The Stock Market Valuation of Research and Development Expenditures

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ABSTRACT

We examine whether stock prices fully value firms' intangible assets, specifically research and development (R&D). Under current U.S. accounting standards, financial statements do not report intangible assets and R&D spending is expensed. Nonetheless, the average historical stock returns of firms doing R&D matches the returns of firms without R&D. However, the market is apparently too pessimistic about beaten-down R&D-intensive technology stocks' prospects. Companies with high R&D to equity market value (which tend to have poor past returns) earn large excess returns. A similar relation exists between advertising and stock returns. R&D intensity is positively associated with return volatility.

THE MARKET VALUE OF A FIRM'S SHARES ultimately reflects the value of all its net assets. When most of the assets are physical, such as plant and equipment, the link between asset values and stock prices is relatively apparent. In modern economies, however, a large part of a firm's value may reflect its intangible assets, such as brand names. Under generally accepted U.S. accounting principles, many types of intangible assets are not reported in firms' financial statements. When a firm has large amounts of such intangibles, the lack of accounting information generally complicates the task of equity valuation.

One type of intangible asset, business research and development (R&D) activity, has lately been the subject of much attention. In part, the interest reflects recent widespread technological change, together with the dazzling growth of science- and knowledge-based industries, which are especially active in R&D. For example, at year-end 1999, the technology sector and the pharmaceuticals industry together account for roughly 40 percent of the value

of the S&P 500 index. Equally strikingly, the amount of R&D spending in some major technology industries is larger than their earnings. Finally, firms are required by U.S. accounting standards to disclose their R&D expenditures in their financial statements, unlike many other kinds of spending on intangible assets.

The rise in the importance of technology-oriented companies raises the question of whether their stock market values reflect their intangible R&D capital. In an efficient market, the stock price impounds the value of a firm's R&D capital (along with other intangible assets), so there is no association between R&D intensity and future stock returns. On the other hand, many R&D-intensive firms have few tangible assets. Instead, their prospects are tied to the success of new, untested technologies and hence are highly unpredictable. Large expenditures are usually required at the outset, and the outcome of many research projects is far from assured. The benefits, if any, are likely to materialize only much later, and the life-cycles of resulting products may be quite short. Finally, accounting information about a firm's R&D activity is generally of limited usefulness. Firms have some leeway in identifying what counts as an R&D cost and all of a firm's R&D spending is reported as one aggregate item. More important, as a result of the expensing convention for R&D, some yardsticks commonly used by investors, such as price-earnings ratios and market-to-book ratios, may be misstated. In particular, many R&D-intensive companies may appear to be priced at unjustifiably high multiples, so they appear to be "expensive" by such criteria.

These complications raise the possibility that stock prices do not fully incorporate the value of R&D capital. Some authors (Porter (1992), Hall (1993), and Hall and Hall (1993)) suggest that investors have short time horizons so they fail to anticipate the rewards from long-term investments such as R&D. Underpricing may also arise if investors mechanically accept firms' financial statements at face value without adjusting for the long-term benefits of R&D (the "functional fixation hypothesis" in the accounting literature). This may be the case if investors, for example, value an R&D-intensive firm at a fixed multiple of its reported book value. Certainly, investors' ardor for technology stocks in recent years reflected their belief that R&D-intensive technology stocks are undervalued.

In contrast, many observers have suggested that investors overestimate the benefits from R&D, so valuations attached to R&D-intensive technology stocks are excessive. There is wide coverage of technology firms by the popular media and intensive marketing efforts devoted to these stocks by the investment industry. As a result, the market may be overly optimistic about the technological breakthroughs that are touted by R&D-intensive firms (such as a biotechnology firm's promise to deliver a cure for cancer). Further, if it is the case that many firms' R&D investments are not profitable (as Jensen (1993) suggests) but investors systematically overlook this possibility, overvaluation may arise.

Accounting variables are widely used by the investment community in determining a firm's cost of capital. In this respect, failing to incorporate the value of a firm's intangible assets can affect its cost of capital. For example,

bond covenants are generally tied to reported earnings or the book value of equity and assets. Since these accounting numbers do not reflect intangible assets, R&D-intensive firms may appear to be more highly leveraged than is the case and may face a higher cost of debt. Additionally, the ratio of book-to-market values is widely used as a measure of a firm's growth opportunities. If lenders and investors disregard a firm's intangible assets in assessing the book-to-market ratio, they may misstate its growth opportunities, and thereby the systematic risk, of an R&D-intensive firm.[1]

This paper documents the importance of firms' R&D capital, and investigates whether the stock market appropriately accounts for the value of R&D expenditures. Section I of the paper provides evidence on the importance of R&D spending, and gauges the impact of expensing R&D on standard valuation measures such as earnings yields and book-to-market ratios. We also report measures of the stock of R&D capital. Section II discusses whether measures of R&D intensity, including R&D spending relative to sales or relative to market value of equity, are related to future stock returns. Section III checks whether our results are robust to a variety of risk-adjustment procedures, including controls for confounding effects due to firm size, book-to-market, and past returns. Also in this section we extend our analysis to another important form of intangible capital, advertising expenditures. The lack of accounting disclosure about firms' R&D, in addition to having possible effects on stock prices, may also influence the level of investors' uncertainty. Accordingly, in Section IV we explore whether the volatility of stock returns is related to R&D. A final section contains the summary and conclusions.

Although many investors are enamored with technology stocks and believe them to be superior investments, the historical evidence suggests otherwise. The average return on stocks that do R&D is comparable to the return on stocks with no R&D. The absence of any differences is consistent with the notion that the market price on average incorporates fully the benefits of R&D spending. The strongest signs of an association between R&D intensity and future returns come from stocks with high R&D relative to market value of equity (that tend to have experienced poor returns in the past). Excess returns for this category of stocks average 6.12 percent per year over the postformation period. The market apparently gives insufficient credit to past losers who are spending heavily on R&D. Such firms probably face strong pressures to cut R&D and improve earnings. Their reluctance to do so, however, may reflect their managers' confidence that future prospects are not so bleak. Nonetheless, the market tends to overlook such signals (just as it tends to discount other indicators of managers' optimism such as stock repurchases and insider trades).[2] Our exploratory investigation of the effects

[1] See, for example, Berk, Green, and Naik (1999) for a discussion of how a firm's expected return and risk dynamics are affected by its asset base and growth options in an equilibrium model.

[2] See, for example, Ikenberry, Lakonishok, and Vermaelen (1995) for evidence on the stock price effects of share repurchases, and Lakonishok and Lee (2001) for evidence on insider trading.

on stock returns of another important intangible asset, advertising, uncovers very similar patterns as with R&D.

Although R&D intensity in general and stock returns are unrelated, this does not imply that the current accounting treatment of R&D is fully informative, or that there are no costs from the limited disclosure of such activity. We provide some evidence that R&D intensity is positively associated with return volatility. Insofar as the association reflects, at least in part, investors' lack of information about firms' R&D activity, there may be benefits from more detailed disclosure about R&D in accounting statements.

I. The Importance of R&D Spending

A. *Measures of R&D Intensity*

Table I provides summary statistics on R&D expenditures (total outlays, representing the amount charged against income under current U.S. accounting procedures), and the estimated stock of R&D capital. R&D spending is expressed relative to either total sales, earnings (net income), total dividends, or book value of equity. The stock of R&D capital is compared to the book value of equity. In each of these ratios, we aggregate separately the items in the numerator and denominator. The virtue of this procedure (compared to calculating the average of the ratios across firms) is that it is insensitive to outlier cases where a firm has very low or no earnings, for example. An added advantage is that the calculation corresponds directly to the result of a capitalization-weighted portfolio investment strategy.[3]

Each firm's R&D capital is estimated from its past history of R&D expenditures as follows. The existing literature suggests no consensus on estimates for the useful life of expenditures and the amortization rate. Lev and Sougiannis (1996) estimate the impact of current and past R&D spending on earnings across a variety of industries. These estimates thereby measure the proportion of past spending that is still productive in a given year. Based on their estimates, we adopt the following tractable approximation of the stock of R&D capital, RDC_{it} for firm i in year t based on current and past R&D expenditure (RD_{it}):

$$RDC_{it} = RD_{it} + 0.8 * RD_{it-1} + 0.6 * RD_{it-2} + 0.4 * RD_{it-3} + 0.2 * RD_{it-4}. \quad (1)$$

Effectively we assume that the productivity of each dollar of spending declines linearly by 20 percent a year. Our assumed capital amortization rate

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[3] All financial information is taken from the COMPUSTAT Active and Research files. R&D expenditure is annual data item 46; sales is annual data item 12; net income is annual data item 172; dividends to common equity are measured as annual data item 21; book value of common equity is annual data item 60. Market value of common equity (price per share times number of shares outstanding) is from the CRSP Stock Return files.

Table I

Intensity of Research and Development Activity for all Firms doing R&D and for Selected Industries

For selected fiscal years from 1975 to 1995 total R&D expenditure and R&D capital are calculated for all firms doing R&D (Panel A) and firms classified into industries based on SIC codes (Panel B). The sample is all domestic firms listed on NYSE, AMEX, and Nasdaq with data on the COMPUSTAT files. The reported statistics are the ratios of R&D totals (either for all R&D firms or for an industry) to total values of the base variable (either for all R&D firms or for an industry). The base variables are: sales, earnings, dividends, and book value of equity. The selected industries comprise at least 10 firms each, and are ranked by R&D expenditures relative to sales.

Panel A: All Firms doing R&D					
	R&D Expenditures as Percent of				R&D Capital as Percent of
Year	Sales	Earnings	Dividends	Book Value	Book Value
1975	1.70	36.1	84.1	4.13	10.55
1980	1.78	34.4	87.6	5.08	12.55
1985	3.01	83.7	145.8	8.11	21.25
1990	3.40	79.4	148.9	9.59	25.76
1995	3.75	65.3	165.2	10.88	28.73

Panel B: Selected Industries						
		R&D Expenditure as Percent of				R&D Capital as Percent of
SIC	Industry	Sales	Earnings	Dividends	Book Value	Book Value
737	Computer programming, software, & services	16.6	207.1	2833.0	27.5	54.9
283	Drugs & pharmaceuticals	11.9	92.2	192.0	21.1	53.3
357	Computers & office equipment	7.1	159.3	1242.4	21.0	55.9
38	Measuring instruments	5.6	89.8	276.9	13.0	36.6
36	Electrical equipment excluding computers	4.9	58.2	242.2	10.3	25.6
48	Communications	3.7	98.1	80.2	13.7	36.4
37	Transportation equipment	3.6	125.5	297.5	16.6	46.1

turns out to be close to the one used (15 percent) in a highly influential database compiled on R&D activity by the National Bureau of Economic Research (see Hall et al. (1988)).[4]

In panel A, R&D spending has grown sharply in importance. As a percentage of sales, R&D expenditures stood at 1.70 percent in 1975 and more than

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[4] In additional unreported work, we assumed a 10 percent amortization rate. The results are qualitatively unaffected.

doubled by 1995 to 3.75 percent.[5] As R&D intensive firms tend to pay little or no dividends, R&D expenditures are as much as 1.65 times cash dividends to shareholders. R&D capital represents an important intangible asset that is not represented on firms' balance sheets, accounting for fully 29 percent of the book value of common equity in 1995.[6] This number suggests that many technology-oriented stocks would appear less expensive if their intangible R&D assets were added to their book values.[7]

R&D spending is heavily concentrated in technology and science-oriented industries. As an illustration, panel B of Table I breaks out several industries (defined by two-digit or three-digit SIC codes) of particular interest and ranks them by 1995 R&D spending relative to industry sales. By far the highest ratio of spending is found in industry 737 (computer programming, software, and services).[8] R&D costs in this industry represent about 17 percent of sales and two times earnings. Next in the industry ranking is the drugs and pharmaceuticals industry (SIC codes beginning with 283), where R&D is about 12 percent of industry sales. Perhaps the recent popular impression that heavy R&D spending is associated with superior stock price performance stems in large part from the success of a few large, well-known companies drawn from these industries, such as Microsoft and Merck, over our sample period.

As a percentage of earnings, R&D expenditures vary from 58 percent in industry 36 to 207 percent in industry 737. The stock of R&D capital is also large relative to the accounting book value of equity. The magnitude of these figures suggests that expensing R&D costs may distort conventional valuation yardsticks such as price-earnings or price-to-book ratios.

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[5] It has been argued that the growth in R&D may be overstated to the extent that firms relabel other expenses as R&D in order to qualify for tax credits (see, for example, the literature surveyed in Hall and van Reenen (1999)). From the standpoint of investors evaluating the benefits from R&D, such reallocation further complicates the valuation problem.

[6] Note that the estimated capital stock is based on the actual outlays incurred, so the capital is valued at cost. Assuming some rate of return on R&D over the cost of capital would lead to an even larger intangible asset.

[7] Not all firms carry out R&D: On average about 40 percent of firms report some value for R&D expenditures. Nonetheless, even when the comparison is relative to the entire set of U.S. firms, the importance of R&D outlays is impressive: Expenditures in 1995 are about 81 percent of all firms' dividends, for example.

[8] Under current accounting rules, software research costs are expensed, as in other industries, but the costs of development for software are capitalized. Development refers to the translation of research findings into plans or designs for new products or processes. In general, firms are not required to report separately their expenses for research and for development. A brief perusal of the financial statements of several large, well-known software companies suggests, however, that in many cases, effectively all their software R&D costs are expensed as incurred (at least over our sample period). For example, Microsoft's balance sheet indicates that all R&D costs are expensed and that the development portion is not material. Netscape and Symantec report similarly. For 1994, Lotus charged $159 million of R&D costs to operations and capitalized $36 million of development costs. It reported that capitalized software costs were amortized on a straight-line basis over the specific product's economic life, generally three years.

B. The Impact of Expensing R&D Costs

To explore further the impact on commonly used valuation measures, we compare earnings under the current practice of immediately expensing R&D spending with "adjusted earnings" calculated using an estimate of R&D expense.[9] Similarly we compare the book value of common equity with a measure of book value ("adjusted book value") that adds to the accounting book value the value of R&D capital.

The results in Table II for R&D-intensive industries highlight the potential distortions from immediately expensing R&D. The amortization adjustment is especially striking for industry 737 (computer programming, software, and services). In panel A, the 1995 price-earnings ratio using reported earnings for this industry is 51.8 whereas the ratio based on adjusted earnings is less than half this amount (23.4). Similarly, the industry's price-to-book ratio comes down from 6.9 to 4.4 when R&D capital is accounted for in Panel B. Arguably, our assumption of a five-year life for R&D expenditures may be too long, given the short product cycles in the software industry. In the drugs and pharmaceuticals industry (industry 283), on the other hand, five years may not be long enough. Even in this industry, however, the amortization adjustments to earnings and book value are quite dramatic. With the adjustment, the price-earnings ratio comes down from 27.2 to 20.9, and the price-to-book ratio changes from 6.2 to 4.1.

In summary, R&D activity represents a significant and growing portion of firm resources. In several industries that are highly R&D intensive, the practice of immediately expensing R&D outlays can have a substantial distortionary effect on earnings and book values. If investors mechanically arrive at valuations based on such reported earnings or book values, the degree of mispricing can be substantial.

II. R&D Activity and Stock Returns

To see if the stock market correctly recognizes the expected future benefits from R&D spending, this paper implements an investment strategy based on R&D intensity. We first measure R&D intensity as R&D expenditures relative to sales. This variable is widely used in practice as an indicator of how much resources a firm devotes to R&D (see, for example, the *Value Line Investment Survey*). Our second measure of intensity, the ratio of R&D expenditures to the market value of equity, is more in keeping with many indicators that are widely used in financial economics. In particular, scaling

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[9] Corresponding to equation (1), R&D expense RE_{it} is the periodic amortization of the R&D capital stock:

$$RE_{it} = 0.2 * (RD_{it-1} + RD_{it-2} + RD_{it-3} + RD_{it-4} + RD_{it-5}).$$

Table II

The Impact of Expensing Research and Development Spending on Earnings and Book Value for Selected Industries

For fiscal year 1995, earnings net of R&D expenditure and earnings net of R&D expense ("adjusted earnings") are calculated for all domestic firms listed on NYSE, AMEX, and Nasdaq with data on the COMPUSTAT files and who are engaged in R&D spending. Firms are classified into industries based on SIC codes. For each industry, total unadjusted and adjusted earnings for the industry are expressed as a percentage of the industry's market value of equity (Panel A). Book value of equity and book value of equity including R&D capital are also calculated for the industry and expressed as a percentage of the industry's equity market value (Panel B). The selected industries comprise at least 10 firms each, and are ranked by 1995 R&D expenditure relative to sales.

	Panel A: Earnings		
SIC	Industry	Earnings as Percent of Market Value	Adjusted Earnings as Percent of Market Value
737	Computer programming, software, & services	1.93	4.28
283	Drugs & pharmaceuticals	3.67	4.79
357	Computers & office equipment	4.46	5.73
38	Measuring instruments	4.11	4.53
36	Electrical equipment excluding computers	5.44	6.43
48	Communications	2.49	2.98
37	Transportation equipment	5.99	7.21

	Panel B: Book Value of Equity		
SIC	Industry	Book Value as Percent of Market Value	Adjusted Book Value as Percent of Market Value
737	Computer programming, software, & services	14.54	22.52
283	Drugs & pharmaceuticals	16.05	24.60
357	Computers & office equipment	33.65	52.46
38	Measuring instruments	28.40	38.81
36	Electrical equipment excluding computers	30.76	38.64
48	Communications	17.84	24.33
37	Transportation equipment	45.22	66.05

R&D by equity market value lets this intensity measure be interpreted in the same way as conventional indicators such as earnings- or book-to-price ratios. Sorting by R&D relative to market tends to highlight stocks that have large R&D spending and at the same time relatively depressed market values.

We take all domestic common stocks listed on the New York and American Stock Exchanges and on Nasdaq. Portfolios are formed at the end of April each year, based on the most recently available accounting information (assuming a four-month delay between the end of a firm's fiscal year and the

release of its financial statements).[10] Eligible stocks are ranked by a measure of R&D intensity and assigned to one of five portfolios. Since we focus on valuation effects over longer horizons, we calculate equally weighted annual buy-and-hold returns over each of the three years following portfolio formation.[11] In addition, the tables report several characteristics of each portfolio.

A. *Portfolio Results Based on R&D Relative to Sales*

Table III provides results for portfolios sorted by R&D intensity relative to sales. Although it is commonly thought that firms doing R&D, such as technology companies, provide superior stock price performance, the raw return (Panel A) of firms that carry out R&D is on average no different from those of firms without R&D. Averaging over all the five groups of stocks doing R&D, for example, the mean annual return in the three years following portfolio formation is 19.65 percent, compared to 19.50 percent for firms without R&D. Put another way, run-of-the-mill cement and utility stocks on average did as well as highly-touted technology stocks. The similarity between the average returns of stocks with and without R&D is consistent with the hypothesis that the market on average correctly values any future benefits from research spending.

When we look within the group of firms engaged in research activity, there is little if any relation between R&D relative to sales and future returns in Panel A. Raw returns are roughly the same across the five portfolios. Over the three postformation years, for example, the most R&D-intensive portfolio, quintile 5, earns an average annual return of 19.52 percent, compared to the overall average of 19.65 percent per year for all R&D firms.

Firms with a high rank by R&D relative to sales tend to be glamour stocks, with lower ratios of book-to-market equity, sales-to-price, dividends, and earnings-to-price (Panel D). On this basis, earlier research (Chan, Hamao, and Lakonishok (1991), Fama and French (1992), Lakonishok, Shleifer, and Vishny (1994)) raises the presumption that these stocks have historically earned comparatively low returns. Yet, as Panel A indicates, their average returns are similar to those of the other portfolios. It would thus appear that one set of glamour stocks, namely highly R&D-intensive stocks, do not have the relatively poor returns that usually accompanied glamour investing.

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[10] The sample is not limited to firms whose fiscal years end in December. In the case of firms with fiscal years not ending in December, their accounting data will be less up-to-date as of the portfolio formation date, given our assumed publication delay. However, most firms in the R&D sample (roughly 59 percent of the observations) have fiscal years that end in December.

[11] When a stock is delisted in the course of a year after portfolio formation, we pick up the CRSP delisting return if it is available. Thereafter we splice the stock's return with the return on the value-weighted market index until the next portfolio formation date. Our analysis of long-horizon returns for a large sample of firms over an extended period differentiates us from other related studies. For example, Chan, Martin, and Kensinger (1990) look at returns on days around announcements of R&D plans for 95 firms from 1979 to 1985.

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Table III

Returns and Characteristics of Portfolios Classified by R&D Expenditure Relative to Sales

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At the end of April each year from 1975 to 1995, all stocks are ranked by their R&D expenditure relative to sales, and assigned to one of five equally sized portfolios. Stocks with no R&D expenditures are assigned to a separate portfolio. The sample includes all NYSE, AMEX, and Nasdaq domestic primary issues with coverage on the CRSP and COMPUSTAT files. In Panel A, each portfolio's average annual buy-and-hold return is reported over the five years prior to portfolio formation; over each year from one to three years after portfolio formation; and averaged over the three postformation years. Panel B reports each portfolio's average return in excess of the equally weighted return on a control portfolio of stocks matched by firm size and book-to-market in the first through third postformation years. Panel C reports excess returns based on control portfolios matched by firm size and adjusted book equity (book equity plus the value of R&D capital) relative to market equity. Panel D reports characteristics of the portfolios: the average number of component stocks; the ratios of R&D expenditures to market value of equity and to sales; book value and adjusted book value of equity relative to market value of equity; sales relative to market value of equity; earnings relative to market value of equity; annual dividends divided by market value of equity; return on equity (earnings divided by the prior year's book value of equity); and the natural logarithm of market value of equity in millions of dollars. Panel E provides the annual growth rate in earnings for each portfolio over the five-year period following portfolio formation, using the procedure described in the Appendix.

	1(Low)	2	3	4	5(High)	Non-R&D
			Panel A: Returns Before and After Portfolio Formation			
Average annual return over 5-year period before portfolio formation	0.1982	0.1904	0.2038	0.2066	0.2254	0.2025
First year after portfolio formation	0.1911	0.2068	0.2114	0.2167	0.1815	0.1987
Second year after portfolio formation	0.1738	0.1936	0.2013	0.1970	0.1971	0.1916
Third year after portfolio formation	0.1806	0.1898	0.2014	0.1984	0.2071	0.1947
Average annual return over 3-year period after portfolio formation	0.1818	0.1967	0.2047	0.2040	0.1952	0.1950
			Panel B: Excess Returns After Portfolio Formation			
First year after portfolio formation	−0.0058	0.0121	0.0185	0.0317	0.0016	−0.0018
Second year after portfolio formation	−0.0116	0.0092	0.0208	0.0254	0.0327	0.0036
Third year after portfolio formation	−0.0066	0.0043	0.0198	0.0235	0.0391	0.0060
Average annual excess return over 3-year period after portfolio formation	−0.0080	0.0085	0.0197	0.0269	0.0245	0.0026

Panel C: Excess Returns Based on Adjusted Book Value						
First year after portfolio formation	−0.0063	0.0095	0.0154	0.0265	−0.0034	−0.0018
Second year after portfolio formation	−0.0130	0.0073	0.0165	0.0185	0.0245	0.0036
Third year after portfolio formation	−0.0075	0.0020	0.0155	0.0173	0.0310	0.0060
Average annual excess return over 3-year period after portfolio formation	−0.0089	0.0063	0.0158	0.0208	0.0174	0.0026
Panel D: Characteristics of Portfolios						
Average number of firms	237.8	238.0	238.3	238.3	238.6	1856.5
R&D to sales	0.0046	0.0136	0.0289	0.0571	0.2262	0.0000
R&D to market value	0.0130	0.0321	0.0569	0.0807	0.1088	0.0000
Book-to-market	0.8997	0.8511	0.8001	0.7033	0.5408	0.9008
Adjusted book-to-market	0.9850	0.9754	0.9796	0.9396	0.8178	0.9008
Sales-to-market	3.1756	2.5879	2.3021	1.7118	1.0297	2.7738
Earnings-to-price	0.0800	0.0759	0.0684	0.0537	0.0058	0.0797
Dividend yield	0.0258	0.0243	0.0208	0.0153	0.0057	0.0257
Return on equity	0.1088	0.1090	0.1069	0.0983	0.0183	0.1060
Log Size	4.6863	4.6456	4.5959	4.5396	4.2323	4.4437
Panel E: Average Annual Growth Rates after Portfolio Formation						
Annual earnings growth over 5 postformation years	0.0728	0.1083	0.1084	0.0772	0.1424	0.1015

Panels B and C take the differences across portfolios in their value–glamour orientation into account. We follow the general approach in the literature and control for size and book-to-market effects.[12] Specifically, in Panel B each stock in a portfolio is assigned a control portfolio based on its ranking by size and by book-to-market. There are a total of 30 control portfolios, corresponding to five possible ranks by book-to-market and six possible ranks by size. The ranking by book-to-market is based on quintile breakpoints over all stocks. The breakpoints for size are based on NYSE issues only. The size categories are as follows: Groups 1 to 4 correspond to the largest four quintiles, respectively, of market capitalization; group 5 is the next-to-smallest decile and group 6 is the bottom decile. The additional breakdown of the bottom quintile of firms reflects the fact that many of the stocks who are active in R&D are small. Further, since the breakpoints for the size classification are based on NYSE stocks only, the bottom quintile comprises numerous firms. Each stock's return is measured net of the buy-and-hold return on its control portfolio.

If investors recognize that a firm's assets should include its intangibles, then firms should be matched on the basis of size and adjusted book-to-market ratios, where book equity values are adjusted to incorporate the value of R&D. This is done in Panel C, which otherwise follows the same procedure as Panel B.[13]

Stocks that are highly R&D intensive tend to earn positive excess returns in the postformation period, although the excess returns are generally not large. In Panel B, for instance, the mean excess return on the highest-ranked portfolio is 2.45 percent per year over the three postformation years.[14] Including R&D capital in book equity knocks the average excess return over the postformation period down to 1.74 percent in Panel C.[15]

Panel E of Table III looks directly at the future operating performance of the different portfolios. The details behind the calculations are provided in the Appendix. The average annual growth rate in earnings over the five postformation years is virtually the same for stocks with R&D and without R&D (the means across all stocks with R&D and all stocks without R&D are

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[12] For evidence that size and book-to-market are important factors for stock returns, see Fama and French (1992) and Chan, Karceski, and Lakonishok (1998).

[13] Adjusted book-to-market ratios, with R&D capital included, spread out returns even more than the unadjusted book-to-market variable. Sorting all stocks (with and without R&D) by adjusted book-to-market ratios into 10 portfolios produces an average spread in size-adjusted returns of 5.9 percent between the extreme deciles in the first subsequent year, compared to 5.1 percent based on unadjusted ratios. The adjusted ratio produces larger spreads every year compared to the unadjusted ratio up to five years following portfolio formation.

[14] When we measure returns over longer horizons in order to give investors enough time to correct any initial mispricing, the excess returns are similar in magnitude.

[15] The excess returns in Panels B and C are also not large relative to their standard errors. For example, in Panel B the highest-ranked quintile portfolio has a t-statistic of 0.96 for the average annual excess return over the three postformation years (where the standard error is adjusted for serial correlation induced by overlapping observations).

10.18 percent and 10.15 percent, respectively).[16] The growth rate of earnings is notably higher only in the case of the most R&D-intensive stocks (quintile portfolio 5). For this quintile, the average growth rate for earnings is 14.24 percent. The high growth rate is partly due to the fact that these stocks on average have the lowest base-year earnings (relative to price) of all the portfolios.

One important lesson from Table III thus seems to be that simply doing R&D by itself does not, on average, give rise to differential stock price performance. Since R&D-intensive stocks tend to be glamour stocks with relatively low book-to-market ratios (even after their book equity values are adjusted to include R&D capital), they might be presumed to earn below-average returns. Rather, Table III says that within the set of such glamour stocks, there are some stocks with large R&D spending whose returns are not lower than average. Putting these together gives rise to our result that a glamour stock that is highly active in R&D earns a slightly higher return than other glamour stocks.

B. Portfolio Results Based on R&D Relative to Market Value

Table IV reports results for portfolios sorted by R&D expenditures relative to market value of equity. In general, the two measures of R&D intensity are correlated (Panel D). However, many firms that are highly R&D intensive relative to sales (such as pharmaceutical firms) do not rank highly on the basis of R&D relative to market equity. Rather, the portfolio of stocks ranked highest by R&D relative to market tends to be populated by stocks with poor past returns (or "losers"). Over the five years prior to portfolio formation, the average annual return of stocks ranked in the top quintile by R&D relative to market is only 9.89 percent (Panel A of Table IV). In comparison, stocks with no R&D have an average return over the same period of 20.25 percent per year. Additionally, the earnings of stocks in quintile 5 are depressed, as reflected by their average earnings-to-price ratio or their average return on equity, which are the lowest in the table.

The stocks in the top quintile portfolio perform well in the years following portfolio formation. High R&D firms earn on average a return of 26.47 percent in the first subsequent year, compared to 19.87 percent for stocks with no R&D. The superior performance continues over the three postformation years. The average annual rate of return over the three postformation years is 26.19 percent for the top R&D quintile and the spread between the two extreme quintiles (11.08 percent per year on average over this period) is also large. The rebound for extreme past losers echoes the pattern uncovered by

[16] Note, however, that our calculation of growth rates differs from the usual measure of growth in earnings per share. In particular our calculated growth rates reflect how much earnings an investor is entitled to per dollar of initial investment. Further we assume a buy-and-hold investment strategy, so the growth rates include the reinvestment of dividends. The average dividend yield is 1.84 percent for R&D stocks and 2.57 percent for stocks with no R&D.

Table IV

Returns and Characteristics of Portfolios Classified by R&D Expenditure Relative to Equity Market Value

At the end of April each year from 1975 to 1995, all stocks are ranked by their R&D expenditure relative to the market value of equity, and assigned to one of five equally sized portfolios. Stocks with no R&D expenditures are assigned to a separate portfolio. The sample includes all NYSE, AMEX, and Nasdaq domestic primary issues with coverage on the CRSP and COMPUSTAT files. In Panel A, each portfolio's average annual buy-and-hold return is reported over the five years prior to portfolio formation; over each year from one to three years after portfolio formation; and averaged over the three postformation years. Panel B reports each portfolio's average return in excess of the equally weighted return on a control portfolio of stocks matched by firm size and book-to-market in the first through third postformation years. Panel C reports excess returns based on control portfolios matched by firm size and adjusted book equity (book equity plus the value of R&D capital) relative to market equity. Panel D reports characteristics of the portfolios: the average number of component stocks; the ratios of R&D expenditures to market value of equity and to sales; book value and adjusted book value of equity relative to market value of equity; sales relative to market value of equity; earnings relative to market value of equity; annual dividends divided by market value of equity; return on equity (earnings divided by the prior year's book value of equity); and the natural logarithm of market value of equity in millions of dollars. Panel E provides the annual growth rate in earnings for each portfolio over the five year period following portfolio formation, using the procedure described in the Appendix.

	1(Low)	2	3	4	5(High)	Non-R&D
Panel A: Returns Before and After Portfolio Formation						
Average annual return over 5-year period before portfolio formation	0.2924	0.2460	0.2095	0.1687	0.0989	0.2025
First year after portfolio formation	0.1582	0.1782	0.1927	0.2135	0.2647	0.1987
Second year after portfolio formation	0.1401	0.1658	0.1869	0.2198	0.2534	0.1916
Third year after portfolio formation	0.1551	0.1677	0.1923	0.1975	0.2677	0.1947
Average annual return over 3-year period after portfolio formation	0.1511	0.1706	0.1906	0.2103	0.2619	0.1950
Panel B: Excess Returns After Portfolio Formation						
First year after portfolio formation	−0.0177	−0.0040	0.0051	0.0161	0.0585	−0.0018
Second year after portfolio formation	−0.0220	−0.0023	0.0125	0.0353	0.0552	0.0036
Third year after portfolio formation	−0.0116	−0.0038	0.0140	0.0139	0.0699	0.0060
Average annual excess return over 3-year period after portfolio formation	−0.0171	−0.0034	0.0105	0.0218	0.0612	0.0026

	Panel C: Excess Returns Based on Adjusted Book Value					
First year after portfolio formation	−0.0182	−0.0063	0.0014	0.0105	0.0542	−0.0018
Second year after portfolio formation	−0.0231	−0.0035	0.0078	0.0284	0.0464	0.0036
Third year after portfolio formation	−0.0122	−0.0060	0.0100	0.0076	0.0611	0.0060
Average annual excess return over 3-year period after portfolio formation	−0.0178	−0.0053	0.0064	0.0155	0.0539	0.0026
	Panel D: Characteristics of Portfolios					
Average number of firms	237.8	238.0	238.3	238.3	238.6	1856.5
R&D to sales	0.0210	0.0461	0.0660	0.0838	0.1137	0.0000
R&D to market value	0.0068	0.0188	0.0358	0.0644	0.1655	0.0000
Book-to-market	0.5832	0.6626	0.7020	0.7934	1.0523	0.9008
Adjusted book-to-market	0.6106	0.7290	0.8168	0.9850	1.5540	0.9008
Sales-to-market	1.6223	1.8656	1.9622	2.2467	3.1035	2.7738
Earnings-to-price	0.0651	0.0666	0.0618	0.0590	0.0311	0.0797
Dividend yield	0.0196	0.0200	0.0189	0.0179	0.0155	0.0257
Return on equity	0.1252	0.1129	0.0966	0.0779	0.0288	0.1060
Log size	5.0420	4.7837	4.6911	4.4042	3.7802	4.4437
	Panel E: Average Annual Growth Rates after Portfolio Formation					
Annual earnings growth over 5 postformation years	0.0730	0.0641	0.0644	0.0985	0.1713	0.1015

DeBondt and Thaler (1985). Firms with a history of poor performance may be subject to the kinds of extrapolative biases noted in the earlier literature. In particular, the market may discount too heavily the possibility of their future recovery. La Porta et al. (1997), for example, find a pattern of positive price reactions for value stocks around future earnings announcement dates, supporting the hypothesis that investors are too pessimistic about these firms.

In the case of stocks with high R&D intensity relative to market value, however, there is more to the story than just the subsequent recovery of past losers. Even after adjusting for size and book-to-market (Panels B and C), their returns are still high.[17] In Panel B, over the postformation period, quintile portfolio 5 has an average excess return of 6.12 percent per year, yielding a mean spread of 7.83 percent per year between the extreme quintiles.[18] Excess returns based on adjusted book-to-market ratios (Panel C) tell a similar story.[19]

One possible explanation for the excess returns on firms with high R&D to market equity draws from related evidence that the market underreacts to managers' signals (see, for example, Ikenberry et al. (1995), Loughran and Ritter (1995), and Lakonishok and Lee (2001)). Despite their poor performance, the firms in the top quintile portfolio spend a large portion of sales (in excess of 11 percent) on R&D. Their managers' willingness to maintain R&D spending represents a vote of confidence that the firms' future opportunities might improve. Their beliefs are all the more credible because R&D spending directly depresses earnings, so their choice is not without pain. The growth rates in Panel E of the table support the extent of the regained profitability for the top quintile of R&D-intensive stocks. For this group, earnings over the five years following portfolio formation grow by 17.13 percent, compared to 10.15 percent for firms with no R&D.

The nature of the investor clientele for R&D-intensive technology companies may be an additional factor in determining stock prices. In particular, R&D-intensive firms who are past losers tend to be sold off by growth-oriented investors. Many value investors, on the other hand, stay away from technology stocks in general because they do not view such stocks as part of their natural investment domain. Additionally, value investors may not be

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[17] The results in Fama and French (1996) suggest that once size and book-to-market are controlled for, long-term past losers do not earn excess returns. Lev and Sougiannis (1996), using a procedure different from ours, also find that R&D relative to market equity predicts future returns. They use the Fama and MacBeth (1973) methodology and estimate cross-sectional regressions of stock returns on beta, size, book-to-market, leverage, earnings yield, and the ratio of R&D capital to market equity. The coefficient on the R&D variable is positive and statistically significant.

[18] The t-statistic for the average excess return on the top quintile portfolio over the three postformation years is 2.68. Excess returns over the five years following portfolio formation are of comparable magnitude.

[19] Earlier research suggests that anomalous patterns in returns are typically more pronounced for small stocks. This turns out to be so for R&D relative to market as well. Over the three postformation years, the average excess return is 9.89 percent per year for the highest-ranked R&D portfolio of firms in the bottom decile of market capitalization.

<div align="center">

Table V

**Excess Returns of Portfolios Classified by R&D Intensity,
and by Past 3-year Return**

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At the end of April each year from 1975 to 1995, all stocks with R&D expenditures are ranked
by R&D expenditures relative to sales, and assigned to one of five equally sized portfolios. The
sample includes all NYSE, AMEX, and Nasdaq domestic primary issues with coverage on the
CRSP and COMPUSTAT files. Within each of the five portfolios, stocks are further ranked by
their compound rates of return over the prior three years and subdivided into two equally sized
groups. The table reports each portfolio's average excess return over each of the first three
years following portfolio formation, and over all three postformation years. In measuring excess
returns, each stock is matched with a control portfolio of stocks based on size and book-to-
market and then past three-year return. The difference is calculated between the stock's annual
buy-and-hold return and the return on the control portfolio.

Classification by		Excess Return in Year after Portfolio Formation			Average Excess Return over 3 Post-formation Years
R&D relative to Sales	Past 3-year Return	First Year	Second Year	Third Year	
1 (Low)	1 (Low)	0.0085	−0.0120	−0.0172	−0.0069
	2 (High)	−0.0164	−0.0180	−0.0081	−0.0142
2	1	0.0282	0.0178	0.0028	−0.0069
	2	−0.0004	−0.0065	0.0029	−0.0014
3	1	0.0477	0.0173	0.0094	0.0248
	2	−0.0071	0.0172	0.0176	0.0092
4	1	0.0492	0.0357	0.0253	0.0368
	2	0.0177	0.0085	0.0106	0.0122
5 (High)	1 (Low)	0.0219	0.0482	0.0618	0.0440
	2 (High)	−0.0150	0.0120	0.0062	0.0010

drawn to technology stocks because they tend to look expensive under con-
ventional criteria. The upshot is that there may be potentially more severe
underpricing when R&D-intensive stocks experience poor performance.

Table V provides further evidence for the hypothesis that past losers who
are spending heavily on R&D tend to be undervalued. This table uses a
two-way sort to capture the influence of past return as well as R&D inten-
sity. Since we directly condition on past return, R&D intensity is measured
relative to sales. Within each of the portfolios sorted by R&D intensity, we
assign a stock to one of two equally sized groups, depending on its rate of
return over the three years prior to portfolio formation. Since previous re-
search suggests that past return helps to predict future return, each stock's
return is measured net of the return on a control portfolio matched on size,
book-to-market and, furthermore, past three-year return. Equally weighted
excess returns on each portfolio are reported in the table.

The two-way classification successfully teases out the firms that earn ex-
cess returns within each quintile by R&D relative to sales. The abnormal
performance is concentrated in stocks with relatively low past returns. No-
tably, past losers in the highest-ranked R&D portfolio earn an average re-

turn of 4.40 percent per year over the postformation period after controlling for size, book-to-market, and past return. The results suggest that any mispricing of R&D stocks is more likely to be associated with firms with poor past performance.

III. Additional Results

A. Alternative Risk Adjustment Procedures

It is possible that any excess returns earned by R&D-intensive stocks reflect risk differentials (beyond what is picked up by our control portfolio procedures). In this section, we check for this possibility by applying a variety of risk-adjustment procedures. The procedures include a version of the Fama and French (1993, 1996) multifactor model to adjust for risk sensitivities; Fama and MacBeth (1973) cross-sectional regressions that account for differences in firm characteristics; Sharpe ratios; and performance across up and down markets. Since the sort by R&D relative to market equity shows the strongest traces of abnormal performance, we focus on this measure of R&D intensity.

Stocks that are highly ranked by R&D to market equity generally have low past returns, so their subsequent returns may be confounded by the reversals generally experienced by past losers. Further, past returns over an intermediate horizon of less than a year may be another factor that predicts future returns (see Chan, Jegadeesh, and Lakonishok (1996)). To control for these effects, in addition to size and book-to-market, in Table VI we estimate time series regressions of the form

$$
\begin{aligned}
R_{pt} - R_{ft} = a_p + b_p[R_{Mt} - R_{ft}] + s_p SMB_t + h_p HML_t + w_p WML_t \\
+ d_p UMD_t + \epsilon_{pt}.
\end{aligned}
\tag{2}
$$

The model is estimated using monthly returns from each of the first three years following portfolio formation. Here $R_{pt} - R_{ft}$ is the monthly return on portfolio p in excess of the Treasury bill rate in month t, $R_{Mt} - R_{ft}$ is the excess return on the value-weighted market index, and SMB_t, HML_t are the returns on the Fama and French (1993) factor-mimicking portfolios for size and book-to-market, respectively. The factors WML_t and UMD_t pick up the effect of long-term and intermediate-term past returns (measured over nonoverlapping horizons), respectively. Each is the difference between the returns in month t on a portfolio of past winners and a portfolio of past losers. Past winners (losers) are defined to be the stocks ranked in the top (bottom) quintile by their past returns beginning five years ago and ending one year ago in the case of WML_t. For UMD_t, past winners and losers are defined by past return beginning seven months and ending one month ago.[20]

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[20] For details on the construction of WML_t and UMD_t, see Chan et al. (1998).

Table VI

**Factor Model Regressions for Monthly Returns (in Percent) on Portfolios Sorted
by R&D Relative to Market Equity**

At the end of April each year from 1975 to 1995, all stocks are ranked by R&D expenditure relative to market value of equity, and assigned to one of five equally sized portfolios. Stocks with no R&D expenditures are assigned to a separate portfolio. The sample includes all NYSE, AMEX, and Nasdaq domestic primary issues with coverage on the CRSP and COMPUSTAT files. Estimated coefficients, t-statistics, and adjusted R^2 are reported for the model:

$$R_{pt} - R_{ft} = a_p + b_p[R_{Mt} - R_{ft}] + s_p\,SMB_t + h_p\,HML_t + w_p\,WML_t + d_p\,UMD_t + \epsilon_{pt}.$$

where $R_{pt} - R_{ft}$ is the monthly return on portfolio p in excess of the Treasury bill rate in month t, $R_{Mt} - R_{ft}$ is the excess return on the value-weighted market index, SMB_t and HML_t are the returns on the Fama and French (1993) factor-mimicking portfolios for size and book-to-market, respectively. WML_t is the difference between the returns in month t on portfolios of past winners and losers, where winners (losers) are the top (bottom) quintile of stocks ranked by past return beginning 60 months and ending 12 months ago. UMD_t is the difference between returns on portfolios of past winners and losers, where winners (losers) are the top (bottom) quintile of stocks ranked by past return beginning seven months and ending one month ago. The model is estimated using monthly returns from each of the first three years following portfolio formation.

	Portfolio	a	t(a)	b	t(b)	s	t(s)	h	t(h)	w	t(w)	d	t(d)	R^2
First year after	1 (Low)	−0.14	−1.99	0.98	57.66	0.68	20.40	−0.09	−2.74	−0.03	−0.97	−0.02	−1.11	0.96
portfolio formation	2	0.05	0.71	0.96	53.87	0.74	21.09	−0.10	−2.89	−0.07	−2.36	−0.06	−2.52	0.96
	3	0.16	1.86	1.01	47.54	0.76	18.26	−0.10	−2.38	−0.08	−2.34	−0.09	−3.53	0.95
	4	0.26	2.91	1.02	46.51	0.81	18.93	−0.11	−2.53	−0.18	−5.13	−0.08	−2.76	0.95
	5 (High)	0.55	4.44	1.04	34.15	0.96	16.08	−0.10	−1.70	−0.32	−6.63	−0.10	−2.73	0.92
Second year after	1	−0.10	−1.51	0.96	58.86	0.61	19.85	−0.07	−2.25	−0.07	−2.68	−0.07	−3.83	0.97
portfolio formation	2	0.04	0.62	0.95	52.43	0.75	22.08	−0.06	−1.88	−0.04	−1.61	−0.09	−4.15	0.96
	3	0.21	2.58	1.00	48.47	0.71	18.37	−0.09	−2.28	−0.11	−3.49	−0.09	−3.49	0.95
	4	0.39	4.02	1.00	40.92	0.79	17.21	−0.16	−3.49	−0.15	−4.15	−0.10	−3.39	0.94
	5	0.52	4.45	1.02	34.61	0.93	16.80	−0.16	−2.91	−0.30	−6.75	−0.05	−1.44	0.93
Third year after	1 (Low)	−0.04	−0.52	0.93	49.70	0.62	17.72	−0.05	−1.32	−0.07	−2.30	−0.07	−2.99	0.96
portfolio formation	2	0.04	0.54	0.95	46.15	0.66	17.08	−0.01	−0.28	−0.06	−1.82	−0.07	−2.80	0.95
	3	0.26	3.09	0.97	45.28	0.63	15.72	−0.14	−3.46	−0.15	−4.69	−0.10	−3.72	0.95
	4	0.19	2.08	1.02	43.77	0.79	18.14	−0.10	−2.26	−0.14	−3.96	−0.18	−3.18	0.95
	5 (High)	0.53	4.61	1.01	34.83	0.89	16.37	−0.23	−4.17	−0.29	−6.43	−0.00	−0.13	0.93

The factor model (2) also helps to remedy one drawback to excess returns based on control portfolios matched by size and book-to-market ratio. In particular, the matching procedure for control portfolios relies on measured book values that do not include the value of intangible assets, or alternatively requires assumptions about the amortization rate for R&D. Additionally, if technology stocks always behave like growth stocks regardless of their book-to-market ratios, the adjustment based on matching portfolios may be misleading.

The evidence in Daniel and Titman (1997) suggests an alternative to using factor loadings as a stock's risk exposures. In particular, firm characteristics such as size, book-to-market, and past returns may yield better risk measures. To implement this approach, we estimate annual cross-sectional regressions of stock returns on firm size (in logarithms), adjusted book-to-market ratio, R&D intensity relative to market, and past returns. The estimated coefficients are then averaged over time. The results from the factor model and the model using firm attributes turn out to be qualitatively similar; so, for the sake of brevity, we concentrate on the factor model adjustment.

Given their poor past performance, stocks with high R&D relative to market tend to have comparatively large negative loadings on *WML* and, in the first year, on *UMD* in Table VI. Even after controlling for the five factors, there are notable differences in alphas across the quintile portfolios. In particular, the alpha for the top quintile portfolio is large and statistically significant in each of the three postformation years. Over the first postformation year, the excess performance for the top quintile is 0.55 percent per month.[21] The spread between the extreme quintiles' alphas is 0.69 percent per month in the first year (or an annualized spread of 8.28 percent). The spread continues to be large in the second and third postformation years as well (they are 7.44 percent and 6.84 percent per year, respectively).[22] To sum up, our earlier findings are not sensitive to how we adjust for size and book-to-market effects. Further, the abnormal performance of stocks with high R&D to market is not solely driven by return reversals associated with past losers.

Other measures of risk-adjusted performance also suggest that the large returns on the portfolio with high R&D intensity relative to market are not entirely due to risk. The Sharpe ratio of the top quintile portfolio, for example, is 0.85 (based on annual returns over the first postformation year). The corresponding Sharpe ratio for the market index is 0.53. If risk is measured as potential losses during down markets, the top quintile portfolio is also not

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[21] In comparison, the alpha for R&D quintile portfolio 4 is lower. Note, however, that in the top quintile portfolio R&D spending as a fraction of market value is much higher than in the other groups, averaging 16.55 percent (see Panel D of Table IV).

[22] It might be argued that abnormal performance shows up because the factor model does a poor job of describing the returns on stocks making up the top quintile portfolio based on R&D to market. However, Fama and French (1996) find no evidence of abnormal performance from a three-factor model applied to small stocks with high book-to-market ratios, or to extreme past losers. Hence, it is not likely that the alphas in Table VI reflect a misspecified factor model.

very risky. For example, across all down-market months (where the return on the market is below the Treasury bill rate) the average return on the top quintile portfolio over the Treasury bill rate is −2.60 percent per month. The corresponding average for the market index is −3.25 percent per month. In up markets, the average return over the T-bill rate is 5.32 percent and 3.28 percent per month for the top quintile portfolio and the market, respectively.[23]

B. Advertising and Stock Returns

Although the promise of technological breakthroughs has pushed R&D capital into the limelight, there are other forms of intangible capital as well. In this subsection, we provide an exploratory analysis of another common form of investment in intangible capital, namely, advertising. Like research and development spending, advertising expenditures have some elements of long-term investment (although the effective lifetime of advertising expenditures may be comparatively shorter). Advertising expenditures are also expensed. Empirically, advertising represents a smaller component of aggregate sales or earnings compared to R&D. Advertising makes up about 0.9 percent of total 1995 sales of all firms, whereas R&D accounts for almost twice as much (1.7 percent). Our objective here is to see if the patterns uncovered in our analysis of R&D extend to advertising.

Table VII provides results for portfolios sorted by advertising expenditures relative to market value of equity.[24] The number of firms that do advertising is roughly the same as those doing R&D (about 1,200 firms on average each year report nonzero expense for either advertising or R&D). For the firms engaged in advertising, their average return over the three postformation years (20.46 percent) is slightly higher than that of firms without advertising (18.95 percent). The difference may reflect the fact that firms who do advertising tend to be concentrated in certain industries.[25]

The results for advertising expenditures relative to market essentially agree with our findings for R&D relative to market. For example, over the three years following portfolio formation, the firms in quintile portfolio 5 have an average excess return of 3.10 percent per year. Advertising-intensive firms with poor past performance also face strong pressures to cut costs. When such firms keep investing in their franchise value through advertising despite these pressures, they are more likely to represent cases of relative undervaluation. Nonetheless, these cases are overlooked by the market.

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[23] Our analysis controls for all the sources of risk that have been uncovered in the empirical literature, using a variety of methodologies. There is always a possibility, however, that some (yet to be identified) source of risk has been omitted. As a consequence, the persistence of excess returns may be an indication of misspecification of the asset pricing models.

[24] As is the case with R&D relative to sales, the sort by advertising to sales does not produce notable differences in future returns across portfolios. Accordingly, for the sake of brevity, these results are omitted.

[25] Compared to the set of firms doing R&D, the firms engaged in advertising, for example, include a larger number of financial institutions, securities firms, media and broadcasting companies, and firms in consumer goods industries.

Table VII
Returns and Characteristics of Portfolios Classified by Advertising Expenditure Relative to Equity Market Value

At the end of April each year from 1975 to 1995, all stocks are ranked by their advertising expenditure relative to the market value of equity, and assigned to one of five equally sized portfolios. Stocks with no advertising expenditures are assigned to a separate portfolio. The sample includes all NYSE, AMEX, and Nasdaq domestic primary issues with coverage on the CRSP and COMPUSTAT files. In Panel A, each portfolio's average annual buy-and-hold return is reported over the five years prior to portfolio formation; over each year from one year to three years after portfolio formation; and averaged over the three postformation years. Panel B reports each portfolio's average return in excess of the equally weighted return on a control portfolio of stocks matched by firm size and book-to-market in the first through third postformation years. Panel C reports characteristics of the portfolios: the average number of component stocks; the ratios of advertising expenditures to market value of equity and to sales; book value of equity relative to market value of equity; sales relative to market value of equity; earnings relative to market value of equity; annual dividends divided by market value of equity; and the natural logarithm of market value of equity in millions of dollars.

	1(Low)	2	3	4	5(High)	Nonadvertising
Panel A: Returns Before and After Portfolio Formation						
Average annual return over 5-year period before portfolio formation	0.3146	0.2286	0.1978	0.1769	0.1402	0.1981
First year after portfolio formation	0.1651	0.1958	0.2179	0.2246	0.2276	0.1946
Second year after portfolio formation	0.1491	0.1945	0.2113	0.2045	0.2321	0.1886
Third year after portfolio formation	0.1648	0.1972	0.2189	0.2196	0.2491	0.1854
Average annual return over 3-year period after portfolio formation	0.1597	0.1958	0.2160	0.2162	0.2363	0.1895
Panel B: Excess Returns after Portfolio Formation						
First year after portfolio formation	−0.0103	0.0037	0.0215	0.0266	0.0187	−0.0028
Second year after portfolio formation	−0.0085	0.0168	0.0272	0.0150	0.0295	0.0036
Third year after portfolio formation	0.0042	0.0189	0.0325	0.0264	0.0447	0.0000
Average annual excess return over 3-year period after portfolio formation	−0.0049	0.0131	0.0271	0.0227	0.0310	0.0003
Panel C: Characteristics of Portfolios						
Average number of firms	231.6	231.7	232.0	232.2	232.3	1887.7
Advertising to sales	0.0162	0.0181	0.0252	0.0342	0.0666	0.0000
Advertising to market value	0.0049	0.0159	0.0341	0.0707	0.2011	0.0000
Book-to-market	0.4723	0.6429	0.7804	0.9191	1.1760	0.8757
Sales-to-market	1.0028	1.5605	2.1899	3.1984	4.9396	2.5053
Earnings-to-price	0.0414	0.0629	0.0659	0.0715	0.0731	0.0758
Dividend yield	0.0096	0.0152	0.0190	0.0219	0.0231	0.0261
Log size	4.5883	4.5264	4.5185	4.4813	3.8427	4.5434

IV. R&D and Return Volatility

Our results suggest that, on average, a firm that does R&D earns a rate of return that is no different from a firm without R&D. Nonetheless, R&D may have effects on firms' financial performance beyond average stock returns. Although there are other sources of information about R&D activity beyond firms' financial statements, the lack of accounting disclosure suggests that investors may not be fully informed about this vital activity. One

consequence may be a high degree of uncertainty surrounding an R&D-intensive firm's future prospects. As a result, the volatility of returns may rise with R&D spending, thereby imposing real costs on investors and possibly affecting the cost of capital for R&D-intensive firms.

The empirical issue is whether there is any association between R&D and return volatility. Higher volatility may be a consequence of the nature of the business in technology-based industries (where R&D spending is mainly concentrated). In addition, many R&D-intensive firms tend to be smaller and younger firms, so there may be an association on this account. Accordingly, we estimate a cross-sectional regression of the form

$$\sigma_{it} = \gamma_{0t} + \gamma_{1t} LNSIZE_{it} + \gamma_{2t} LNAGE_{it} + \gamma_{3t} RDS_{it} + \sum_{j=1}^{L} \phi_{jt} IND_{ijt} + \epsilon_{it} \quad (3)$$

at the end of April each year over the sample period, using all available stocks (doing R&D or not). The regression relates each stock's return volatility σ_{it} (the standard deviation of monthly returns based on the subsequent 12 months) to the following variables: the firm's stock market capitalization (in logarithms), $LNSIZE_{it}$; the firm's age (in logarithms), $LNAGE_{it}$; as well as its R&D intensity relative to sales, RDS_{it}. To capture volatility associated with business conditions in the technology sector, the regression also includes dummy variables for industries IND_{ijt}. The industry classifications are based on two-digit SIC codes and, specifically, include the technology industries considered in Table II (some of which are based on three-digit SIC codes). Then we average the estimated coefficients from the cross-sectional regressions over all portfolio-formation years and use the time series standard deviation of the coefficients to calculate t-statistics.

The average coefficient for R&D intensity is 0.0963 with a t-statistic of 6.49. The stocks ranked in the top quintile by R&D relative to sales have an average R&D intensity of about 23 percent (see Table III). Compared to firms with no R&D, therefore, the regression model predicts that monthly return volatility for highly R&D-intensive companies is larger by about 2.21 percent, everything else being equal. Since the average monthly volatility of returns for companies with R&D is about 13 percent, the impact of R&D intensity is economically important. The coefficients for the other variables in equation (3) generally conform to intuition. In short, insofar as the limited disclosure of R&D contributes to higher return volatility, there may be a cost associated with the present accounting treatment of R&D.

V. Summary and Conclusions

In modern economies many firms have large amounts of intangible assets such as investments in R&D. Under generally accepted accounting principles in the United States, however, such intangibles are generally not recorded on financial statements. Since R&D spending is treated as a current

expense, there can be potentially large effects on many firms' financial statements. This paper addresses the question of whether stock prices appropriately incorporate the value of firms' R&D investments.

The high level of spending on R&D suggests that large distortions can arise from expensing rather than capitalizing R&D costs. If investors fail to adjust standard valuation measures such as price-to-earnings or price-to-book ratios for the long-term benefits of R&D, potentially severe mispricing can arise.

Our evidence does not support a direct link between R&D spending and future stock returns. In the three-year period following portfolio formation, stocks doing R&D have an average return of 19.65 percent per year, and stocks doing no R&D have an average return of 19.50 percent. Thus it does not appear that, historically, a highly touted technology stock on average outperformed a more mundane cement company. This finding is consistent with the hypothesis that the stock price incorporates investors' unbiased beliefs about the value of R&D.

For firms engaged in R&D, the evidence on an association between R&D intensity measured relative to sales and future returns is not strong. The clearest evidence that high R&D plays a distinctive role arises from stocks with high R&D relative to the market value of equity. Their average excess return over the following three years is 6.12 percent per year. Stocks ranked highly by R&D relative to market equity generally tend to be past losers. Firms that spend heavily on R&D despite poor past performance and pressures to cut costs represent instances where managers are relatively optimistic about the firms' future prospects. However, the market tends to discount this information and appears to be sluggish in revising its expectations. Our findings are not sensitive to how returns are adjusted for effects due to size, book-to-market, and return reversal effects. Further, we obtain similar results for spending on another type of intangible asset, advertising.

Although the historical record reveals little difference between the average stock price performance of R&D stocks and stocks with no R&D, this may not be the end of the story. We provide evidence that R&D intensity is associated with return volatility, after controlling for firm size, age, and industry effects. Even if market prices on average incorporate the future benefits from R&D, the lack of accounting information on such an important intangible asset may impose real costs on investors through increased volatility.

Appendix: Growth Rates of Portfolio Earnings

This Appendix describes how we construct measures of operating performance for a portfolio. In the text, we report returns based on a buy-and-hold strategy, where the composition of the portfolio is revised each year. In parallel with this strategy, we calculate growth rates in portfolio earnings, based on the ideas in Givoly and Lakonishok (1993), as well as Ikenberry and Lakonishok (1993). The procedure is as follows (see also the description in Chan, Karceski, and Lakonishok (2000)). In year t, we select stocks for a

portfolio and we track the earnings on this portfolio from years $t - 5$ to $t + 5$. In the base year $t - 5$ we invest one dollar in each of the selected stocks. For the ith firm in the base year, we are entitled to the proportion $1/V_{i,t-5}$ of its earnings, where $V_{i,t-5}$ is the market value of firm i's equity in year $t - 5$ and $E_{i,t-5}$ is its total earnings available to common shareholders that year. Accordingly, the base level (at year $t - 5$) of portfolio p's earnings, $e_{p,t-5}$, per dollar invested, is given by

$$e_{p,t-5} = \frac{1}{N_{t-5}} \sum_{i=1}^{N_{t-5}} \frac{E_{i,t-5}}{V_{i,t-5}} \tag{A1}$$

where N_{t-5} is the number of firms in the portfolio available for investment.

In each subsequent year τ, where $t - 5 < \tau \le t + 5$, the earnings on the buy-and-hold portfolio, per dollar originally invested in the base period, is given by

$$e_{p,\tau} = \frac{1}{N_{t-5}} \sum_{i=1}^{N_\tau} \frac{\prod_{l=5}^{t-\tau+1} (1 + r_i[t - l, t - l + 1]) E_{i,\tau}}{V_{i,\tau}}. \tag{A2}$$

The amount held in stock i in year τ is given by its compound return $\prod_{l=5}^{t-\tau+1}(1 + r_i[t - l, t - l + 1])$ from the base year to the given year, where $r_i[t - l, t - l + 1]$ is the return on the stock between years $t - l$ and $t - l + 1$. For each year τ relative to the portfolio formation year, this procedure gives a time series of annual portfolio earnings per dollar originally invested. Finally, we average each time series to yield 11 average values for portfolio earnings; these serve as the inputs for calculating the geometric average growth rates over the years preceding and following portfolio formation. These directly measure the operating performance of portfolios obtained from a buy-and-hold strategy and hence correspond to the returns reported in the text. Additionally the earnings for the portfolio as a whole are much less likely to be negative or very low in any given year.

Since firms entering a portfolio in a formation year t are not required to exist through the entire period from years $t - 5$ to $t + 5$, one further modification to the above procedure is necessary. As new firms enter the portfolio in year τ leading up to the formation year $(t - 5 < \tau \le t)$, the total amount held in the portfolio $\sum_{i=1}^{N_\tau} \prod_{l=5}^{t-\tau+1}(1 + r_i[t - l, t - l + 1])$ is equally divided across the new number of stocks. Thereafter the dollar value held in each stock is calculated based on this revised amount. Similarly, as a stock drops out of the portfolio in year τ following the portfolio formation year $(t < \tau \le t + 5)$, we liquidate the position in the stock and equally prorate the proceeds across the remaining stocks. The subsequent value of each holding is compounded from this revised amount.

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