Analyseinstitut for Forskning

The Effect of R&D Expenditures on Stock Market Returns for Danish Firms

Carter Bloch

The Danish Institute for Studies in
Research and Research Policy
Finlandsgade 4
DK-8200 Aarhus N
www.afsk.au.dk

Working papers 2003/6
Analyseinstitut for Forskning
ISSN 1399-8897

The Effect of R&D Expenditures on Stock Market Returns for Danish Firms

Carter Bloch[*]

December 8, 2003

Abstract
This paper examines how stock prices are affected by research and development activities for Danish firms for the period, 1989 to 2002. Both through analysis of portfolios and regression analysis, the role of R&D assets is considered along with a number of other fundamental factors, such as size, the book to market ratio, leverage and the CAPM beta. There is at best a weak indication that R&D intensity has an effect on stock returns on its own – average returns for R&D intensive firms are slightly higher than those with no R&D. However, R&D intensity seems to have strong effects on stock market returns when controlling for other factors. For example, among firms with high book to market ratios (a possible sign of under pricing), R&D intensive firms tend to generate higher future returns. And while some indications of risk compensation are found for other factors, such as leverage, these are not found for R&D effects. In addition, the ratio of R&D assets to market value is explored as a potential financial indicator of undervaluation for R&D intensive firms.

[*]Comments from Ebbe Graversen, Michael Mark and seminar participants at the Danish Institute for Studies in Research and Research Policy are gratefully acknowledged.
Address: The Danish Institute for Studies in Research and Research Policy, Finlandsgade 4, DK-8200 Aarhus N., Tel.: (45) 8942 2398, Fax: (45) 8942 2399, Email: cbl@afsk.au.dk

1. Introduction

This paper examines the stock market valuation of research and development expenditures for listed, non-financial firms in Denmark. The main questions considered here are whether stock prices fully reflect the value of R&D investments and how stock prices behave for R&D intensive firms. The assessment of R&D is problematic for two main reasons. First, there may be little information on the nature of firms' R&D expenses, and what they encompass. Furthermore, in Denmark as in a number of other countries in Europe, reporting R&D expenses is not compulsory. Hence, it may not be the case that all firms' R&D expenditures are included in their financial statements. Second, by far the majority of R&D expenditures are deducted as current expenses. Given that the benefits, or returns to R&D, may be longer lived or may not materialize until later on, these expenditures may be more appropriately treated as capital expenditures. This implies that conventional indicators, such as the price-earnings ratio and the book-to-market ratio, may be somewhat misstated.

A general view is that R&D intensive firms may be 'under priced', yielding abnormally high returns. Arguments for this are that mechanical investment strategies based on conventional indicators will lead to under pricing (see e.g. Chan et. al. (2001)). Additionally, if investors are myopic (Hall and Hall (1993)) they may undervalue longer-term investments such as R&D. Instead, higher returns for R&D intensive firms may reflect greater risk, due to the uncertainty surrounding R&D expenses (see Lev and Sougiannis (1999)). Here, a lack of information on R&D activities can contribute to investors' uncertainty on future performance for R&D intensive firms. An alternative view, especially in recent years, is that 'irrational exuberance' has lead to an over optimism both with respect to potential returns to R&D and on their chances of success leading to overpricing (see e.g. Chan et. al. (2001)).

The increase in the importance of technology-based companies and other R&D intensive firms on stock market indices makes questions on the stock market valuation of R&D of great interest. This is especially the case in Denmark where R&D intensive firms, particularly those in the medical and biotech industries, have assumed an increasingly large presence on the Copenhagen Stock Exchange.

This paper examines the stock price behavior of listed firms in Denmark for the period 1989 to 2002, focusing on the role of R&D expenditures. As a point of departure, it draws on analyses based on US data, in particular work by Fama and French, Lev and Sougiannis, and Chan, Lakonishok and Sougiannis. I investigate the role of R&D in affecting stock returns both through a detailed examination of stock price and earnings behavior in terms of a number of factors, among them, the book to market ratio, size, and R&D intensity, and through regression analysis along the lines of Fama and French (1992) and Lev and Sougiannis (1999).

Fama and French (1992) consider the effect of firms' size, book to market ratio, their leverage, CAPM beta, and earnings to price ratio on returns for US data, 1963-1990.

They find that both size and book to market have explanatory power, with size having a negative coefficient and the book to market ratio a positive effect.

Lev and Sougiannis (1999) perform the same regression using US data for 1975-1989, though with the addition of the ratio of R&D capital to the market value of equity. They find that in addition to size and book to market effects as in Fama and French (1992), R&D to market has a significant, positive effect on returns. Furthermore, when only highly R&D intensive firms are considered, they find that the R&D effect "subsumes" the book to market effect, i.e. the coefficient on the book to market ratio becomes insignificant.

A large amount of attention has been on the book to market effect – that stock market returns are increasing in firms' ratio of the book value to the market value of common equity (see e.g. Fama and French (1992), Lakonishok et. al. (1994), Lev and Sougiannis (1999)). Two explanations posed for this are 1) a risk premium – higher returns for stocks with high book to market ratios compensate for higher risk; and 2) mispricing – excess returns for stocks with high book to market ratios are due to a systematic under pricing of these stocks. This is a central question for any association found between factors and stock returns – is the association due to risk compensation or to systematic mispricing? – and one which I will also examine in this paper, in particular concerning R&D.

It is important in this respect to note that, unlike other factors examined here, the figures on R&D expenditures used in this analysis are not publicly available. The R&D data used in this analysis are obtained from a confidential survey of R&D activity for Danish firms[1]. While it may be the case that most R&D intensive firms include their R&D expenditures in their annual reports, this cannot be taken as given, nor is it necessarily the case that these figures are exactly the same as those reported in the survey. The implication in terms of questions of market efficiency is that excess returns can potentially be due to a lack of public information on R&D activities[2].

Fama and French (1992) and Lev and Sougiannis (1999) use a cross-sectional approach to regress monthly stock returns on a number of fundamental variables hypothesized to explain expected returns. They then calculate time series averages and t statistics from these cross sectional regressions. Instead of using this approach I utilize panel data estimation methods in the regression analysis.

Panel data estimation offers a number of advantages to the cross-sectional approach. First, by pooling all data, it allows for more efficient econometric estimates. Second,

---

[1] The survey is conducted by the Danish Institute for Studies in Research and Research Policy, covering all firms in Denmark with over 250 employees and a fraction of firms with under 250. See Danish Institute for Research Policy (2003).

[2] Along with the other possibilities of mispricing (based on the idea that we can at the very least assume that the market has a general idea of what firms spend on R&D) or risk compensation.

there is substantial variation in values of fundamental variables for individuals over time, with this 'within-firm' variation potentially being at least as important as cross-sectional differences between firms. The cross-sectional approach neglects this within-firm variation. Finally, different panel data estimation methods can potentially shed light on which forms of variation are most important in explaining returns, cross-sectional differences or within-firm fluctuations.

Additional related work is Chan et al. (2001). They examine whether stock prices fully reflect the value of firms' intangible assets, in particular R&D. They find that, on average, R&D intensive firms do not generate higher returns. However, when evaluating portfolios based on size and book to market ratios, they find that R&D intensive firms do in fact have higher returns.

Also, Bayer (2003) considers the stock market valuation of R&D for Danish firms, following Lev and Sougiannis (1999). The paper here extends his work, using a more comprehensive data set that includes two additional years of data and adding non-R&D firms to the analysis. The paper here also contains a more detailed portfolio analysis and investigation of the fundamental factors behind stock returns, and utilizes panel data estimation methods in the regression analysis as opposed to time series averages of cross sectional regressions.

The main results of the paper are the following:

- Panel data analysis using both fixed effects and random effects estimators produces a number of insights that are not obtainable using time series averages of cross-sectional regressions. For example, the data here indicate that much of the effects of fundamental factors on returns stem from within-firm variation over time. This variation is not captured in cross-sectional regressions.
- There is at best a weak indication that R&D intensity has an effect on stock returns on its own – average returns for R&D intensive firms are slightly higher than those with no R&D. However, R&D intensity seems to have strong effects on stock market returns when controlling for other factors. For example, among firms with high book to market ratios (a possible sign of under pricing), R&D intensive firms tend to generate higher future returns.
- There is greater indication that R&D to market is (positively) associated with future returns. R&D to market acts as a financial variable, providing an indicator of the value of the firm and its R&D assets.
- As in other work on the relation between fundamental factors and stock market returns, I find a strong 'size effect' - subsequent returns are decreasing in the market value of equity. However, the interpretation here seems less that large firms have lower risk premiums, and instead that firms that experience an increase in market value tend to have lower future returns.
- Additionally, I identify a book to market effect - subsequent returns are increasing in the ratio of book value to market value of common equity - and a

leverage effect - returns are increasing in the ratio of the book value of firm assets to common equity.

- To examine whether these effects are due to risk compensation or instead reflect mispricing, I consider performance over different economic states, and over the time period of the sample. While there is some evidence of risk compensation for market value and leverage, there is little evidence for R&D and book to market effects.

The remainder of the paper is organized in the following way. Section 2 contains an overview of the data sample used in this paper, including a brief look at R&D for the Copenhagen Stock Exchange (CSE) as a whole. Section 3 examines the association of a number of factors with stock market returns by constructing portfolios with respect to the book to market ratio and measures of R&D intensity. Section 4 contains an econometric analysis of the effects of fundamental factors on stock returns, and section 5 investigates whether the results reflect risk compensation or mispricing. Finally, section 6 concludes.

2. R&D data – an overview

2.1. The data

This analysis concerns firms listed on the Copenhagen Stock Exchange (CSE) for the period 1989 to 2002. The data stems from three sources. Data on R&D expenditures is based on data from the Danish Institute for Studies in Research and Research Policy's R&D database (see Danish Institute for Research Policy (2003)). The database contains R&D data for Danish firms over the period 1989 to 2001 (see the appendix for more details on the R&D data.). Annual account data is from the Account Database from the Copenhagen Business School. The Account Database contains data for all firms listed on the CSE. And, finally, stock price data for the period 1988 to 2003 (corrected for dividends and emissions) is obtained from the Danish Stock Database from the Center of Analytical Finance (CAF) at the Aarhus School of Business.

In order to allow for the estimation of the stock of R&D capital (which requires lagged values of R&D expenditures - see below), only firms that were listed as of 1992 or later were included. Additionally, all financial firms were excluded[3]. Finally, account data is not available from the Account Database for firms listed on the CSE but based in another country, and a number of firms were eliminated from the sample due to a lack of R&D data (see the appendix for the criteria used). In all, this gives a total of 170 firms with a total of 1551 years of annual account data.

Additionally, I follow Fama and French (1992) in assuming that the fiscal year coincides with the calendar year for all firms. While this is not actually the case for all firms, I make this assumption in order to use stock returns measured at the same point in time.

2.2. Measuring R&D capital

Far the majority of R&D expenditures are immediately expensed, making it necessary to construct a measure of the stock of R&D capital. A number of methods have been suggested for measuring the stock of R&D capital. Lev and Sougiannis (1996) and Bayer (2003) estimate the contribution of R&D spending to earnings. These estimates are then used to form estimates of depreciation rates for R&D, which can then be used to construct a measure of R&D capital. While this method is appealing in an economic sense, it requires estimations using a number of lagged values of R&D. This is somewhat problematic given the size of our sample, and also given that estimates are highly sensitive to minor changes in the specification of the estimation.

For this reason, I follow here the pragmatic and tractable approximation method of, among others, Chan et al. (2001). As in Chan et al. (2001), I assume that the

[3] Also not included in the sample are a number of sports teams that are listed on the CSE.

productivity of R&D spending declines linearly by 20 percent each year, so that the stock of R&D capital for a firm, RDC, is given by;

$$RDC_t = RD_t + 0.8 * RD_{t-1} + 0.6 * RD_{t-2} + 0.4 * RD_{t-3} + 0.2 * RD_{t-4}$$

where RD_i is the firm's R&D expenditures in period i.

An additional method that can be used to estimate R&D capital is the perpetual inventory model[4]. This approach has also been considered in order to see whether the results are affected by estimation method.

2.3. Stylized Facts

In order to provide some background for the analysis to follow, this section provides some details on R&D spending over the period under consideration here. The CSE consists of markets for bonds, equities, derivatives and investment funds in Denmark. Between 250 and 300 firms are listed on the stock market, with a total market capitalization of 738 billion DKK at end-2001, which is equivalent to about 55% of Denmark's GDP in 2001[5]. R&D expenditures among publicly traded firms in Denmark have increased steadily over the period, as Figure 1 indicates[6].

R&D among firms listed on the CSE amounts to a little under half of total private sector R&D in Denmark, which was 21.9 billion DKK in 2001 (see Danish Institute for Research Policy (2003))[7]. This reflects both increases in R&D among firms in general, and also changes in the make up of the stock exchange.

---

[4] I.e. assuming that $RDC_t = (1-\delta) * RDC_{t-1} + RD_t$ where δ is the rate of depreciation. See e.g. Hall (1992, 1993). Initial values for RDC are then estimated based on aggregate and sectoral R&D data.

[5] As a reference, the market capitalization of the NYSE (source: NYSE's web site) was slightly larger than US GDP in 2001 (GDP data is from OECD).

[6] The stylized facts shown here focus on the period, 1993-2001, since some firms that were delisted prior to 1993 have not been included in the sample. This might distort overall figures for 1989-1992.

[7] Note that Figure 1 includes both own and bought R&D. Thus, to the extent these firms bought research from each other, these numbers may be slightly overstated. Though, given that this figure serves only as an illustration, I have not attempted to correct for this.

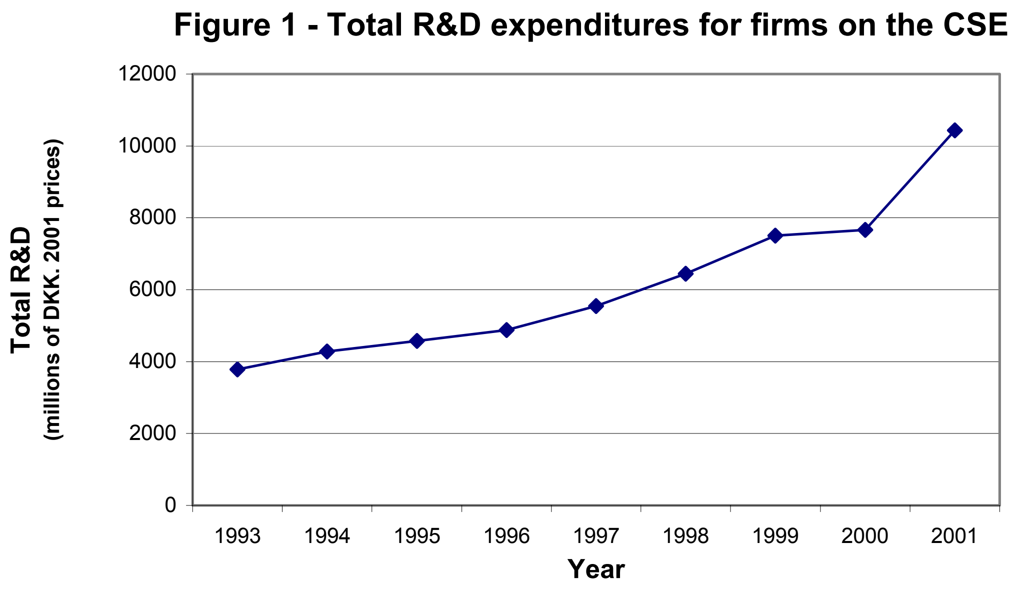
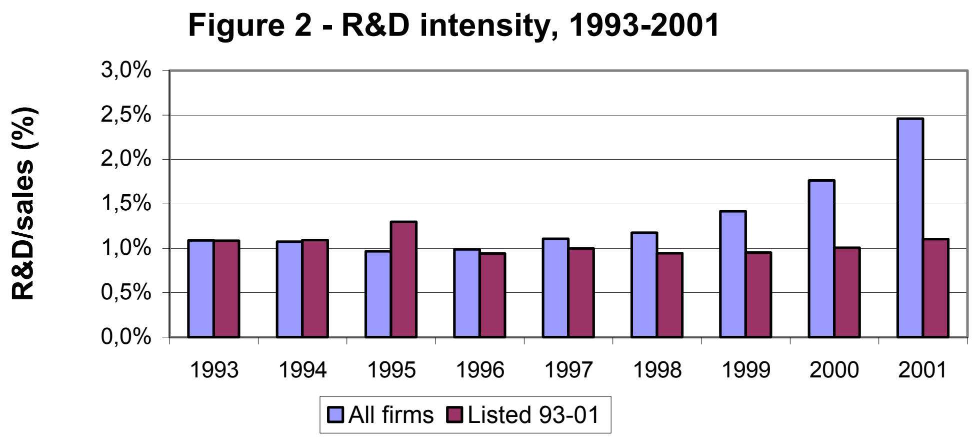


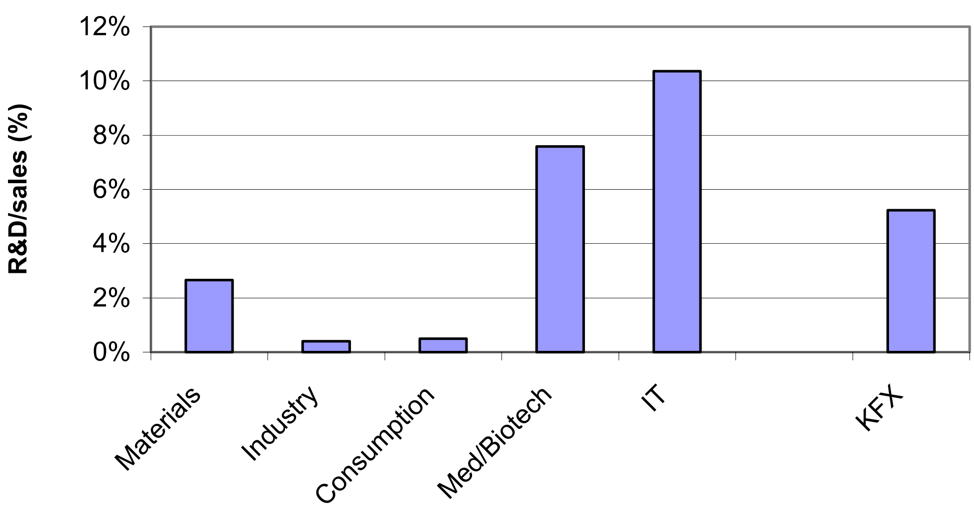
Figure 2 shows the change in R&D intensity from 1993 to 2001, measured as the ratio of R&D to sales, both overall and for firms listed over the whole period.



For firms listed over the entire period, R&D intensity is unchanged, with both sales and R&D doubling from 1993 to 2001. The entire increase in R&D intensity is then due to the introduction of new firms, mainly after 1997. In particular, there has been a large increase in the presence of firms from the Medical/Biotech and IT sectors over the period, from 12 firms in the two sectors in 1993 to 28 in 2001.

Reducing the classification down to five groups[8], Figure 3 shows R&D intensity by sector for 2001. Note also that the Danish blue chip index, the KFX index[9], is heavily populated with R&D intensive firms. Of the seventeen non-financial firms in the index at the end of 2001, four had R&D expenditures in excess of 10% of sales, and seven were among the top ten ranked firms in terms of R&D expenditures. In other words, and in contrast to, for example, the US, large firms on the CSE are in general also R&D intensive firms.

Figure 3 - R&D intensity by sector in 2001



[8] Where the CSE's own classification is used. The system was introduced in 2001, so the classification of firms delisted prior to 2001 was made by the author based on the classification of similar firms. Though, the classification has been reduced from seven to five non-financial groups. This is done due to the fact that some of the sectors have very few firms.

[9] The KFX is the CSE's leading share index. It was introduced in 1989 and includes the 20 largest firms (in terms of market value) among the 25 most actively traded shares. The index was initially revised every year and is now revised biannually.

3. Portfolio Analysis

In this section I examine the characteristics of the sample, both considering statistics for the sample as a whole and investigating the relation of the book-to-market (BM) ratio, size and R&D intensity to stock returns by forming a number of portfolios. Lev and Sougiannis (1999), in considering US data for 1972-1989, rank all observations in ten BM portfolios. Their portfolios suggest among other things: the book to market ratio is negatively correlated with size (market value, MV) and R&D intensity, and positively correlated with the earnings to price ratio and year ahead returns.

To examine the Danish data, Table 1 ranks the data here in eight book to market portfolios[10]. Panel A includes all observations (or firm years) while panel B includes firms (firm years) with positive R&D expenditures[11].

There are a number of things that can be noted from Table 1. First, there is a strong negative correlation between size and the book to market ratio - large firms tend to have low BM ratios. Second, the ratio of R&D to sales (RDS) seems to be negatively correlated with book to market, as Lev and Sougiannis (1999) also find using the ratio of R&D to firm assets, indicating that high R&D firms tend to have low BM ratios.

In contrast, the ratio of R&D to market value (RDM) is negatively correlated with book to market. This is despite the fact that R&D to sales and R&D to market are strongly (positively) correlated. While they do not point it out explicitly, this interesting pattern is also present in the US data examined by Chan et al. (2001)[12]. Note that these correlations between R&D intensity and the book to market ratio are also present when considering only firms with positive R&D, as shown in Panel B.

Third, it can be seen from Table 1 that there is a negative association between book to market and returns prior to and at the time of portfolio formation. However, BM is positively associated with returns after portfolio formation. In other words, the portfolios here suggest that there is a book to market effect also in Danish data. The pattern is even more pronounced for R&D firms in Panel B. Finally, annual returns for portfolios according to market value are included at the bottom of Table 1. This is in order to show two things: first that market value is positively associated with future returns; and second that despite this, large firms have had the highest average returns over the

---

[10] Portfolios here and below are formed in the following way. For each year, median values and other percentiles are calculated for firm observations, and each observation is assigned to a portfolio. Portfolios for a given year are of equal size, though the number of observations in each portfolio for the whole sample may differ due to differences in the number of firms present for each year. The time of portfolio formation for a given year of firm data is six months after the end of the calendar year (i.e. end June). For example, the annual return at the time of portfolio formation for 1992 is the return from end June 1992 to end June 1993.

[11] The same book to market ranges were used for both panel A and B.

[12] Lev and Sougiannis (1999) do not examine R&D to market ratios in their analysis of BM portfolios.

sample period. I will come back to this in the discussion of the results towards the end of the paper.

Table 1 - Characteristics of book to market portfolios

BM Portfolio	Low			**Panel A**				High
	1	2	3	4	5	6	7	8
No. obs.	178	186	183	189	180	186	183	188
Book to market	0.248	0.428	0.582	0.710	0.835	0.995	1.212	1.822
Size (million DKK)	9538	5211	2567	1804	671	604	562	376
Earnings/Price	0.062	0.077	0.090	0.118	0.103	0.111	0.089	0.090
Leverage	3.536	2.950	2.573	2.842	2.923	2.839	2.630	2.928
R&D to market	0.013	0.015	0.019	0.014	0.027	0.023	0.012	0.038
R&D to sales	0.051	0.031	0.027	0.009	0.012	0.010	0.005	0.007
Annual return	0.191	0.085	0.037	0.057	0.048	0.048	0.004	0.011
Annual return (+1)	0.026	0.026	0.005	0.025	0.062	0.089	0.065	0.131
Annual return (+2)	0.024	0.032	0.070	0.084	0.095	0.040	0.110	0.093
Earnings on book	0.283	0.215	0.165	0.191	0.131	0.114	0.056	0.005
Positive R&D only				**Panel B**				
No. obs.	119	114	107	109	90	90	68	55
R&D to market	0.020	0.024	0.033	0.025	0.054	0.047	0.033	0.132
R&D to sales	0.076	0.051	0.046	0.015	0.023	0.021	0.012	0.023
Annual return	0.197	0.089	0.001	0.084	0.061	0.028	-0.020	-0.062
Annual return (+1)	0.048	0.051	-0.023	0.028	0.044	0.061	0.051	0.170
Annual return (+2)	0.058	0.025	0.089	0.120	0.142	0.005	0.133	0.133
Earnings on book	0.286	0.232	0.170	0.171	0.091	0.138	0.028	-0.018
Memorandum:								
Market value portfolio	1	2	3	4	5	6	7	8
Size (million DKK)	36	95	176	298	521	1043	2088	16314
Annual return	-0.042	0.033	0.018	0.063	0.046	0.112	0.088	0.147
Annual return (+1)	0.113	0.054	0.073	0.013	0.035	0.038	0.046	0.060

Size is the firm's market value, MV, calculated as its stock price times the number of shares outstanding. MV is calculated at the time account information is assumed to become known; i.e. six months after fiscal year-end. *Book to market* (BM) is the ratio of the book value of common equity to market value of equity, where the market value is calculated based on the stock price at year-end (in contrast to the price used for the size variable, MV). *Leverage* (AB) is measured by the ratio of total assets to book value of common equity. The *Earnings to price* ratio (EM) is calculated as the ratio of positive earnings before extraordinary items to market value of equity at year-end. EM is set equal to zero when earnings are negative. *R&D to market* is the ratio of R&D expenditures to (year-end) market value of equity at year-end. *R&D to* sales is the ratio of R&D to sales. *Annual return (i)* is the annual return i years after portfolio formation. *Earnings on book*, EB, is the ratio of earnings to book equity (see the more detailed definition below).

In forming an initial (albeit incomplete) impression of this data, it seems somewhat difficult to imagine that the large turnaround in returns for high and low book to market firms can be fully attributed to changes in earnings (e.g. increases in expected future earnings for high BM firms). The data in Table 1 seems to suggest more that the turnaround in returns reflects a correction in valuations following overreaction to previous results. If anything, this pattern seems to be more pronounced for R&D firms. In considering annual returns in Panel B, the difference in returns between low and high BM firms is even greater than that for all firms.

Table 1 also indicates that low book to market values are associated with high earnings. Rational pricing theory implies that a firm's market value should reflect the present value of future dividends. Thus, a low book to market ratio should indicate strong and persistent profitability, or that the firm is expected to generate high earnings long into the future. This can be examined further for Danish data along the lines of Fama and French (1995).

Fama and French (1995) form portfolios based both on size and book to market, and examine the evolution of earnings and other factors. I follow Fama and French (1995) in examining Size/Book to market portfolios, and in measuring earnings by the ratio of earnings (before extraordinary items) to the book value of common equity in the previous period;

$$EB_t = \frac{\text{Earnings}_t}{\text{Book equity}_{t-1}}$$

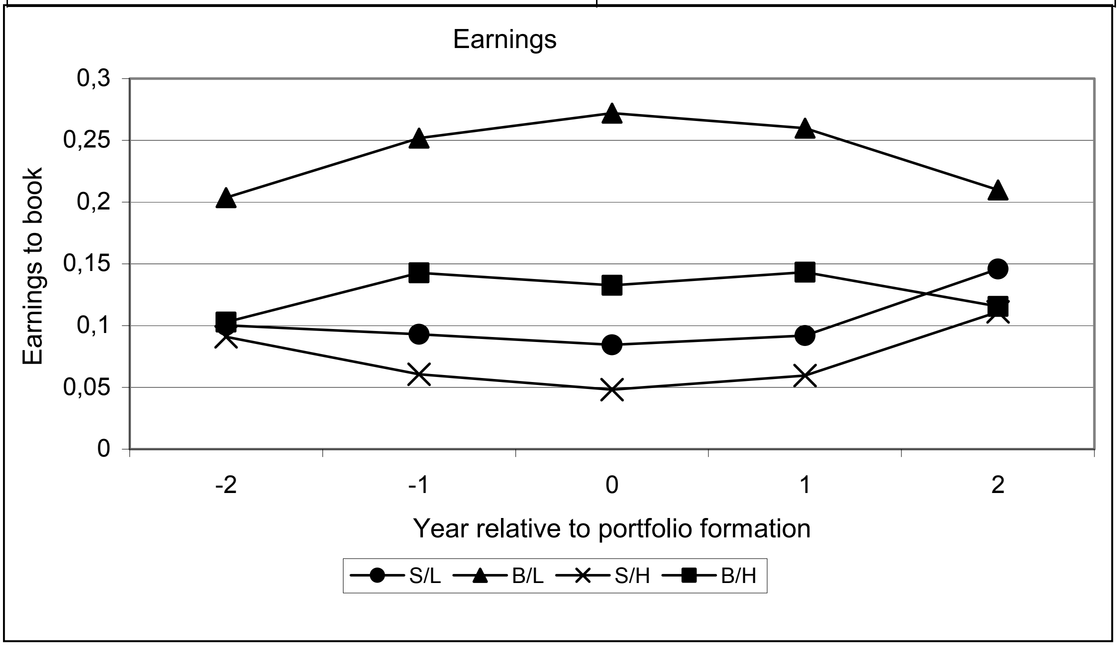
Given the size and time span of the data sample here, I form four Size/Book to market portfolios, and consider a 5 year evolution, from –2 to +2 years from portfolio formation[13]. Small (S) and Big (B) indicate whether market value is larger or smaller than the median size, and Low (L) and High (H) indicate whether book to market is below or above the median ratio. The statistics are shown in Table 2.

With respect to earnings, patterns can be seen both in relation to size and book to market. For a given book to market ratio, big firms have higher earnings than small firms, and large firms with low book to market have consistently the highest earnings. However, concerning small firms, the difference in earnings is not as substantial for high and low book to market firms. However returns are quite different for small firms: those with low book to market have high returns prior to portfolio formation and low returns afterward, while the opposite is the case for high BM firms.

[13] Fama and French (1995), for example, use 6 portfolios and examine an eleven-year evolution.

Table 2 - Evolution of earnings and returns for size/BM portfolios

		Annual returns				
Year relative to portfolio formation		-2	-1	0	1	2
Size - Book to market group	Small/Low	0.135	0.116	0.032	-0.005	0.068
	Big/Low	0.116	0.159	0.118	0.031	0.045
	Small/High	0.024	-0.019	0.014	0.093	0.094
	Big/High	0.030	-0.022	0.057	0.075	0.065



Using the ratio of R&D to the book value of firm assets, Lev and Sougiannis (1999) find a negative association of R&D intensity and book to market; R&D intensive firms generally have low book to market ratios. Following Lev and Sougiannis (1999), I divide the data here into portfolios based on both the book to market ratio and R&D intensity. There are five R&D rankings, one for no R&D and four for positive R&D, and 4 rankings for book to market. This gives 20 portfolios in all.

Panel A in Table 3 shows the average annual returns for each portfolio over the first two years after portfolio formation. Results are shown both for R&D to sales and R&D to market. While it must be noted that these portfolios do not contain a large number of observations[14], one can see a pattern both with respect to R&D intensity and with respect to book to market. For each R&D ranking, post returns are in general increasing in BM, and for each book to market ranking post returns are, with a few exceptions, increasing in R&D intensity.

[14] For positive R&D, i.e. R&D portfolios 1 to 4, each individual portfolio has 58 observations for the first BM portfolio, 54 for the second, 45 for the third and 31 observations for the final BM portfolio. The size of non-R&D portfolios ranges from 131 to 250 observations.

Table 3 - Book to market and R&D portfolios

Panel A

Average post returns

		Low		R&D to sales portfolio		High
BM portfolio		0	1	2	3	4
Low	1	-0.004	0.026	0.095	0.065	0.033
2		0.030	0.013	0.008	0.120	0.092
3		0.078	0.000	0.051	0.061	0.142
High	4	0.101	0.129	0.048	0.179	0.172

		Low		R&D to market portfolio		High
BM portfolio		0	1	2	3	4
Low	1	-0.005	0.020	0.067	0.038	0.108
2		0.031	0.028	-0.010	0.079	0.133
3		0.076	0.001	0.015	0.048	0.193
High	4	0.100	0.124	0.028	0.180	0.215

Panel B

			R&D to sales portfolio		
	0	1	2	3	4
R&D to sales	0.000	0.001	0.006	0.020	0.117
R&D to market	0.000	0.005	0.014	0.038	0.101
Annual return	0.060	0.017	0.055	0.104	0.071
Annual return (+1)	0.065	0.002	0.065	0.042	0.070
Annual return (-1)	0.053	0.022	0.061	0.145	0.049
Excess return (+1)	0.006	-0.054	0.011	0.016	0.020
Excess return (-1)	0.022	-0.027	-0.019	0.027	-0.046

Panel C

			R&D to market portfolio		
	0	1	2	3	4
Annual return	0.057	0.046	0.060	0.073	0.067
Annual return (+1)	0.063	0.000	0.009	0.005	0.164
Annual return (-1)	0.053	0.094	0.057	0.117	0.008
Excess return (+1)	0.005	-0.040	-0.031	-0.025	0.090
Excess return (-1)	0.022	-0.004	-0.018	0.019	-0.061

Panel A show averages for each Book to market/R&D to sales portfolio. *Average post* return is the average of annual returns for the firms two years after portfolio formation. Panel B shows statistics for portfolios based on R&D to sales only. *R&D to market* is the ratio of R&D expenditures to (year-end) market value of equity at year-end. *R&D to* sales is the ratio of R&D to sales. *Annual return (i)* is the annual return i years after portfolio formation. *Excess return* is calculated as the difference between a firm's return and the average return in portfolios based on size and book to market. Panel C shows statistics for R&D to market portfolios.

Panel B of Table 3 shows a number of statistics for each R&D to sales portfolio. Annual returns are similar before and after portfolio formation. Returns for R&D intensive firms (portfolios 3 and 4) are slightly higher, though the difference is not great, in particular given the size of the sample and large variation in returns. Thus, it does not seem that R&D intensity on its own has much of an effect, if any, on returns. With respect to the other fundamental factors, note the somewhat surprising result that non-R&D firms are in general much smaller than those that engage in R&D. This is a further indication of the strong presence that R&D intensive sectors have on the CSE.

In calculating 'excess returns', I control for size and book to market effects, following the approach by Chan et al. (2001). The motivation for doing this is the recognition that size and book to market are often found to have an effect on subsequent returns. All observations are divided up into 4 x 4 = 16 portfolios according to size and book to market. Excess returns are then calculated as the difference between each individual return and the average for its size/book to market portfolio. After controlling for size and book to market, R&D intensive firms generate excess returns of two percentage points in the year after portfolio formation, while excess returns are negative in the year before.

Noting the difference for R&D to market and R&D to sales in terms of correlation with book to market, Panel C shows statistics for portfolios formed according to R&D to market. Considering R&D to market portfolios, it can be seen that while there is no clear pattern for returns at the time of portfolio formation, subsequent returns are noticeably large for firms with high R&D to market. In addition, Panel C shows large excess returns in the year after portfolio formation and equally large negative returns beforehand for high R&D to market firms, after controlling for size and book to market.

These results for R&D to sales and R&D to market are qualitatively similar to those found in Chan et al. (2001) for US data. Additionally, Chan et al. (2001) find that excess post returns for high R&D to market firms are concentrated among those with low past returns ("past losers"). This is somewhat similar to the findings here that firms with high R&D to market and high book to market tend to have the highest returns. These firms both have high R&D intensity and low valuation, likely due to poor past performance[15]. This could either be due to increases in perceived risk or simply to undervaluation. Here a lack of information on R&D activities may potentially play a role, by increasing investors' uncertainty about firms' future performance.

Table 3 also shows that while book to market and R&D to market are both positively associated with post returns, this association is still present after controlling for the other factor. Furthermore, firms with a high R&D to market ratio on average have

[15] Note the low annual returns for high R&D to market firm (portfolio 4) in the year prior to portfolio formation.

generated large excess returns. And, as we will see later, these positive excess returns are present for almost every year in the sample period.

In addition to examining the data in terms of various portfolios, the data sample can be considered as a whole. Table 4 concerns average values of a number of factors for firms over the course of the sample period. Panel A shows the sample means and standard deviations for the sample. There is large variation in average levels of market value, book to market, and leverage[16]. It seems, just as some firms can be called large or small, firms can also be categorized as having a high or low book to market ratio, or high or low leverage, etc.

Table 4 - Descriptive statistics for the sample

	Book to market	Size	Leverage	R&D to market	R&D to sales	R&D capital to sales
Panel A - All firms						
Sample means	0,863	2,640	2,913	0,020	0,012	0,033
Standard deviations	0,578	9,878	4,014	*	*	*
Avg. of (firm std.dev./firm mean)	0,412	0,462	0,255	*	*	*
Panel B - R&D to Market > 0.01						
Sample means	0,708	3,038	3,248	0,062	0,039	0,104
Standard deviations	0,483	11,278	7,100	0,111	0,044	0,109
Avg. of (firm std.dev./firm mean)	0,453	0,521	0,271	0,642	0,361	0,271

Sample mean and standard deviation are calculated as the average value and standard deviation of firm year observations for the whole sample. For std.dev./mean, the ratio of the standard deviation to mean values are calculated for each firm, and then the mean is taken of these ratios.

However, it is also the case that within-firm variation in these values is also large – size, book to market, etc. vary substantially over time for an individual firm. In order to gain an idea of this, consider the ratio of standard deviations to mean values for individual firms. The higher this ratio, the greater these values vary over time. This ratio is calculated for each firm and then sample averages of these firm ratios are found. On average, standard deviations of book to market and size are over 40% of mean values for individual firms. The ratio for leverage is lower, though still significant.

Panel B gives these ratios for firms with average R&D to market greater than 0.01, along with ratios for measures of R&D intensity. The figures here indicate a large amount of fluctuation within–firm variation in R&D intensity, in particular for R&D to

[16] Standard deviation is not calculated for R&D intensity in Panel A since a number of firms in the full sample have no R&D.

market. The main point that can be drawn from these statistics is that within-firm variation in these values is large, making it important to include this variation in an analysis of the effects of these factors on subsequent returns.

Here I can sum up the main results of this section. When forming portfolios in terms of firms' book to market ratio (or market value) a pattern emerges in that low BM firms tend to have high returns up to the time of portfolio formation and low returns thereafter. When considering R&D to sales on its own, there is at best a weak association with returns. However, when R&D portfolios are further divided up in terms of their book to market ratios, subsequent returns are increasing in both R&D to sales and book to market. If R&D to market is considered instead, then subsequent returns are increasing in R&D to market, with large excess returns for firms with high R&D to market. I interpret R&D to market as a financial variable much in the same way as book to market. R&D to market seems to function as an indicator of the valuation of R&D intensive firms. High R&D to market, in particular relative to R&D to sales, may give an indication that the firm is undervalued.

4. Regression Analysis

To gain greater insight into the association of these factors and returns, this section contains econometric analyses of effects on both monthly and annual returns. Fama and French (1992) and Lev and Sougiannis (1999) regress monthly stock returns on a number of fundamental variables hypothesized to explain expected returns. For each year of data, 24 cross sectional regressions are run using 24 subsequent monthly stock returns for each firm year, starting seven months after the fiscal year-end and ending two years later. This then gives a number of cross-sectional regressions equal to 24 times the number of years of account data. In determining the overall coefficient estimates, they then calculate time series averages and t statistics from these cross sectional regressions.

In the analysis here I will utilize a similar equation to that in Lev and Sougiannis(1999):

$$R_{i,t+j} = b_0 + b_1 Beta_{i,t} + b_2 lnMV_{i,t} + b_3 lnBM_{i,t} + b_4 lnAB_{i,t} + b_5 EM_{i,t} + b_6 EM\_dummy_{i,t} + b_7 lnRDCS_{i,t} + e_{i,t}; \quad i = 1..N; \; t = 1..T; \; j = 7..18$$

$R_{i,t+j}$ is monthly stock returns for firm i, starting with seven months after the end of year t and continuing for twelve months. Beta is the CAPM based beta which, following standard methods, are estimated from 60 monthly stock returns prior to a given return[17]. MV is the firm's market value, calculated as its stock price times the number of shares outstanding. BM is the ratio of the book value of common equity to market value of equity. AB is the ratio of total assets to book value of common equity. EM is the earnings to price ratio, calculated as the ratio of positive earnings before extraordinary items to market value of equity. EM is set equal to zero when earnings are negative. The EM dummy is set equal to zero when earnings are positive and equal to one when they are negative. RDCS is the ratio of R&D capital (calculated as described above) to firm sales[18]. MV is calculated at the time of portfolio formation (i.e. end of June, six months after fiscal year-end), while all other variables are calculated at fiscal year-end (i.e. end of December).

Beta is a measure of risk, based on the Capital Asset Pricing Model (CAPM). Since higher beta means greater risk, the CAPM implies that returns should be increasing in beta. The CAPM beta has been the subject of considerable scrutiny over the years, and in general has not been found to have great explanatory power.

---

[17] Standard procedure requires at least 24 months of data. Since the CAPM beta is not the focus of the analysis, there is a reluctance to sacrifice additional observations in estimating beta. For this reason, in a few cases, estimates are also included where less than 24 months of data was available.

[18] Both the ratio of R&D capital to sales and to market value are considered below, along with measures in terms of R&D expenditures.

Size and the book to market ratio are factors that have often been found to have explanatory power in terms of stock returns. While explanations for beta are grounded in theory, size and book to market effects stem mainly from empirical investigations, and there is little consensus on why they affect returns or what they proxy. Though, the conventional explanation is that low size and high book to market proxy risk factors (see Fama and French (1992,1993,1995).

Leverage is meant to capture the risk associated with the amount of debt a firm has. To the extent that firms with greater debt are more likely to come into financial difficulties, returns may be increasing in leverage. Though high leverage can be interpreted in the opposite way as well, that solid healthy firms are able to take on greater debt.

An additional factor that is often used as a measure of whether a stock is a good value, is the earnings to price ratio. This can be considered as a proxy for other factors or can potentially be considered as an indicator of whether a stock is correctly valued. Expectations here would be that a high earnings to price ratio leads to greater subsequent returns.

I follow Fama and French (1992) and Lev and Sougiannis (1999) closely in terms of the specification of the basic equation and also in terms of the definition of the variables. However, I do not use the same estimation method or number of months of subsequent returns. Following Lev and Sougiannis (1999) but in contrast to Fama and French (1992), I only use 12 months of subsequent returns. The reason is that it seems reasonable to assume that the stock market acts on the latest information available as opposed to less recent accounting data. Additionally, preliminary examinations indicate that fundamental variables had little explanatory power for returns more than twelve months ahead.

Given that interest here is in finding average coefficient estimates both across firms and over time, it seems more appropriate to pool the data and run all regressions simultaneously in one large panel. In other words, each cross section contains (up to) 12 monthly returns for each firm, with a cross section for each year of the sample. Panel data estimation offers a number of advantages to the cross-sectional approach. First, by pooling all data, it allows for more efficient econometric estimates. Second, there is substantial variation in values of fundamental variables for individuals over time, with this ‘within-firm’ variation potentially being at least as important as cross-sectional differences between firms. The cross-sectional approach neglects this within-firm variation. Finally, different panel data estimation methods can potentially shed light on which forms of variation are most important in explaining returns, cross-sectional differences or within-firm fluctuations. What I find below is that the results vary greatly, depending on the estimation method used, with each set of results providing an economic interpretation.

4.1. Model specification and estimation techniques

In terms of panel data estimation techniques, the basic choice is between using a fixed effects (FE) or a random effects (RE) estimator. It may be instructive for interpreting the results to discuss briefly the two estimates. The basic panel data model is the following:

$$y_{it} = \mu + \beta' x_{it} + v_{it}$$

where

$$v_{it} = \alpha_i + u_{it}; \qquad i = 1,..,N; \qquad t = 1,..,T$$

y_{it} is the dependent variable, β is a vector of coefficients, x_{it} is a vector of explanatory variables, and v_{it} is a residual in which α_i are individual effects[19] and u_{it} is a random error term, which is assumed to be iid with zero mean.

It is in general recognized that there may be unobservable effects that are not captured by the data, and that these effects may potentially differ from firm to firm. Note that if the latter is the case, i.e. that some of these unobservable effects differ according to each individual firm, there may be a problem in that the errors are correlated with the exogenous variables.

The two estimators differ in their treatment of the error term, v_{it}. In the random effects model, individual effects are assumed to be random and to affect all firms equally, i.e.;

$$E(\alpha_i) = E(u_{it}) = 0, \qquad E(\alpha_i u_{it}) = 0, \qquad E(\alpha_i \alpha_j) = 0 \quad if \quad i \neq j$$

In the fixed effects model, individual effects are assumed instead to be constant though allowed to vary across firms, so that the model becomes;

$$y_{it} = \mu + \alpha_i + \beta' x_{it} + u_{it}$$

The fixed effects model can be estimated using Least Squares with Dummy Variables (LSDV), while the random effects model can be estimated using Generalized Least Squares (GLS). Which method is best depends on whether the error terms are uncorrelated with the exogenous variables, i.e. if $E(\alpha_i | x_i) = 0$. If $E(\alpha_i | x_i) = 0$ then GLS is more efficient, utilizing both information from variation between firms and within firms. However, if $E(\alpha_i | x_i) \neq 0$ then GLS is biased and inconsistent. The fixed effects estimator (i.e. LSDV) assumes means are different for each firm, and as such ignores variation among individual means.

A test to determine which estimator is most appropriate, or rather whether errors are correlated with exogenous variables, is the specification test suggested by Hausman (1978), which is essentially a test of whether the coefficients of the two estimators are different. GLS is biased and inconsistent if $E(\alpha_i | x_i) \neq 0$, while as Hausman (1978) shows, LSDV is still consistent in this case. If coefficients are very different (which

[19] Which for simplicity are assumed not to vary over time.

gives a large test statistic) then this is a sign that the random effects estimator is biased and inconsistent.

4.2. Regression results using monthly returns

Given that four lags are used in the estimation of R&D capital, the regression period is from 1993 to 2001, while for regressions using R&D expenditures, the period is from 1989 to 2001. And, in order to focus on the effects of R&D expenditures, only firms engaged in R&D are included here[20].

Table 5 reports the results for the estimations according to three approaches: fixed effects, random effects, and the cross-sectional approach used in, among others, Fama and French (1992) and Lev and Sougiannis (1999).

Given that results for random effects and fixed effects are in general quite different, I include results for both estimators in the table. Additionally, it was found that regressions using R&D expenditures produced the lowest Hausman statistics (and thus are less subject to bias and inconsistency), so I have chosen to focus on them[21]. Note that this also implies that in these cases the random effects estimator is more efficient than the fixed effects estimator.

---

[20] Specifically, only firms with R&D expenditures greater than 1% of their market value (on average) are included in the sample. This leaves a total of 57 firms for the regressions here.

[21] However, coefficient estimates for regressions with R&D capital are qualitatively similar. In addition to the estimates for R&D capital using linear depreciations of 20% (see section 2.2), I have also run these regressions with R&D capital estimated using the perpetual inventory method. While not shown due to space considerations, these regressions gave qualitatively similar results as well. For the perpetual inventory method, initial values of R&D capital were estimated using initial values of R&D expenses and assuming that firms' earlier values of R&D expenditures followed the growth rates of aggregate R&D. R&D capital is then $RDC_t = (1 - \delta) * RDC_{t-1} + RD_t$. The depreciation rate used was 15%.

Table 5 - Regressions using monthly returns

Estimation	FE	RE	FE	RE	FE	RE	RE	FF
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Dep. var.	R	R	R	R	R	R	R	R
Intercept	0.5320*	0.2513*	0.3759*	0.1856*	0.7033*	0.0919	0.1954	-0.0482
	(3.089)	(2.858)	(2.032)	(2.063)	(2.504)	(0.679)	(1.579)	(-0.583)
Beta	0.0101**	0.0102	0.0184	0.0184*	0.3630**	0.0277*	0.0262	0.0074
	(1.776)	(3.089)	(1.348)	(2.2648)	(1.740)	(2.068)	(1.959)	(0.634)
LnMV	-0.0271*	-0.0140*	-0.0203*	-0.0121*	-0.0367*	-0.0063	-0.0116*	0.0038
	(-3.015)	(-3.120)	(-2.136)	(-2.711)	(-2.539)	(-0.935)	(-1.907)	(0.931)
lnBM	0.0054	0.0036	0.0140	0.0158*	0.0200	0.0185**		-0.0010
	(0.508)	(0.584)	(1.309)	(2.855)	(1.381)	(1.905)		(0.110)
lnAB	0.0294*	0.0277*	0.0340*	0.0352*	0.0377**	0.0357*	0.0219*	0.0135
	(2.150)	(3.599)	(2.316)	(4.588)	(1.905)	(2.623)	(1.897)	(0.862)
lnRDM	0.0015	0.0089*						
	(0.186)	(1.976)						
lnRDS			-0.0018	0.0038				
			(-0.220)	(0.897)				
lnRDCS					-0.0025	0.0149**	0.0116	0.0155*
					(-0.163)	(1.652)	(1.310)	(2.448)
EM	0.0254	0.0291	0.0177	0.0191	0.0360	0.0350	0.0629	0.0392
	(0.428)	(0.815)	(0.297)	(0.583)	(0.421)	(0.527)	(0.971)	(0.694)
EMD	0.0023	0.0004	0.0033	0.0030	0.0061	0.0044	0.0117	0.0021
	(0.164)	(0.044)	(0.225)	(0.366)	(0.289)	(0.265)	(0.730)	(0.112)
No. obs.	5258	5258	5043	5043	3591	3591	3591	3591
R^2	0.198		0.200		0.168			
Hausman		3.472		1.485		10.923	12.479	
(p value)		(0.838)		(0.983)		(0.142)	(0.052)	

Estimation methods: FE is fixed effects; RE is random effects; FF is the cross-sectional approach of Fama and French (1992). T statistics are given in parentheses. Time dummies are included in all regressions and also sector dummies in random effects models. '*' indicates significance at the 5% level. '**' indicates significance at the 10% level. Hausman is the Hausman specification test statistic. The statistics are Chi-squared distributed under the null hypothesis, with degrees of freedom equal to the number of regressors. High values indicate bias and inconsistency for the random effects estimator. For regressions with R&D to sales, firms with R&D to sales greater than 2 (due to the fact that they had little or no sales) were excluded (though these firms are included in regressions with R&D to market).R is monthly stock returns. For each firm year of data, there are up to 12 monthly returns, starting seven months after the end of the fiscal year (which is assumed to be the calender year). Beta is the CAPM based beta; lnMV is the log of market value. lnBM is the log of the ratio of the book value of common equity to market value of equity. lnAB is the log of the ratio of total assets to book value of common equity. EM is the earnings to price ratio, calculated as the ratio of positive earnings before extraordinary items to market value of equity. EM is set equal to zero when earnings are negative. The EM dummy, EMD, is set equal to zero when earnings are positive and equal to one when they are negative. lnRDCS is the log of the ratio of R&D capital, calculated as described above, to firm sales. lnRDM is the log of the ratio of R&D expenditures to market value. lnRDS is the log of the ratio of R&D expenditures to sales.

In interpreting the results from Table 5, it can be seen that R&D to market has a positive effect on returns (column 2) and seems to dominate book to market, which, in contrast to other regressions, is insignificant when R&D to market is included. Results on R&D to market also demonstrate the importance of both within-firm and cross-sectional variation in capturing the effects of R&D on returns. In the fixed effects model, for example, the coefficient for R&D to market is insignificant (column 1).

R&D to sales, which can perhaps be considered a better indicator of a firm's R&D intensity (whereas R&D to market can be subject to large fluctuations in market value), has a much weaker effect. R&D to sales is insignificant in the full equation (column 4). However, R&D capital to sales is weakly significant (column 6). Though, the effect of R&D capital to sales seems to depend on book to market and is both smaller in size and insignificant when book to market is not included in the regression (column 7).

These results suggest that R&D intensity on its own does not have a substantive impact on returns, but it does have an important effect when controlling for financial factors. R&D to market proxies to an extent these financial factors. Firms with high R&D to market are R&D intensive, but also in general have had poor past results and, as these results indicate, generate excess future returns.

There are a number of other interesting results. First, I find, in contrast to results of the majority of studies of this type, that Beta has a significant (positive) effect on returns. Second, leverage has in general a significant positive effect on returns. Finally, I find strong evidence of a 'size effect' – market value has a negative effect on returns. However, an interpretation that large firms have low risk premiums is problematic, in particular since large firms have on average had higher returns than small firms over the period here (see Table 2). The results seem to indicate more that firms that experience an increase in market value in general have lower returns in the future.

Also included in Table 5 are time series averages of coefficient estimates from cross sectional regressions, following the procedure used in French and Fama (1992) and Lev and Sougiannis (1999). Here the only variable found to have a significant effect is R&D intensity (column 8)[22].

4.3. Regressions using annual returns

These regressions can also be run using annual returns[23]. While this greatly limits the number of observations[24], the specification is perhaps a more natural one for a panel data set framework (i.e. so that there is only one observation per firm in each cross section). Additionally, this, combined with estimations using monthly returns, provides a more detailed picture of how these factors affect returns.

---

[22] Results were qualitatively the same for all measures of R&D intensity considered.
[23] Lakonishok et al. (1994) also use annual returns.
[24] To around 300 observations. See Table 6.

Table 6 reports the results of the regressions using annual returns. *RET1* is the return one year afterwards.

Table 6 - Regressions using annual returns

Estimation	FE	RE	FE	RE
	(1)	(2)	(3)	(4)
Dep. Var.	RET1	RET1	RET1	RET1
Intercept	3.797*	0.450	5.534*	0.180
	(2.753)	(0.685)	(3.554)	(0.276)
Beta	-0.138	-0.053	-0.205**	-0.064
	(-1.373)	(-0.824)	(-1.882)	(-0.897)
LnMV	-0.188*	-0.038	-0.277*	-0.021
	(-2.653)	(-1.173)	(-3.442)	(-0.621)
LnBM	0.254*	0.223*	0.193*	0.063
	(3.627)	(4.765)	(2.062)	(1.064)
LnAB	0.521*	0.432*	0.457*	0.250*
	(5.459)	(6.620)	(4.229)	(3.516)
LnRDCM			-0.009	0.103*
			(-0.104)	(2.058)
LnRDCS	0.055	0.106*		
	(0.723)	(2.436)		
EM	0.655	0.584**	0.615	0.620
	(1.582)	(1.861)	(1.295)	(1.588)
EMD	0.173	0.160	0.180	0.157**
	(1.680)	(2.043)	(1.586)	(1.702)
No. obs.	307	307	293	293
R^2	0.295		0.248	
H test stat.		17.619		34.789
(p value)		(0.014)		(0.000)

The dependent variable here is annual returns. RET1 is the return one year after the time that the data is assumed to be known to the public (6 months after the end of the fiscal year, i.e. end June. All other variables are the same as in Table 5.

For regressions with annual returns, the Hausmann test was rejected in all cases. Given this, I choose to show the results for R&D capital here[25]. It can be seen that the results are similar to those for monthly returns.

[25] Though again, the qualitative results are similar for both R&D intensity in terms of R&D expenditures and R&D capital using the perpetual inventory model.

5. Risk or mispricing?

Having found that these factors are able to explain (some of) the cross-sectional variation of stock returns in Danish data, a natural next question is why. Often the search for explanations as to why fundamental factors are associated with returns boils down to a question of whether higher returns reflect compensation for risk or whether they are the result of mispricing.

A number of papers have investigated this question, in particular concerning size and book to market effects[26]. Fama and French (1993, 1995) argue that higher returns on small firms with high book to market ratios are compensation for higher risk. They suggest that book to market and size are proxies for firm distress.

Lakonishok et al. (1994) argue that higher returns associated with these factors are due to incorrect extrapolation of past earnings – investors are overly optimistic about firms that have had high earnings in the recent past and overly pessimistic about firms with low past earnings.

In this section I examine whether excess returns are due to the fact that these stocks are riskier. Determining whether abnormally high returns are due to risk compensation or mispricing is a difficult task, even more so here, given the limited time span for the data set. However, we are still able to shed some light on these questions.

It may be instructive to discuss briefly a few aspects of the question of risk vs. mispricing. First, it is important whether the risk is due to a general effect of a particular factor, or if it is firm specific. Standard microeconomic theory implies that a risk averse investor will require a greater expected return for a single risky asset. However, for several risky assets, the investor may require a much smaller premium if he or she is able to diversify this risk to some extent. This would be the case if the outcome of one firm has little effect on the other, or if they are not affected by some common factor. For this reason, a fair amount of attention has been given to examining whether size and book to market effects are due to common risk factors (see, e.g. Fama and French (1993), Chan et al. (1998)). While I will not examine the effects of 'factor loadings' here, an indicator of whether risk is at least partially diversifiable can be found in the behavior of average returns.

An additional aspect is the availability of R&D data. The fact that the information on R&D is not public makes it problematic in terms of examining market efficiency with respect to R&D. While it seems reasonable to assume that much of the R&D information is known to investors, it cannot be taken for granted. However, if we are able to find an association between R&D intensity and returns, then this provides a

[26] See e.g. Fama and French (1993, 1995), Daniel and Titman (1997), Lakonishok et al. (1994), Chan et al. (2001), Lev and Sougiannis (1999).

strong argument to make this information public, by requiring listed firms to disclose information on their R&D expenditures.

In considering whether excess returns reflect risk compensation, I will examine returns in two ways here. First, I will examine returns across economic states (measured in terms of outcomes for the stock market as a whole). In 'bad states' of the world, the marginal utility of wealth is relatively high implying that poor returns in bad states are particularly unattractive for a risk averse investor. Thereafter I will look at the performance of various portfolios over time. Stocks are riskier if excess returns on average are actually the result of high returns in some years and poor returns in other years.

An indication that excess returns compensate higher risk is that a portfolio's performance is particularly poor in bad economic states. Table 7 divides all years of the sample into 2 groups according to the overall performance of the stock market. Of particular interest here is whether portfolios with, for example high R&D intensity, high book to market, etc., do poorly relative to other portfolios in bad periods.

For R&D to sales, there does not seem to be any pattern. However, for market value and book to market, small and high book to market firms, respectively, do better on average in both good and bad times. This result is even more pronounced for R&D to market – firms with the highest R&D intensity relative to market value have on average generated much higher returns in the year after portfolio formation. Lastly, for leverage (AB) there are some signs that returns depend on overall states: high leverage firms have in general done worse in bad states and better in good states.

Summing up, the only indications here are that excess returns may reflect risk compensation for high leverage. For size, book to market and R&D to market, excess returns are generated in both good and bad times.

Table 7 – Annual returns by portfolio and overall performance of the stock market

		R&D to sales portfolio				
Overall		0	1	2	3	4
market	Bad	-0.020	-0.081	-0.074	-0.060	-0.065
returns	Good	0.148	0.099	0.221	0.175	0.238
		R&D to market portfolio				
		0	1	2	3	4
	Bad	-0.023	-0.101	-0.120	-0.098	0.035
	Good	0.146	0.118	0.167	0.136	0.312
		Leverage portfolio				
			1	2	3	4
	Bad		-0.025	-0.026	-0.043	-0.098
	Good		0.086	0.163	0.184	0.223
		Book to market portfolio				
			1	2	3	4
	Bad		-0.100	-0.103	-0.006	0.017
	Good		0.160	0.150	0.165	0.186
		Size portfolio				
			1	2	3	4
	Bad		-0.046	-0.033	-0.033	-0.081
	Good		0.224	0.135	0.113	0.190

Bad (good) years are defined as years where annual returns for the total market index of the CSE (the KAX index) are below (above) the median value for the entire sample. All other variables are as defined above. Observations are assigned to a portfolio according to the variable in question, and then the observations are divided in terms of good and bad years for the overall market. Annual returns are one year after portfolio formation.

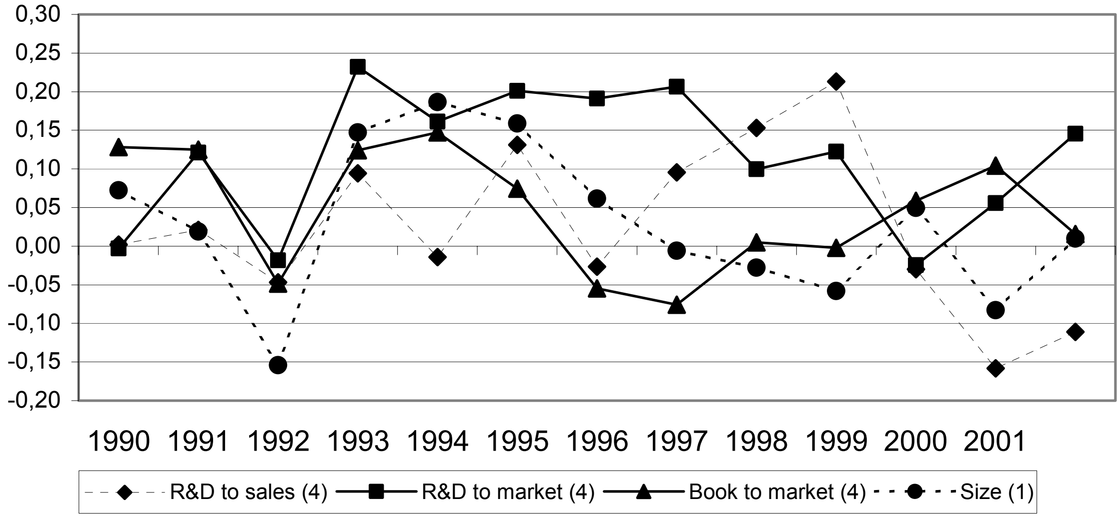
Portfolio returns can also be considered over time. A sign that excess returns reflect risk compensation may be that there is great variation in performance relative to other portfolios, with these firms doing poorly in some years. Figure 4 plots the return differentials of selected portfolios compared to the overall sample over time: the highest R&D to sales portfolio, the highest R&D to market portfolio, the highest book to market portfolio, and the smallest size portfolio.

All the portfolios considered in Figure 4 have in general done better than the overall sample here[27]. However, R&D to sales and market value portfolios have experienced large, negative return differentials over the sample. These negative return differentials are much smaller for the book to market and R&D to market portfolios. The returns for R&D to market are particularly noteworthy. Annual returns for high R&D to market firms

[27] A simple summation of annual return differentials gives total excess returns for the sample period of 32% for R&D to sales, 149% for R&D to market, 60% for book to market, and 38% for market value.

are consistently higher than sample averages, and in years when they are not, losses are very small[28].

Figure 4 - Return differentials for R&D portfolios



The figure plots the year ahead annual return differential between the portfolio indicated and the sample average for each year. Portfolios are formed as in section 3: each year, portfolios are formed based on percentiles for that year. The number in parentheses indicates the portfolio number, with 4 being the highest portfolio for R&D to sales, R&D to market, and Book to market, and 1 being the lowest (out of 4) market value portfolio.

This evidence thus does not provide any support for the idea that excess returns for high R&D to market firms reflect risk compensation, nor does it for high book to market firms. It should be kept in mind the shortness of the time period and also the relatively small number of firm observations in each portfolio in Figure 4[29]. Even so, the consistency with which high R&D to market firms have generated abnormally high subsequent returns gives a strong impression that these firms are undervalued at the time of portfolio formation.

[28] Return differentials for the highest R&D to market portfolio relative to the overall sample are negative in three years: 1990 (-0.003), 1992 (-0.018), and 2000 (-0.025). These negative differentials are very small in comparison to the positive differentials in other years.

[29] For R&D portfolios, the number of observations for each year are between 11 and 19. For size and book to market, the portfolios are larger, ranging from 21 to 31 observations per year.

6. Summary and conclusion

This paper has examined how firms engaged in R&D are valued by the stock market. It has done so both by dividing stocks up into a number of portfolios and also through panel data analysis. The main objective has been to investigate how R&D affects returns.

I find little evidence that R&D intensive firms in general earn greater returns. While R&D to sales has a positive effect on returns in some of the regressions, this effect seems somewhat dependent on other factors. And the portfolio analysis revealed small excess returns for high R&D firms in terms of R&D to sales. In other words, considering firms irrespective of their financial condition, there does not seem to be much indication that there is a risk premium attached to firms solely due to the fact that they invest heavily in R&D, nor do these firms seem to be systematically undervalued.

This, however, does not mean that R&D does not have any impact on returns. When controlling for indicators of firms' financial condition, such as the book to market ratio, R&D has a positive effect on returns. For example, for firms with high book to market, which is often an indicator that a firm has had poor results in the recent past, R&D firms earn excess returns. Hence, R&D seems to affect return volatility as opposed to average returns. If things go bad for an R&D intensive firm, they generally experience greater falls in returns, followed by larger future returns. In a way, the 'R&D effect' magnifies the 'Book to market effect'.

These interpretations are supported by examination of R&D to market. To a greater extent than R&D to sales, R&D to market is positively associated with returns. This is because R&D to market may be to a large extent due to a fall in the market value of the firm. Poor results now seem to increase concern about the future performance of R&D investments, perhaps due to a lack of information on R&D expenditures. The recognition that R&D has an impact on future sales and earnings, combined with the identification here that R&D has an effect on returns, provides a strong argument for requiring the disclosure of R&D information in financial statements.

In addition, I have investigated whether excess returns associated with factors such as R&D to market, book to market, market value, and leverage are due to risk compensation – i.e. whether the market prices them accordingly. In considering portfolios for these factors, firms with high R&D to market or high book to market have fairly consistently produced excess returns, over the sample period and in good and bad times. And in cases where they did not generate excess returns, losses were relatively small. Only for high leverage firms was there a marked sign of increased risk. Focusing in particular on R&D to market, my interpretation is that high R&D to market firms may indeed be riskier, but that this risk is mainly due to firm specific factors. Hence, it seems that for a portfolio of high R&D to market firms, much of this risk can be diversified, generating abnormally high returns. However, these results are based on a small sample and should be considered as indicative.

7. References

Bayer, Mads, 2003, The Stock Market Valuation of R&D Intensive Firms and the Capitalization of R&D expenditures (in Danish), Report 2003/1, The Danish Institute of Studies in Research and Research Policy.

Chan, Louis K.C., Jason Karceski and Josef Lakonishok, 1998, The Risk and Return from Factors, *Journal of Financial and Quantitative Analysis*, 33, 159-88.

Chan, Louis K.C., Josef Lakonishok and Theodore Sougiannis, 2001, The Stock Market Valuation of Research and Development Expenditure, *Journal of Finance*, 56, 2431-56.

Daniel, Kent and Sheridan Titman, 1997, Evidence on the Characteristics of Cross Sectional Variation in Stock Returns, *Journal of Finance*, 52, 1-33.

Danish Institute for Research Policy, 2003, Forskningsstatistik 2001: Erhvervslivets Forskning og Udviklingsarbejde, The Danish Institute for Studies in Research and Research Policy.

Fama, Eugene F., and Kenneth R. French, 1992, The Cross Section of Expected Stock Returns, *Journal of Finance*, 47, 427-465.

Fama, Eugene F., and Kenneth R. French, 1993, Common Risk Factors in the Returns on Stocks and Bonds, *Journal of Financial Economics*, 33, 3-56.

Fama, Eugene F., and Kenneth R. French, 1995, Size and Book-to-Market Factors in Earnings and Returns, *Journal of Finance*, 50, 131-155.

Hall, Bronwyn, 1992, Investment and Research and Development and the Firm Level: Does the Source of Financing Matter?, Working Paper 4906, NBER.

Hall, Bronwyn, 1993, The Stock Market's Valuation of R&D Investment During the 1980's, *American Economic Review*, 83, 259-264.

Hall, Bronwyn, and Robert E. Hall, 1993, The Value and Performance of U.S. Corporations, *Brookings Papers on Economic Activity*, 1, 1-34.

Hausman, Jerry, 1978, Specification Tests in Econometrics, *Econometrica*, 46, 1251-71.

Lakonishok, Josef, Andrei Shleifer and Robert W. Vishny, 1994, Contrarian Investment, Extrapolation, and Risk, *Journal of Finance*, 49, 1541-1578.

Lev, Baruch and Theodore Sougiannis, 1996, The Capitalization, Amortization and Value Relevance of R&D, *Journal of Accounting and Economics*, 21, 107-138.

Lev, Baruch and Theodore Sougiannis, 1999, Penetrating the Book-to-Market Black Box: The R&D Effect, *Journal of Business Finance & Accounting*, 26, 419-449.

OECD, 2002, Frascati Manual: The Measurement of Scientific and Technological Activities. Proposed Standard Practice for Surveys on Research and Experimental Development.

Appendix - R&D data for non-financial firms on the Copenhagen Stock Exchange

This section describes the compilation of R&D data for non-financial firms listed on the Copenhagen Stock Exchange. The data is taken from the Danish Institute for Studies in Research and Research Policy's (AFSK) database for private sector R&D. The data is gathered and compiled in accordance with the definitions and guidelines of the OECD's Frascati Manual (OECD(2002)).

The majority of the firms listed consist of more than one company or own a number of subsidiaries. In order to ensure to the greatest degree possible that all R&D data is registered for each firm, the database was checked for R&D data both at the overall concern level and for their subsidiaries. If R&D expenditures were reported at the concern level then these were used as total R&D expenditures. If not, then R&D was calculated as the sum of R&D expenditures for its subsidiaries (times percent ownership).

There are also a group of firms that have not reported any R&D statistics. In these cases, their annual reports were examined. If R&D expenditures were reported in their annual reports, then these numbers were used. In the case where firms did not report any statistics to AFSK, nor were there any R&D expenditures listed on their annual reports, then these data were considered as missing. Note though, that the definitions used by each individual firm in their annual reports may not be exactly the same as those used by AFSK. However, given the somewhat limited size of the sample here, it was considered best to include them.

The R&D database at AFSK contains data for every other year from 1989 to 1997 and annually from 1997 onwards. For the years missing between 1989 and 1997 (i.e. 1990, 1992, 1994 and 1996), R&D data was interpolated from years before and after. Additionally, the database for listed firms was checked for missing values. These missing values were then estimated. However, if more than two years were missing from the sample (among those years where data was gathered) then the firm was removed from the sample. By this criterion, 11 firms were removed from the sample.