2000 (except of industry 37 where it is 180). For the regression statistics, the first row reports the coefficient and the second reports the t-statistic. For the portfolio characteristics, the reported statistic is the time-series mean of the portfolio value (cross-sectional mean across the stocks in the portfolio). BVDIST measures the "optimal" R&D adjustment to book value, deflated by total assets. SIZE (log of market value of equity) is measured at the end of April in year t+1. BETA is estimated using monthly stock returns and the CRSP value-weighted returns including all distributions during the five years that end in April of year t+1 (at least 30 observations are required). VOLAT is the root mean squared error from the BETA regression. R&D/M is the ratio of R&D expense to the market value of equity in year t.

To the extent that the idiosyncratic volatility of returns (VOLAT) captures uncertainty regarding firm value, and SIZE is negatively related to the efficiency of stock prices, the differences in the mean values of these characteristics across the portfolios are consistent with the differences in abnormal returns. In particular, VOLAT is substantially larger, and SIZE is substantially smaller, for firms in the business services industry relative to firms in the chemical and pharmaceutical industry (0.178 compared with 0.127 for VOLAT, and 10.6 compared with 12.8 for SIZE; both differences are highly significant). Another noticeable difference between these two industries is that R&D intensity (R&D/M) is substantially higher for the business services firms.

These findings may have policy implications with respect to the capitalization of R&D. They indicate that the usefulness to investors of capitalizing and amortizing R&D (in terms of improving market efficiency) is increasing in BVDIST (which is positively related to R&D intensity and the duration of R&D benefits), and the perceived uncertainty of obtaining R&D benefits, as proxied by idiosyncratic volatility, firm size (negative relation), and industrial membership. This latter result suggests that investors do not fully incorporate R&D benefits, especially when the benefits are highly uncertain.

Year-by-year returns to high BVDIST firms

In Tables 5.4 through 5.7 we document that high BVDIST firms earn substantial abnormal returns in the year following portfolio formation, and argue that these returns suggest that stock prices do not fully impound R&D information. An alternative explanation is that BVDIST is correlated with an omitted risk factor. If, however, the documented abnormal returns to the high BVDIST portfolio are compensation for risk bearing, that risk should surface in the form of negative realized returns in at least some periods. In particular, during periods of negative market performance (e.g., declining stock market indices), high-risk stocks should *underperform* lower risk stocks. On the other hand, if the returns are always positive, risk-based explanations are strained; they must be based on the notion that even though such losses were never observed within the sample period, their ex ante probability is still significant.

Figure 5.1 presents the annual (post-portfolio formation) mean raw returns and mean abnormal returns earned by the high BVDIST portfolio. Abnormal returns are measured using the 25 SIZE and B/M matched portfolio approach. While the mean raw and abnormal returns are high for the entire period (27 percent and 12 percent respectively, in Table 5.4), it is also clear from Figure 5.1 that they are highly volatile. However, these future raw (abnormal) returns are negative in only three (four) out of the 16 years, and the losses observed in those years are relatively small. In fact, the largest contribution to the return volatility is due to the years 1994 and 1998, in which the returns are very high. When these years are omitted, the mean total returns (abnormal returns) drops to 16.6 percent (5.2 percent), but, because the volatility drops even more, the significance of the returns increases (t-statistics of 4.0 and 2.23 respectively). In other words, the high volatility of abnormal returns appears to be

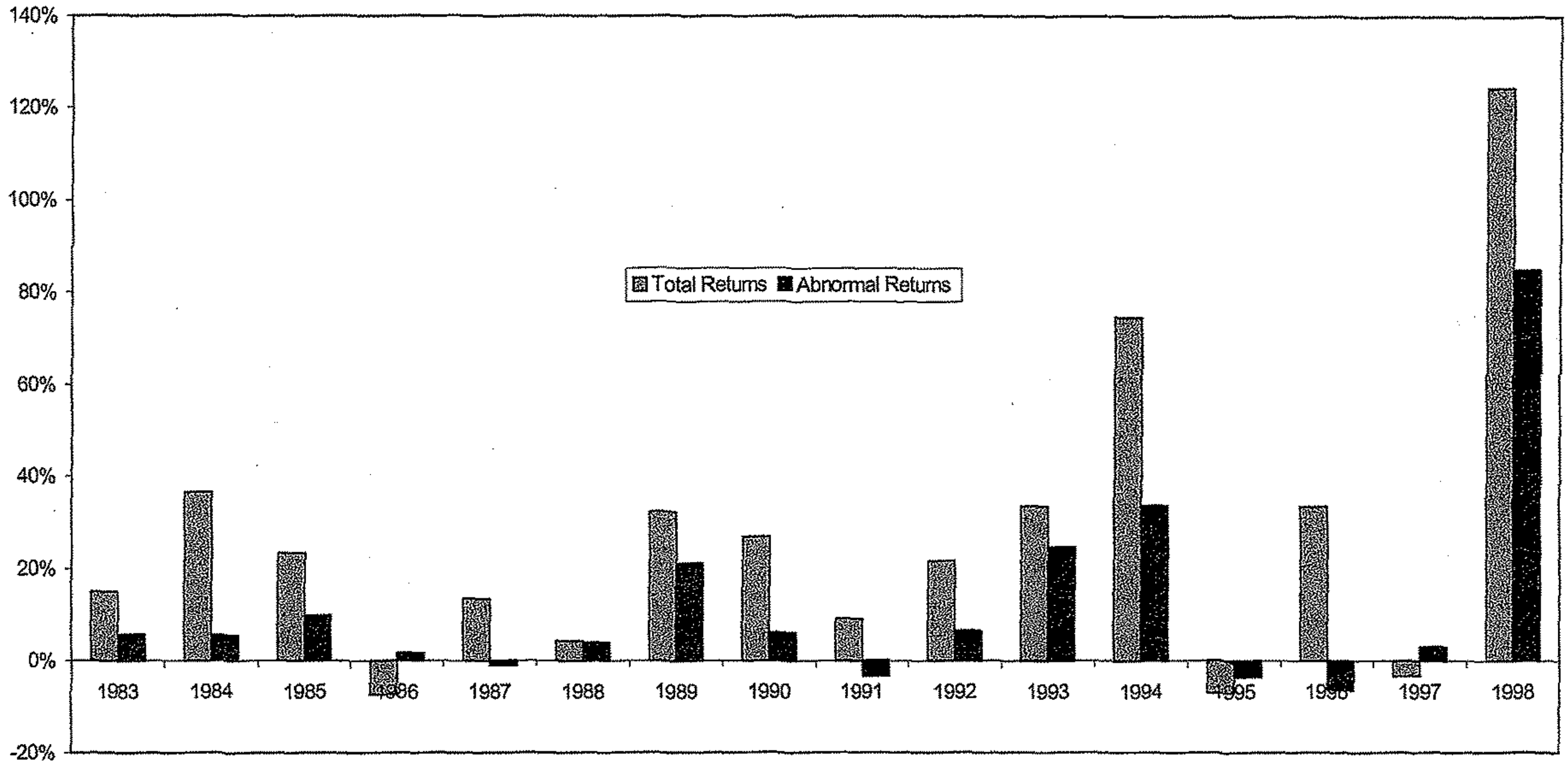

Figure 5.1 Year-by-year 1-year ahead raw and abnormal returns (adjusted for size and B/M) for the high BVDIST portfolio

The figure plots the annual total returns and abnormal returns for the high (top twenty percent) BVDIST portfolio. Annual abnormal return is measured as the difference between the firm's annual return and the contemporaneous return on a SIZE and B/M matched portfolio.

largely driven by positive skewness, which in turn implies that the downside risk is limited and the "price" of such volatility is likely to be relatively low.

In addition, the correlation between the annual abnormal return for the high BVDIST portfolio and the market return (as measured using the CRSP value-weighted returns including all distributions on NYSE, AMEX and NASDAQ firms) is negative (albeit insignificant), which is inconsistent with the significant positive coefficient predicted by the risk-based explanation. Overall, the year-by-year forward returns appear more consistent with market mispricing than with compensation for risk.

Figure 5.1 indicates that in 1994 and 1998 the portfolio with high BVDIST earns high returns in the following year. Since the late 1990s have been characterized by some as a period when technology stocks were overvalued, these unusually high returns could potentially be due to that bubble. Note, however, that the returns earned in other periods are also positive. Specifically, the one-year returns for high BVDIST portfolios formed in 1983 through 1993 are mostly positive and statistically significant (mean abnormal returns equal to 7.3 percent, t-statistic of 2.8). Accordingly, the miscpricing we document here is unlikely to be due to the high valuations for technology firms during the late 1990s.

Long-term returns

If the documented abnormal forward stock returns on the high BVDIST portfolio are compensation for bearing risk, they should persist for long time periods. On the other hand, if BVDIST captures market mispricing, the returns should fade out relatively quickly as investors learn about the mispricing. We therefore examine abnormal returns over three years subsequent to portfolio formation (from May of year t+1 through April of year t+4).

Figure 5.2 presents the cumulative abnormal return (CAR) for each of the five BVDIST portfolios for the 36 months subsequent to portfolio formation. CAR is measured as the cumulative sum of the portfolio monthly abnormal returns. Portfolio monthly abnormal return for each of the 36 months is calculated as the average abnormal return for the corresponding month across all firm-year observations. Monthly abnormal return is calculated as the difference between the firm's return and the contemporaneous return on a SIZE and B/M matched portfolio (SIZE and B/M are updated every twelve months). To control for characteristics that are unique to our sample, and which may have affected returns during the sample period (see Table 5.4), the 25 SIZE and B/M benchmark portfolios are based only on firms from the seven R&D intensive industries included in our sample.

Because the reference group for measuring abnormal returns includes only firms from the seven R&D intensive industries, the abnormal returns in Figure 5.2 are smaller than those in Table 5.5 (as reported in Table 5.4, the average abnormal return for these industries in the first twelve months is about 3.7 percent). Figure 5.2 indicates that for the first nine months after portfolio formation, the CARs increase in absolute value almost linearly and the slopes are positively related to BVDIST. Between the tenth and twentieth month, the slopes are smaller in absolute value, although they are still positively related to BVDIST. However, from month 21 through 36,

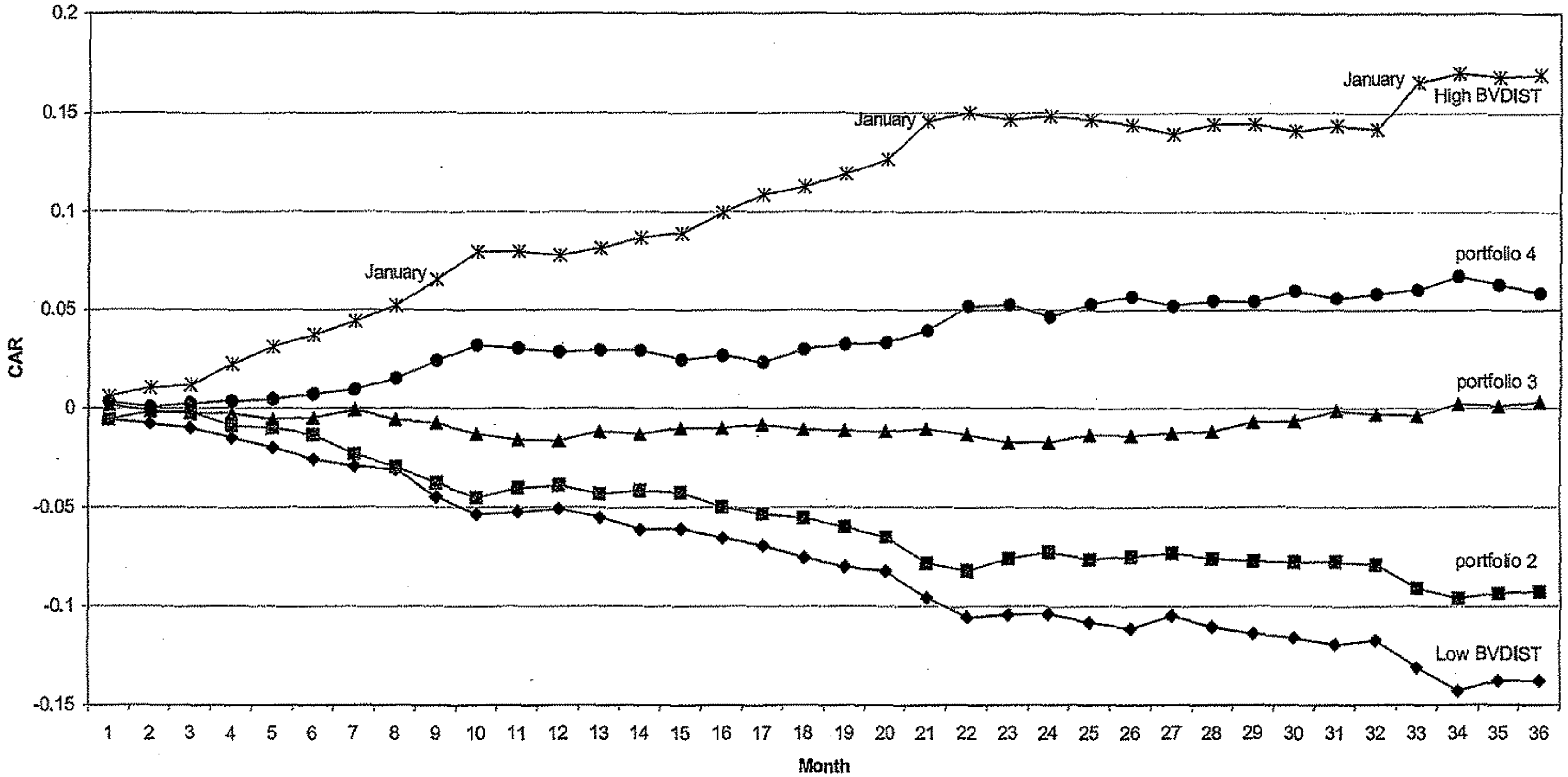

Figure 5.2 Cumulative abnormal returns (CAR) for BVDIST quintiles over the three years following portfolio formation

Cumulative abnormal return (CAR) is measured as the cumulative sum of the portfolio monthly abnormal returns. Portfolio monthly abnormal return for each of the 36 months is calculated as the average abnormal return for the corresponding month across all firm-year observations that "belong" to the portfolio. Monthly abnormal return is calculated as the difference between the firm's return and the contemporaneous return on a SIZE and B/M matched portfolio (SIZE and B/M are updated every twelve months).

excluding the January returns (months 21 and 33), the slopes are generally flat for all five portfolios. As argued earlier, such a pattern of prices initially adjusting to new information and then flattening out after a few months is consistent with BVDIST capturing market mispricing rather than compensation for risk.

We consider next the substantially higher returns earned by the high BVDIST quintile in January of the second and third years (months 21 and 33), even after controlling for SIZE and B/M. Previous studies (e.g., Chen and Singal 2001) have linked the January effect to SIZE (negative relation) and to the potential for tax-loss selling in December (positive relation).[24] The potential for tax-loss selling increases with the probability of large price movements, which in turn is likely to increase with BETA, VOLAT and R&D/M (see Chan, Lakonishok and Sougiannis 2001). Since Table 5.4 shows that BVDIST is indeed positively related to these firm characteristics, the strong January effect for the highest BVDIST portfolio may be due to the relatively large values of BETA, VOLAT and R&D/M, which in turn proxy for potential tax-loss selling.

Table 5.8 Cross-sectional Fama-MacBeth (1973) monthly regressions for January returns

	Int.	*SIZE*	*ln(B/M)*	*BETA*	*VOLAT*	*R&D/M*	R^2	*N*
Mean	0.092	-0.007	0.002	0.006	0.297	0.145	0.054	805
t-stat	3.657	-3.232	0.372	1.250	3.712	3.297		

Note:
The first row reports the time-series mean of each coefficient. The second row reports the *t*-statistic based on the time series distribution of the coefficient (mean coefficient divided by its standard error). The number of monthly regressions is 16 (January 1985 through January 2000). The dependent variable is the stock return in January. SIZE is measured in April of the previous year. BETA is estimated using monthly stock returns and the CRSP value-weighted monthly returns including all distributions during the five years that end in April of the previous year (at least 30 observations are required). VOLAT is the root mean squared error from the BETA regression. R&D/M is the ratio of R&D expense to the market value of equity a year ago.

To examine whether BETA, VOLAT and R&D/M proxy for potential tax-loss selling, we estimate for each year the cross-sectional regression of January returns on SIZE, B/M, BETA, VOLAT and R&D/M. Table 5.8 presents estimates from the 16 cross-sectional regressions. In contrast to the results in Table 5.5, and consistent with prior evidence on the January effect, the coefficients on VOLAT (BETA) are positive and highly (marginally) significant, the coefficient on SIZE is highly significant, and the coefficient on B/M is insignificant. In addition, the coefficient on R&D/M is substantially larger than the corresponding coefficient in Table 5.5. These results support the conjecture that the strong January effect for high BVDIST firms in Figure 5.2 is due to the potential for tax-loss selling. The fact that the January

24 Roll (1983) argues that SIZE is negatively related to the January effect because it proxies for the potential for tax-loss selling.

effect in the ninth month is small relative to the 21st and 33rd months may be due to the high stock returns in year t+1, which reduce the potential for tax loss selling in that year.

In summary, the evidence suggests that prices do not fully impound the information in adjusted earnings and book value, calculated assuming capitalization and straight-line amortization of R&D. The tentative conclusion is that allowing firms to capitalize and subsequently amortize R&D costs would improve the relevance of earnings and book value.

Conclusion

This study evaluates the potential improvement in the informational usefulness of earnings and book value when R&D expenditures are capitalized and amortized equally over assumed useful lives. We first examine the effect of these R&D adjustments on the association of earnings and book value with current stock price and future pre-R&D earnings, and find that this association is increased for adjusted earnings and book value numbers. Our results suggest that firms in some but not all industries may improve the informativeness of their financial statements if they capitalize and amortize R&D expenditures over industry-specific useful lives. This suggestion is based on the implicit assumption that increasing the association of reported numbers with intrinsic value is a desirable objective of financial reporting.

Given that our R&D adjustments are relatively crude, it is reasonable to project that allowing firms to follow individual amortization schedules would increase further this association between adjusted numbers and intrinsic values (and future earnings). To be sure, accounting standard setters should also weigh concerns about firms managing their earnings and assets when more measurement freedom is allowed.[25] While our results do not address directly the impact of providing such freedom, we believe they encourage standard setters to review the current policy of requiring immediate write-off of all R&D investments by all firms.[26]

The results of our main analysis, which links future returns to the crude adjustments we make to book value for unamortized R&D, emphasize even more strongly the need for standard setters to review current rules. To the extent our results are due to stock prices systematically undervaluing unamortized R&D, requiring firms to capitalize and amortize R&D should unambiguously increase the efficiency of market prices and resource allocation. Again, even though our evidence relates

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25 Proponents of capitalization have argued that the actual incidence of earnings/asset management caused by allowing more freedom in choosing amortization schedules is likely overstated, and the benefits of managers using this opportunity to reveal truthfully their estimates of future prospects is likely understated. Also, the simulation study conducted by Healy, Myers and Howe (1999) suggests that earnings is quite robust to such management. Finally, it should be noted that the timing of R&D (and other intangibles) expenditures can also be manipulated, and the impact on current earnings of such manipulation is greater under immediate expensing, relative to capitalization and amortization.

26 We hope that the January, 2002, announcement by the FASB that it has added an "intangibles disclosure" item to its agenda will result in deliberation of this issue.

only to the case where firms are required to follow strict industry-specific guidelines for amortization of R&D, we believe our evidence also suggests a review of the trade-offs associated with a more flexible policy.

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