R&D Intensity and Abnormal Stock Returns

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ABSTRACT

Technology is one of the most important drivers in the current economy. Many firms listed on the U.S. stock exchange conduct research and development (R&D) activities in order to gain competitive advantages. However, R&D activity negatively impacts the reported financial performance of a firm due to the current accounting rules. Under current U.S. accounting standards, intangible assets are not reported and R&D spending is expensed. Previous research has analyzed whether a potential positive relation between R&D expenditure and future abnormal stock returns exists. Some studies concluded R&D intensity is positively associated with abnormal returns, others concluded this was due to the interaction effect of other variables. This study provides new evidence, based on more recent observations, a positive relation between the level of R&D intensity of a firm and the abnormal stock return exists. A portfolio analysis is conducted to compare different measures of R&D intensity and to determine whether high R&D intensity firms experience higher abnormal returns. Companies with a high level of R&D intensity also tend to be more resilient in times of economic distress.

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1. INTRODUCTION

Investment in research and development (R&D) has been an increasingly important driver of long-term economic growth for many firms in the past decades (Li, 2011). Many firms listed on the US stock market invest substantial amounts in R&D projects, especially in the technology sectors. These R&D expenditures can have a huge impact on the reported profitability of these firms due to the way these expenses have to be reported. The public information regarding these expenses can lead to misvaluation by investors.

Various models have been developed to explain stock returns, such as the three-factor model by Fama and French (1992), the four-factor model by Carhart (1997), the q-factor model by Hou et al. (2015) and the five-factor model by Fama and French (2015). All of these models have been developed to minimize the amount of anomalies that can be found in explaining the stock returns of firms or portfolios. Many variables have been researched in the literature that could explain these anomalies. A variable mentioned in multiple studies is the level of R&D intensity. The q-factor model and the five factor model incorporate investments as a factor to reduce the amount of anomalies found, however these investments are not limited to R&D activities. There is still no consensus in the literature whether R&D expenditure and abnormal stock returns are positively related without the interaction effect of other variables. This paper provides new evidence whether the relation between R&D expenditure and abnormal returns is positive in more recent years and whether General Accepted Accounting Principles (GAAP) influence this relation. The research question for this paper is as follows:

> *Can the level of R&D intensity explain abnormal stock returns of US-based technology firms?*

In order to answer the research question the following structure will be used in this research. First, a literature review is conducted in order to create a theoretical framework. Second, multiple variables will be constructed to measure R&D intensity and estimate the abnormal returns of a portfolio. The construction of the R&D intensity variables is explained in the methodology section. Third, the research design is defined. A portfolio analysis will be conducted in order to be able to test the hypotheses. Portfolios will be formed based on the individual R&D intensity of a specific stock. The abnormal returns of these portfolios will be compared to identify whether there is a relation between the level of R&D intensity and abnormal returns. Fourth, the results are reported separately for each R&D intensity variable. Both the excess returns and the abnormal returns of the portfolios are reported. A significantly higher excess and abnormal return is observed for the most R&D intensive portfolios. Portfolios with a low R&D intensity tend to underperform non-R&D portfolios. Estimations of abnormal returns based on a twelve month period do not generate significant results. The results based on the three year period post portfolio formation are all statistically significant and indicate a positive relation between the R&D intensity of a firm and the abnormal stock return does exist. However, more extensive research with a larger data sample is required in order to confirm this positive relationship for different time frames and to increase the applicability of the R&D intensity ratios. High R&D intensive firms tend to have more resilience in periods of economic distress such as the recent corona crisis.

2. THEORETICAL FRAMEWORK

2.1 Literature Review

2.1.1 R&D Input Versus R&D Output

Traditionally, measures of R&D performance have more frequently been related to R&D input, instead of the output of R&D activities. R&D input can be defined as R&D outlays or expenditure. This value represents the amount of money spend on R&D activities and is reported in the annual financial report of a firm. R&D output can be defined as patent count or patent citations. Variables that involve patents are often analyzed on importance or quality (Pandit et al., 2011). Other variables that are mentioned in the literature that act as an indication for R&D output are press releases or guidance on R&D activities (Cifti et al., 2011).

The literature states multiple reasons why R&D input is used as a measure for R&D performance: the degree of uncertainty of an R&D activity is very high; after the completion of an R&D activity the output is often not definable and therefore not measurable; the benefits of an R&D activity tend to take years to materialize and is often the result of the combined efforts of the R&D unit and other company units, such as marketing (Chiesa & Masella, 1996). The belief amongst investors, directors and governments is that there should be a positive relationship between the amount of resources allocated to R&D and the R&D output. Increased R&D spending does not necessarily results in improved firm performance or firm growth (Demirel & Mazzucato, 2012).

2.1.2 Accounting and R&D Expenses

Accounting rules also have a major impact on the reported financial performance of a firm when it comes to R&D expensing. Firms have the freedom to report R&D expenditure from the moment the activity is undertaken till completion. This results in creative accounting where firms report expenses when it suits best and produces a favorable income statement (Lev & Sougiannis, 1996). R&D expenses are often investments that cover multiple years. Misinterpretation of reported expenses or inaccurate information on the income statement of a firm can lead to the mispricing of assets. In order to analyze the consequences of these accounting principles multiple R&D intensity variables will be constructed to test the relation between R&D intensity and abnormal returns. The construction of the variables will be elaborated in the following chapter.

2.1.3 R&D Expenditure and Stock Returns

A substantial body of work can be found in the literature regarding the relation between R&D expenditure and stock returns. Lev and Sougiannis (1996) report a positive association between measures of the level of R&D investment and subsequent abnormal returns. Their research is based on the discussion whether R&D outlays have a future benefit for the company and whether R&D investments should be reported as an asset instead of an expense. An asset is defined in accounting rules as something with future economic benefits. If R&D could be capitalized, a company's balance sheet would show more assets, which would increase the value of the company. If R&D investment would not be treated as an expense, the reported profits of the company would be higher, at least on paper.

Chan et al. (2001) state in an efficient market, the stock price impounds the value of a firm's R&D capital, along with other intangible assets, resulting in no association between R&D intensity and future stock returns. However, the outcome of many research projects is far from assured and the benefits, if any, are likely to materialize much later. They do not find evidence that supports a direct link between R&D expenses and future stock returns. Chambers et al. (2002) find evidence that the positive association between the level of R&D investment and subsequent abnormal returns persists for at least ten years following investment, that abnormal returns are much more highly variable through time for R&D intensive firms than for firms with little or no R&D investment, and that both analysts' forecasts of future earnings and actual future earnings are more highly variable for R&D-intensive firms than for others. They state that the relation between R&D intensity and future abnormal returns is more likely due to inadequately accounting for risk-bearing than accounting-induced mispricing. They also support the statement there is a gap regarding the R&D intensity variable in the three-factor model by Fama and French (1992) and the model may substantially underestimate the expected returns for R&D intensive firms. Eberhart et al. (2004) report consistent evidence that shareholders experience significantly positive abnormal stock returns for the 5-year period following their firm's R&D increase. They attribute the positive abnormal returns to mispricing and argue the market takes years to react to an increase in R&D spending. The results provide strong evidence investors systematically underestimate the benefit of R&D expenses. Cifti et al. (2011) continue to research whether the future abnormal returns are due to mispricing or risk-bearing. The study documents that R&D outlays and their changes are positively associated with future abnormal returns, suggesting investors underreact to R&D outlays which is partly attributable to conservative accounting of R&D expenses. In contrast, Chambers et al. (2002) argue that future abnormal returns due to R&D expenses are positive over the long-term, suggesting these returns are primarily attributable to risk. The study by Cifti et al. (2011) concludes firms with a high R&D intensity systematically are undervalued. The undervaluation is cut in half when these firms release earnings guidance that frequently discusses R&D related topics. They state that fundamental breakdowns of R&D outlays could result in a more accurate valuation of firms. Such disclosures include data on the consequences of R&D, periodic innovation revenue and basic project descriptions. An important statement made in this research is:

> "The R&D risk-or-mispricing controversy has important implications for the state of capital market efficiency, for practicable portfolio management (mispricing can be exploited by arbitrage), and particularly for accounting standard-setting."

2.1.4 Interaction Effects on the R&D Intensity and Stock Return Relation

The following papers have studied the relation between R&D intensity and future stock returns and report this relation only exists because of the interaction effect. The interaction effect exists when the effect of an independent variable on a dependent variable changes due to the change of another independent variable (Andersson et al., (2014). Li (2011) adds to the body of literature regarding R&D intensity and abnormal stock returns that this positive relation can only be found among financially constrained firms. The findings in the study suggest financial constraints have a significant impact on R&D intensive firms' risk and return which potentially drives the positive R&D return relation. Cohen et al. (2015) incorporate past firm performance in their research to explain the positive return relation between R&D intensity and abnormal stock returns. Firms are classified as high- or low-ability based on their past track records to produce tangible results with their R&D efforts. They find evidence that positive abnormal returns are related to past performance combined with the level of R&D intensity and this public information is generally not recognized in the stock market. Gu (2016) incorporates the level of competition in his research about the relation between R&D intensity and abnormal stock returns. A high R&D intensity results in higher abnormal returns in a competitive environment, but this pattern does not exist among firms with a low R&D intensity. The paper documents that competition independently drives a significant portion of the positive R&D-return relation. A thorough understanding of the R&D anomaly in capital asset pricing models is still lacking.

2.1.5 Summary of the Literature

The prevailing argument in the literature is the fact that current return models fail to explain the R&D anomaly that persists when it comes to accurately estimate future returns of stocks and portfolios. There seems to be a positive relation between the amount of R&D spending of companies and future stock returns, however this often materializes slowly. Capitalizing and amortization of R&D expenses seems to generate a more consistent relation between the two variables. More recent research provides evidence that the relation between R&D intensity and stock returns exists only under influence of the interaction effect. Factors such as competitiveness, financial constraints and earning guidance are stated as potential interaction variables that cause the relation between future abnormal returns and the amount of capital spend on R&D activities.

2.2 Hypotheses

An incredible amount of research has been conducted regarding the possible relation between R&D intensity and abnormal stock returns. A definitive statement about the positive relation between these two variables, without the interaction effect of other variables, is not made. The current capital asset pricing models fail to explain the R&D investment anomaly. The most prominent reasons for the undervaluation of high R&D intensive firms are mispricing and inadequately adjusting for risk-bearing. This study aims to confirm a positive relation between R&D intensity and abnormal returns exists. In order to generate meaningful results two hypotheses will be tested in this research.

I. Firms with a high level of R&D intensity experience a higher abnormal stock return.

In order to test this hypotheses multiple portfolios will be formed based on R&D intensity levels of the separate stocks. Four different methods will be used to construct the R&D intensity variables. The variables regarding abnormal stock return will be constructed by using the Capital Asset Pricing Model (CAPM) and the three-factor model. These variables will be explained in more detail in the following chapter.

II. The abnormal returns of formed portfolios that conduct R&D activities increases year on year over the three year period post portfolio formation.

Eberhart et al. (2004) and Cifti et al. (2011) state in their research that investors typically are slow to recognize the benefits of R&D expenditures. These statements can be confirmed by testing this hypothesis by reviewing the trend of the abnormal returns of the portfolios in this research. It also provides information on whether the benefits of R&D activities materialize years later based on the performance of the stock.

3. METHODOLOGY AND DATA

The following sections clarify the construction of the variables used in this research. The impact of the current accounting rules on the way R&D expenses are reported and the value of this information will be discussed. Following, the various models that have been developed to determine stock returns and consequently abnormal stock returns are analyzed.

3.1 Research and Development: Expensing Versus Capitalization

For the purpose of this research the R&D intensity ratios will be solely based on R&D input rather than output due to the fact that information regarding R&D input is available to investors at an earlier stage and potential benefits will not be priced in yet. R&D output, such as patents and guidance, is often anticipated on by investors and possible positive news tends to be priced in prior to these announcements (Cifti et al., 2011).

R&D investments and the way these costs are documented on the balance sheet have been a popular subject for accountants for decades (Lev et al., 2005). In the past, R&D costs would be considered as an expense but also as an asset. The Financial Accounting Standards Board (FASB) issued the following statement in 1974: "A direct relationship between R&D costs and specific future revenue generally has not been demonstrated". The presumed absence of this relation was a major reason for the FASB's decision in 1974 to require full expensing of R&D outlays in financial reports of public corporations (Lev & Sougiannis, 1996). Generally under GAAP R&D expenditures should be expensed when they are incurred. Since R&D expenditure is now public information, multiple studies were conducted to analyze whether this information could be valuable to investors.

Sougiannis (1994) states, on average, a one-dollar increase in R&D leads to a two-dollar increase in profit over a seven-year period and a five-dollar increase in market value. The long-run impact of R&D on market value consists of two effects: one indirect and one direct. The indirect effect is the capitalized value of realized R&D benefits reflected in earnings and expected to persist in the future. The direct effect relates to new R&D information conveyed directly by R&D variables. On average, the indirect effect is much greater than the direct, indicating the importance of earnings and implying that R&D variables are valued conditional on earnings. Lev and Sougiannis (1996) analyze whether capitalization of R&D expenses could be a useful value estimate for investors. R&D capitalization means removing R&D expenses from the income statement and classifying these costs as an asset on the balance sheet, basically increasing profit. They also notice a significant association between firms' R&D capital and subsequent stock returns, suggesting either a systematic mispricing of shares of R&D intensive companies, or a compensation for an extra-market risk factor associated with R&D. They conclude R&D capitalization yields statistically reliable estimates of the amortization rate of the R&D capital in this study. These amortization rates are used to compute firm-specific R&D capital and adjust reported earnings and equity (book) values to reflect the capitalization of R&D. The major outcomes of these adjustments to reported earnings and book values for R&D capitalization were found to be strongly associated with stock prices and returns, indicating the R&D capitalization process yields value-relevant information to investors. Taken together, these findings suggest that R&D capitalization yields statistically reliable and economically relevant information, contradicting a major tenet of the FASB Statement in 1974.

Chan et al. (2001) suggest two different ratios to estimate R&D intensity related to future stock returns. The first measure is 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. The second measure of R&D intensity is the ratio of R&D expenditure relative to the market value of equity or market capitalization. This ratio shows more similarity with many indicators that are widely used in financial economics. In particular, scaling 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. The study conducted by Chambers et al. (2002) builds on the work of Chan et al. (2001) and uses the ratio R&D assets relative to market value of equity to estimate R&D intensity. R&D assets is the asset that would have been reported if R&D expenditures were capitalized and amortized over five years beginning in the year after the expenditure was made. Lev et al. (2005) continue to research the effect of R&D expensing and find that R&D expensing is both conservative and aggressive relative to R&D capitalization. Conservative expensing results in understated earnings and growth due to directly expensing of growing R&D expenditures, whereas aggressive expensing results in overstated earnings and growth due to expensing of shrinking R&D expenditures. They find evidence this variation in conservatism in expensing directly affects investor valuations due to profitability reporting biases. Stocks of conservatively reporting firms appear to be undervalued, while stocks of aggressively reporting firms appear to be overvalued. These misvaluations appear to be corrected when the reporting bias reverses from conservative to aggressive, or vice versa.

Chambers et al. (2002) conclude: "capitalizing and amortizing R&D costs on a pro forma basis results in summary accounting measures that are more closely associated with security prices and security returns than those based on the current requirement to expense R&D costs when incurred".

3.1.1 Research and Development Intensity Variables

As discussed in the previous sections it is important to use a measure of R&D intensity that provides an accurate representation of the impact of R&D expenses on the performance of the firm. Since various accounting measures can generate completely different results, this research will be conducted using four variations of the R&D intensity variable. Two variables will be constructed using the direct expensed R&D expenses found in the income statement of a firm. The remaining two variables will be constructed using the capitalized and amortized value of the R&D expenses in a particular year. Following Lev and Sougiannis (1996), Chan et al. (2001) and Chambers et al. (2002), the net R&D amortization is estimated as if all R&D expenses were capitalized and amortized over five years, rather than expensed immediately. The *pro forma* R&D amortization for year *t* ($RDAMORT_t$) is given by

$$RDAMORT_1 = 0.2(RDEXP_{t-1} + RDEXP_{t-2} + RDEXP_{t-3} + RDEXP_{t-4} + RDEXP_{t-5})$$

Where $RDEXP_t$ is the R&D expense reported for year *t* under the current accounting rules (Chambers et al., 2002).

In previous studies by Lev and Sougiannis (1996), Chan et al. (2001) and Chambers et al. (2002) various ratios have been used to measure the level of R&D intensity. Two ratios that have been used repeatedly are R&D expenses relative to sales and R&D expenses relative to the market value of equity (market capitalization). For this research both ratios will be used in order to construct a total of four variables that represent R&D intensity:

R&D direct expensed relative to sales

R&D direct expensed relative to market capitalization

R&D amortized relative to sales

R&D amortized relative to market capitalization

For each R&D intensity measure the relation to the abnormal returns of the portfolios will be analyzed.

3.2 Measurements of Stock Return

In the literature multiple models can be found which try to explain the stock return of individual stocks or portfolios. The most prominent ones will be discussed, such as: The Capital Asset Pricing Model (CAPM), the three-factor model, the four-factor model and the five-factor model.

The CAPM model describes the relationship between systematic risk and expected return for capital assets. Risk consists of systematic market risk and unique risk. The security market line is a visualization that shows different levels of market risk against the expected return of the entire market at any given time. The model can be used to calculate expected returns when the unique risk of a company or portfolio is known. CAPM is considered a one-factor model, where the beta of an asset or portfolio is the determining factor (Sharpe, 1964; Lintner, 1965).

Fama and French (1992) state, on average, a portfolio's beta relative to the market explains about 70 percent of its actual returns. Based on these findings they introduce their own model, the three-factor model. They expand on the CAPM model by adding two more factors in order to more accurately estimate stock returns. The first factor that is added is 'Small minus Big' (SMB), which is based on the fact that, historically, small-cap companies have a higher excess return than large-cap companies in the long run. The second factor that is added is 'High minus Low' (HML), which is a value premium based on a high book-to-market value ratio compared to a low book-to-market value ratio. Value stocks typically have a high book-to-market ratio, while growth stocks tend to have a low book-to-market ratio. In the long run value stocks tend to have higher excess return than growth stocks. Once the three factors are identified, the beta coefficients can be determined via linear regression. The three-factor model explains over 90 percent of the diversified portfolio returns, a significant increase compared to the CAPM model.

In a series of papers Carhart (1995 & 1997) builds on the work of Fama and French by expanding their three-factor model with a fourth factor: momentum. In a series of papers is explained how the fourth factor improved the explanatory of multifactor models aimed at explaining portfolio performance. The momentum factor represents the tendency of an asset to continue on a given path. The factor can be calculated by subtracting the equal weighted average of the lowest performing firms from the equal weighted average of the highest performing firms, lagged one month (Carhart, 1997). The intercept of the four-factor model is referred to as the four-factor alpha.

Over the years multiple studies were conducted to analyze the performance of both the three-factor model and the four-factor model. Years later Hou et al. (2012) introduce a new model because they argue the three-factor model failed to account for a wide array of asset pricing anomalies. They called this model the q-factor model. The model is inspired by investment-based asset pricing, which is in turn built on the neoclassical q-theory of investment. In the q-model, the expected return of an asset in excess of the risk-free rate is described by the sensitivities of its returns to four factors: the market excess return (MKT), the difference between the return of a portfolio of small size stocks and the return on a portfolio of big size stocks (r_{ME}), the difference between the return on a portfolio of low investment stocks and the return on a portfolio of high investment stocks ($r_{I/A}$), and the difference between the return on a portfolio of high profitability (return on equity, ROE) stocks and the return on a portfolio of low profitability stocks (r_{ROE}). An important finding in this study was the fact that the investment and profitability factors are almost completely uncorrelated, which means that these are independent factors. The investment factor states the level of investments of firms is based on the market value of capital. A high cost of capital means low investment and a low cost of capital means high investment. The evidence in this paper suggests many claims in the anomalies literature regarding the three-factor model and four-factor model seem exaggerated. The q-factor model outperforms the three-factor model and four-factor model in capturing many of the significant anomalies found in the literature (Hou et al., 2012).

Shortly after the publication of the q-factor model research Fama and French decided to add the two independent factors found in the q-factor model, investment and profitability, to their three-factor model. They called this new model the five-factor model. The five-factor model does not fully explain the cross-section of returns, there are still some anomalies present, but it provides a more accurate estimation of average returns. One problem that remains is the failure of the model to explain low average returns on small stocks that invest a lot despite low profitability. Fama and French (2015) estimate that the five-factor model explains between 71 percent and 94 percent of the cross-section variance of expected returns. They conclude, if the sole interest is explaining abnormal returns, the HML factor is redundant and the remaining four-factor model performs as well as the five-factor model.

3.2.1 Estimations of Abnormal Returns

In order to estimate abnormal returns of a portfolio a stock return model is required. In this research two models will be used to estimate the alpha of the portfolios. First, the abnormal return of the portfolios will be estimated with the CAPM model:

$$R_{pt} = R_{ft} + B_{pt}\,(R_{mt} - R_{ft}) + \alpha_{pt}$$

Where R_{pt} is the return on portfolio p at time t, R_{ft} is the risk-free rate, β_{Pt} is the beta of portfolio p, $R_{mt} - R_{ft}$ is the excess return on the value-weighted market index (Sharpe, 1964; Lintner, 1965).

Second, the abnormal return of the portfolios will be estimated with the three-factor model:

$$R_{pt} - R_{ft} = \alpha_{pt} + B_1(R_{mt} - R_{ft}) + B_2\,SMB_t + B_3\,HML_t + e_{pt}$$

Where R_{pt} is the total return of the portfolio at time t, R_{ft} is the risk-free rate, $R_{mt} - R_{ft}$ is the excess return on the value-weighted market index, SMB_t and HML_t, are the returns on the Fama and French (1992) factor-mimicking portfolios for size and book-to-market, respectively, and $B_{1,2,3}$ are the factor coefficients found by performing linear regression on the three factors and the portfolio returns. The values of the factors for the three-factor model can be directly found on Kenneth French's' website.

To remain consistent with prior research this study will be limited to using these two measures of stock return and exclude the four-factor model, q-factor model and five factor model (Lev & Sougiannis, 1996; Chan et al., 2001; Chambers et al., 2002; Eberhart et al., 2004; Cifti et al., 2011; Lu, 2015).

3.3 Sample

In order to study whether R&D intensity can explain abnormal returns of technology firms it is important to choose a sample that can be representative for the stocks that investors, with a focus on the technology sector, might add to their portfolio. The NASDAQ-100 is considered the most tech heavy index in the US and for this reason the firms listed in the NASDAQ-100 index will be analyzed. Since most investors tend to add mega cap stocks to their portfolio the DOW-30 index will also be included in the sample. The study will analyze these firms over a ten year period from 2010 to 2020. Data regarding R&D expenses will be collected on an annual basis following the accounting requirements to report these expenses in the published annual reports. This data will collected in the period 2005-2020 because, in order to capitalize and amortize R&D expenses, a five year period prior to the start of this analysis is required to estimate the amortized R&D expenses (Lev & Sougiannis, 1996). Data regarding stock return variables will be collected on a monthly basis in order to estimate the excess and abnormal stock returns annually.

The data required for this research will be extracted from the Thomson Reuters Eikon database. Whenever data is missing, Yahoo Finance will act as a back-up source for financial data. If data regarding R&D expenses is missing over an extended period of time the stock will be excluded from this research. The factor values for the three-factor calculation of the three-factor model will be extracted from the website of Kenneth R. French where these values are published on a monthly basis.

3.4 Portfolio Analysis

To analyze the relation between the R&D intensity ratios and the abnormal stock return a portfolio analysis will be conducted. Following Chan et al. (2001), each year portfolios will be created at the beginning of May in order to account for the lag between the end of the fiscal year and the release of financial reports. Most companies end their fiscal year in December and publish their annual reports in March or April. Only 33 percent of the firms analyzed in this research end their fiscal year in a different month. Therefore, inaccurate estimates of the R&D intensity of the portfolios is limited.

The portfolios will be divided in four categories: 1 (Low R&D intensity), 2 (Mid R&D intensity), 3 (High R&D intensity) and non-R&D, based on their relative ranking. First, all companies that do not report any R&D expenses in that specific year will be placed in the non-R&D portfolio. Second, the remaining amount of firms will be divided into tertiles and each stock will be placed in one of the three portfolios based on their individual ranking of R&D intensity. On average, there are 26 stocks in each of the portfolios that conduct R&D activities and 45 stocks in the non-R&D portfolios. The last year in which portfolios will be formed is 2017, due to the fact that future abnormal returns will be estimated for the three post formation years. This results in a total of seven years in which portfolios will be formed and in total 112 portfolios[1] will be analyzed in this study.

4. RESULTS

In the first section of this chapter the industry distribution and the relative R&D intensity per sector is presented. Following, the remaining four sections report the results based on the respective measure used to construct the R&D intensity variable. Following Chan et al. (2001) both excess returns and abnormal returns will be reported. Excess return is defined as portfolio return minus risk-free rate. Abnormal return is defined as the component of the return that is not due to systematic influences (market-wide influences). Abnormal return is also known as alpha and is included in both the CAPM model and 3-factor model (Sharpe, 1964; Fama & French, 1992). The following reporting structure will be used throughout the result tables of all the four R&D intensity sections. In Panel A, each portfolio's average annual buy-and-hold excess return is reported over the five years prior to portfolio formation; over each year from one to three years after portfolio formation; and averaged of the three post formation years. Panel B reports each portfolio's average abnormal return based on the CAPM model estimation over each year from one to three years after portfolio formation and the average annual abnormal return of the three post formation years. The average annual alpha over the three post formation years is estimated independently as a single regression in order to increase the statistical significance of the alphas of the portfolios. Panel C reports each portfolio's average abnormal return based on the three-factor model estimation over each year from one to three years after portfolio formation and the average annual abnormal return of the three post formation years. The average annual alpha over the three post formation years is estimated independently as a single regression over all three years in order to increase the statistical significance of the alphas of the portfolios. Panel D reports characteristics of the portfolios: the average number of stocks per portfolio; the average firm size per portfolio; the average revenue per firm for each portfolio; the average value of the R&D intensity variable per portfolio; the average beta coefficients of the three-factor model.

Table 1. Industry distribution of the sample.

Global Industry Classification Standard (GICS)	Number of Stocks	Average R&D Intensity: Direct Expensed Relative to Sales	Direct Expensed Relative to Market Cap	Amortized Relative to Sales	Amortized Relative to Market Cap
Communication Services	16	0.0716	0.0295	0.0443	0.0184
Consumer Discretionary	20	0.0540	0.0269	0.0250	0.0116
Consumer Staples	9	0.0024	0.0012	0.0023	0.0010
Energy	2	0.0079	0.0065	0.0079	0.0061
Financials	4	0.0000	0.0000	0.0000	0.0000
Health Care	19	0.2363	0.0291	0.1557	0.0211
Industrials	12	0.0161	0.0116	0.0143	0.0114
Information Technology	39	0.1483	0.0510	0.1177	0.0453
Utilities	2	0.0000	0.0000	0.0000	0.0000

[1] Every year portfolios will be formed based on the four R&D intensity variables and divided into four categories resulting in a total of 16 portfolios per year. The period in which portfolios will be formed is between May 2011 and May 2017 resulting in a total of 7 years, generating a total of 112 portfolios.

4.1 Industry Distribution

The sample consists of stocks listed in the NASDAQ-100 and Dow Jones-30. The NASDAQ-100 is a tech heavy index and the Dow Jones-30 consists mostly of mega-cap stocks. The industry distribution shows most stocks in the sample are classified in the information technology sector. This sector is also amongst the most R&D intensive sectors together with communication services, consumer discretionary and health care. Information technology ranks the highest on R&D intensity when R&D intensity is measured relative to market cap, which indicates this sector includes small cap companies. The stocks in the financials and utilities sectors do not report or conduct any R&D activities. Noteworthy is the fact that sectors that tend to include stocks which are favored by value investors rank low on R&D intensity. Sectors which are generally classified as growth sectors rank higher on R&D intensity. This pattern is also observed when looking at the beta coefficients in the three-factor model of the various portfolios in the following sections.

4.2 Abnormal returns of Portfolios Classified by R&D Direct Expensed Relative to Sales

Table 2 in appendix A provides results for the portfolios sorted by R&D intensity measured as R&D expenses reported on the income statement relative to sales. Panel D reports the characteristics of the portfolios. The high R&D intensity portfolios experience more exposure to small cap companies. The average size of the companies in the low and mid R&D intensity portfolios is twice as big compared to the high R&D portfolios. The beta coefficient SMB shows similar results. Most small cap companies in the sample are in the health care and information technology sector. The market beta of the portfolios shows a positive linear relation with the R&D intensity of the portfolios. All four categories experience exposure to low book-to-market stocks, which is indicated by a negative value for the beta coefficient HML.

Panel A reports higher excess returns for the most R&D intensive portfolios compared to the less intensive R&D portfolios for both the 5-year period prior to portfolio formation, as well as the 3-year period after portfolio formation. The results in panel A show a positive linear relation between the excess returns and R&D intensity per category. The abnormal returns of the portfolios based on the CAPM model show a positive relation between the R&D intensity and the alpha of the portfolio. Panel C reports on the abnormal returns of the portfolios based on the three-factor model. There seems to be a positive relation between the R&D intensity of a portfolio and the abnormal returns based on the three-factor model. The average alpha of the non R&D portfolios in this three year period is 3.89 percent compared to 8.39 percent for the high R&D intensity portfolios. Table 6 in appendix B reports the results of the regression analysis between the R&D intensity measured as R&D direct expensed relative to sales and the abnormal returns for both return models. The first, second and third year post portfolio formation in both the CAPM and the three-factor model show a positive coefficient between these two variables. However, these observations have no statistical significance. This is most likely the result because of how the abnormal returns are estimated for these periods. The estimations of alpha are based on twelve data points, which is generally not enough to guarantee statistical significance. The average annual alpha over the three year period post portfolio formation report a positive coefficient for both the CAPM model and the three-factor model, with P-values of 0.0006 and 0.0019 respectively. These results are highly significant and confirm hypothesis I for this R&D intensity variable.

When looking at the trend over the first, second and third year post portfolio formation in table 2, the alphas in the CAPM model do not confirm hypothesis II. The only observation that confirms hypothesis II for this R&D intensity variable are the low R&D portfolios in the three-factor model. These observations might be inaccurate due to the fact that the estimations of alpha are based on twelve data points. Hypothesis II is rejected for this R&D intensity variable based on the results in table 2, as well as the lack of statistical significance.

4.3 Abnormal returns of Portfolios Classified by R&D Direct Expensed Relative to Market Capitalization

Table 3 in Appendix A provides results for the portfolios sorted by R&D intensity measured as R&D expenses reported on the income statement relative to the market value of equity or market capitalization. This variable is closely related to various financial ratios investors use to valuate firms. Panel D shows a similar pattern in firm size, compared to the previous R&D intensity variable. High R&D intensity portfolios experience greater exposure to small cap firms. All portfolios that conduct R&D activities report a positive beta coefficient SMB, which indicates the low and mid R&D intensity portfolios experience exposure to small cap companies as well. The market beta per category shows a positive linear relation with the R&D intensity of the portfolios. All four categories experience exposure to low book-to-market stocks, which is indicated by a negative value for the beta coefficient HML.

Panel A shows a completely different pattern for the excess returns, compared to the previous R&D intensity measure. The high R&D intensity portfolios show weaker performance prior to portfolio formation. Chan et al. (2001) observed a similar pattern in the most R&D intensive portfolios based on the R&D intensity relative to market capitalization and argued the stocks in this portfolio were poor performers in the past. However, the excess returns post portfolio performance are significantly higher compared to the non-R&D portfolios and the low R&D intensity portfolios. Panel B and C report the abnormal returns of the portfolios. In both models the mid R&D intensity portfolios underperform the non R&D portfolios. The high R&D portfolios show a significantly higher abnormal return compared the other categories. In the years 2012 and 2013 the R&D intensity ratios of the firms in the high R&D portfolio were almost 20 percent higher than the average ratio over the seven year period. Following, the alpha estimated over the three year period 2011-2013 and 2012-2014 were the highest reported. Table 7 in appendix B reports the results of the regression analysis between the R&D intensity measured as R&D direct expensed relative to market capitalization and the abnormal returns for both return models. The average annual alpha over the three year period post portfolio formation report a positive coefficient for both the CAPM model and the three-factor model, with P-values of 0.0040 and 0.0055 respectively. Most observations of the individual years post portfolio formation are not statistically significant. Based on the combined results reported in table 3 and table 7 hypothesis I can be confirmed for this R&D intensity variable.

Similar to the previous R&D intensity measure the results for the first, second and third year post portfolio formation do not report an increasing trend in the abnormal returns year on year. Based on these observations and the lack of statistical significance hypothesis II is rejected for this R&D intensity measure. In prior research by Chan et al. (2001) and Chambers et al. (2002) this ratio explained the returns of the portfolios more accurately than R&D intensity measured relative to sales. This is not the case for the abnormal returns of the portfolios for this R&D intensity ratio.

4.4 Abnormal returns of Portfolios Classified by R&D Expenses Amortized Relative to Sales

Table 4 in appendix A provides results for the portfolios sorted by R&D intensity measured as R&D expenses capitalized and amortized relative to sales. According to Lev and Sougiannis (1996) and Lev et al. (2005) this accounting technique results in a more realistic representation of the actual funds that are active in that particular year regarding R&D activities. Panel D reports the characteristics per category. The average firm size per category shows a similar pattern compared to first R&D intensity variable. The high R&D intensity portfolios experience the most exposure to small cap firms. The market beta per category shows a nonlinear pattern. The mid R&D intensity portfolios have a lower market beta compared to the low R&D intensity portfolios. All four categories experience exposure to low book-to-market stocks, which is indicated by a negative value for the beta coefficient HML.

The return profile, reported in Panel A, seems consistent with the previous R&D intensity ratio which is surprising since the R&D intensity measures are completely different. The high R&D intensive portfolios report the highest excess returns over the three years past portfolio formation and the return is almost twice as high as the non-R&D portfolios, 22.19 percent compared to 14.25 percent respectively. Panel B and C report the abnormal returns per category. The average annual abnormal returns in the three year period post portfolio formation support hypothesis I. The high R&D intensive portfolios report an alpha of 8.21 percent in the CAPM model and 7.55 percent in the three-factor model. The non-R&D portfolios report an alpha of 3.54 percent in the CAPM model and 4.01 percent in the three-factor model. Table 8 in appendix B reports the results of the regression analysis between the R&D intensity measured as R&D expenses amortized relative to sales and the abnormal returns for both return models. The coefficient for the first year after portfolio formation in the three-factor model reports the only negative value that is observed in this research, however this observation is far from significant. This might be due to the inaccuracy of estimating alpha in a twelve month period. The results based on the three year period post portfolio formation show a positive coefficient in both models with P-values of 0.0051 and 0.0042. The results reported in table 4 and table 8 combined confirm hypothesis I for this R&D intensity variable. The high R&D intensity portfolios seem to consistently outperform all other categories in the three year period post portfolio formation.

Hypothesis II is rejected for this R&D intensity ratio. There is no increase in abnormal returns year on year observed in the low and high R&D portfolios for both the CAPM and the three-factor model in table 4. This most likely caused by a lack of statistical significance when estimating the alphas of the portfolios.

The high R&D intensity portfolio formed in May 2017 reports a market beta of 0.89 which is unexpected since most high R&D portfolios report a beta of 1.1 or higher. This also reflects in the estimated alpha, which is 1.44 percent on average annually for the three year period post portfolio formation. Both the low and mid R&D intensive portfolios report a higher market beta in the same period, however the alphas for both portfolios are negative. The explanation for these observations is most likely linked to the financial crisis in early 2020 due to the corona virus outbreak. It highlights the fact that firms with a high R&D intensity seem to be more resilient. This is also confirmed when the excess returns per year are analyzed. The most negative excess return reported for the high R&D portfolios in any particular year is -4.37 percent compared to -14.7 percent for the non-R&D portfolios. The low and mid R&D portfolios report maximum negative excess returns of -15.66 percent and -16.18 percent respectively.

4.5 Abnormal returns of Portfolios Classified by R&D Expenses Amortized Relative to Market Capitalization

Table 5 in appendix A provides results for the portfolios sorted by R&D intensity measured as R&D expenses capitalized and amortized relative to market capitalization. Panel D reports the characteristics of the portfolios per category. All R&D categories experience exposure to small cap companies. The market beta per category shows a linear pattern, where the high R&D portfolio shows a significantly higher market beta compared to previous R&D intensity variables. All four categories experience exposure to low book-to-market stocks, which is indicated by a negative value for the beta coefficient HML.

Panel A reports the excess returns of the portfolios per category. The high R&D portfolio shows very poor past performance in the five years prior to portfolio formation. The three year period after portfolio formation of the high R&D intensive portfolios show the highest excess returns, on average 22.71 percent. Panel B and C report the abnormal returns of the portfolios sorted by R&D intensity. The average annual alpha over the three year period post portfolio formation shows a positive relation between the level of R&D intensity of the portfolios and the abnormal returns. The alpha of the high R&D intensive portfolios is on average 8.34 percent, compared to 3.54 percent for the non-R&D portfolios in the CAPM model. The alphas reported in the three factor model for the high R&D intensive and non-R&D portfolios are 7.86 percent and 4.01 percent respectively. The mid R&D intensity portfolios underperform the low R&D intensity portfolios in both models, reporting alphas of 4.01 percent and 3.16 percent compared to 4.84 percent and 3.82 percent. The regression results reported in table 9 in appendix B show highly significant observations for the average annual alpha over the three year period post portfolio formation with P-values of 0.0039 and 0.0043. All reported coefficients are positive, however the observations of the individual years show a lower statistical significance. Based on the combined results reported in table 5 and table 9 hypothesis I can be confirmed for this R&D intensity variable.

Based on the observations in table 5, hypothesis II is rejected. Only the low R&D intensity portfolios show an increasing trend in year on year abnormal returns.

5. CONCLUSION

Technology is one of the most important drivers in the modern economy. Many firms conduct R&D activities in order to gain or maintain competitive advantages. R&D activities generally require substantial amounts of capital investments and investors do not always anticipate the future benefits of these investments. Under the current accounting rules in the United States these investments are generally reported as an expense, rather than an intangible asset. Large R&D investments will result in lower financial performance of the firm in the financial report. Future benefits of R&D expenditure tend to materialize over time. This paper addresses the question whether abnormal returns are positively related to the level of R&D intensity of a firm.

The results of the analysis in this paper confirms hypothesis I, which states that firms with a high level of R&D intensity experience higher abnormal returns. All four R&D intensity variables produce the same results in which the most R&D intensive portfolios show a significantly higher abnormal return in the three year period post portfolio formation. The R&D intensity variables that are related to sales show a linear trend over the three categories of R&D intensity. The non-R&D portfolios tend to outperform the low R&D intensive portfolios when firms are classified by R&D intensity relative to sales. The results based on the R&D intensity ratios related to market capitalization do not show a linear pattern in the abnormal returns per category based on the average annual alpha over the three year period post portfolio formation reported in table 3 & 5. However, all four variables produce a positive relation between the R&D intensity and the abnormal returns with a similar magnitude. Based on the observations there is no significant difference in the abnormal returns of the high R&D intensive portfolios for the four different R&D intensity measures.

Hypothesis II is rejected for all four R&D intensity measures due to the fact that the alphas that are estimated by regression are not statistically significant, thus result in an inaccurate estimation for the one year period. This error in the research design can be mitigated by analyzing the abnormal returns on a weekly basis, rather than a monthly basis, in order to expand the data set that is required to estimate alpha.

The evidence in this paper suggests the level of R&D intensity can explain the abnormal stock returns of U.S based technology firms. There is a strong relation between high R&D intensive firms and high abnormal stock returns. High R&D firms outperform non-R&D firms on average by almost 4 percent per year. However, for firms with a lower R&D intensity the relation with the abnormal returns becomes weaker. On average over the three year period post portfolio formation, some low and mid R&D intensive portfolios experienced lower abnormal returns than the non-R&D portfolios. R&D expenses, both direct and amortized, relative to sales provide a better explanation of the abnormal stock returns over the full spectrum of R&D intensity. This is a surprising result since most previous studies reported a more direct relation between the R&D intensity relative to market capitalization.

Previous studies suggest the positive relation between R&D intensity and abnormal returns is present due to the interaction effect of variables such as competition or financial constraints. Due to the nature of this research and the limited amount of time this could not be analyzed in this research. Future research is needed to confirm the statement that there is a positive relation between the R&D intensity of a firm and the abnormal stock return without the influence of another variable.

Finally, this analysis is based on the period between 2010 and 2020, which covers the full recovery of the worldwide economy after the great recession between 2007 and 2009. The estimated alphas of most portfolios are positive due to the fact that the market has been in a bull run for most of the observation period. In early 2020 the corona virus outbreak caused all portfolios to experience negative alphas. Over all four R&D intensity portfolios, the high R&D intensity portfolios experienced a maximum negative alpha of -4.37 percent. All other R&D intensity categories including the non-R&D portfolios experienced negative alphas exceeding -15 percent. This observation suggests high R&D firms tend to be more resilient during periods of economic distress.

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7. APPENDIX

7.1 Appendix A

Table 2. Returns and characteristics of portfolios classified by R&D expenses relative to sales.

	1 (Low)	2 (Mid)	3 (High)	Non-R&D
Panel A: Excess Returns Before and After Portfolio Formation				
Average annual return over 5-year period before portfolio formation	0.1819	0.1934	0.2008	0.1749
First year after portfolio formation	0.1460	0.2031	0.2242	0.1546
Second year after portfolio formation	0.1796	0.1902	0.2374	0.1516
Third year after portfolio formation	0.1557	0.1877	0.2186	0.1147
Average annual return over 3-year period after portfolio formation	0.1604	0.1937	0.2267	0.1403
Panel B: Abnormal Returns After Portfolio Formation (CAPM Model)				
First year after portfolio formation	0.0196	0.0845	0.0796	0.0410
Second year after portfolio formation	0.0437	0.0587	0.0826	0.0301
Third year after portfolio formation	0.0527	0.0869	0.0820	0.0099
Average annual alpha over 3-year period after portfolio formation	0.0291	0.0616	0.0839	0.0343
Panel C: Abnormal Returns After Portfolio Formation (3-Factor Model)				
First year after portfolio formation	0.0101	0.0610	0.0687	0.0340
Second year after portfolio formation	0.0309	0.0483	0.0862	0.0230
Third year after portfolio formation	0.0353	0.0752	0.0605	0.0074
Average annual alpha over 3-year period after portfolio formation	0.0208	0.0517	0.0787	0.0389
Panel D: Characteristics of Portfolios				
Average number of firms	25.4	25.1	25.0	47.4
Average firm size (in $b)	87.0	89.2	40.0	63.6
Average revenue (in $b)	53.4	24.1	7.5	41.2
Average R&D intensity	0.0499	0.1325	0.3462	0.0000
Average 3-factor beta coefficients				
Mkt-Rf	1.1124	1.1352	1.1675	0.9018
SMB	-0.0653	-0.0980	0.3826	-0.0675
HML	-0.2106	-0.3020	-0.6658	-0.0878

Table 3. Returns and characteristics of portfolios classified by R&D expenses relative to market capitalization.

	1 (Low)	2 (Mid)	3 (High)	Non-R&D
Panel A: Excess Returns Before and After Portfolio Formation				
Average annual return over 5-year period before portfolio formation	0.2208	0.1859	0.1662	0.1749
First year after portfolio formation	0.1649	0.1583	0.2436	0.1546
Second year after portfolio formation	0.1703	0.1670	0.2642	0.1516
Third year after portfolio formation	0.1602	0.1682	0.2274	0.1147
Average annual return over 3-year period after portfolio formation	0.1651	0.1645	0.2450	0.1403
Panel B: Abnormal Returns After Portfolio Formation (CAPM Model)				
First year after portfolio formation	0.0526	0.0092	0.0752	0.0410
Second year after portfolio formation	0.0368	0.0191	0.1221	0.0301
Third year after portfolio formation	0.0604	0.0487	0.1115	0.0099
Average annual alpha over 3-year period after portfolio formation	0.0411	0.0320	0.0856	0.0343
Panel C: Abnormal Returns After Portfolio Formation (3-Factor Model)				
First year after portfolio formation	0.0454	-0.0002	0.0476	0.0340
Second year after portfolio formation	0.0318	0.0088	0.1356	0.0230
Third year after portfolio formation	0.0469	0.0331	0.0910	0.0074
Average annual alpha over 3-year period after portfolio formation	0.0300	0.0235	0.0829	0.0389
Panel D: Characteristics of Portfolios				
Average number of firms	25.4	25.1	25.0	47.4
Average firm size (in $b)	99.7	79.3	37.2	63.6
Average revenue (in $b)	41.3	24.2	19.6	41.2
Average R&D intensity	0.0146	0.0369	0.1005	0.0000
Average 3-factor beta coefficients				
Mkt-Rf	1.0879	1.1172	1.1687	0.9018
SMB	0.0507	0.0231	0.1377	-0.0675
HML	-0.4328	-0.3529	-0.3600	-0.0878

Table 4. Returns and characteristics of portfolios classified by R&D expenses amortized relative to sales.

	1 (Low)	2 (Mid)	3 (High)	Non-R&D
Panel A: Excess Returns Before and After Portfolio Formation				
Average annual return over 5-year period before portfolio formation	0.2082	0.1907	0.1712	0.1777
First year after portfolio formation	0.1643	0.1922	0.2135	0.1564
Second year after portfolio formation	0.1859	0.1835	0.2302	0.1548
Third year after portfolio formation	0.1633	0.1725	0.2220	0.1163
Average annual return over 3-year period after portfolio formation	0.1711	0.1828	0.2219	0.1425
Panel B: Abnormal Returns After Portfolio Formation (CAPM Model)				
First year after portfolio formation	0.0410	0.0747	0.0676	0.0415
Second year after portfolio formation	0.0538	0.0529	0.0735	0.0316
Third year after portfolio formation	0.0548	0.0770	0.0884	0.0102
Average annual alpha over 3-year period after portfolio formation	0.0383	0.0521	0.0821	0.0354
Panel C: Abnormal Returns After Portfolio Formation (3-Factor Model)				
First year after portfolio formation	0.0349	0.0665	0.0416	0.0327
Second year after portfolio formation	0.0397	0.0551	0.0659	0.0244
Third year after portfolio formation	0.0407	0.0710	0.0567	0.0081
Average annual alpha over 3-year period after portfolio formation	0.0291	0.0443	0.0755	0.0401
Panel D: Characteristics of Portfolios				
Average number of firms	25.9	25.4	25.1	46.6
Average firm size (in $b)	100.6	80.9	38.6	61.0
Average revenue (in $b)	57.1	20.2	8.9	40.4
Average R&D intensity	0.0319	0.0938	0.2491	0.0000
Average 3-factor beta coefficients				
Mkt-Rf	1.1291	1.1162	1.1469	0.9104
SMB	-0.0651	-0.0088	0.2852	-0.0624
HML	-0.2080	-0.4268	-0.5369	-0.0893

Table 5. Returns and characteristics of portfolios classified by R&D expenses amortized relative to market capitalization.

	1 (Low)	2 (Mid)	3 (High)	Non-R&D
Panel A: Excess Returns Before and After Portfolio Formation				
Average annual return over 5-year period before portfolio formation	0.2371	0.2017	0.1344	0.1777
First year after portfolio formation	0.1687	0.1843	0.2161	0.1564
Second year after portfolio formation	0.1909	0.1613	0.2479	0.1548
Third year after portfolio formation	0.1760	0.1634	0.2173	0.1163
Average annual return over 3-year period after portfolio formation	0.1785	0.1697	0.2271	0.1425
Panel B: Abnormal Returns After Portfolio Formation (CAPM Model)				
First year after portfolio formation	0.0407	0.0510	0.0909	0.0415
Second year after portfolio formation	0.0592	0.0146	0.1069	0.0316
Third year after portfolio formation	0.0774	0.0416	0.1006	0.0102
Average annual alpha over 3-year period after portfolio formation	0.0484	0.0401	0.0834	0.0354
Panel C: Abnormal Returns After Portfolio Formation (3-Factor Model)				
First year after portfolio formation	0.0430	0.0249	0.0739	0.0327
Second year after portfolio formation	0.0484	0.0210	0.0917	0.0244
Third year after portfolio formation	0.0630	0.0361	0.0690	0.0081
Average annual alpha over 3-year period after portfolio formation	0.0382	0.0316	0.0786	0.0401
Panel D: Characteristics of Portfolios				
Average number of firms	25.9	25.4	25.1	46.6
Average firm size (in $b)	103.7	73.7	42.6	61.0
Average revenue (in $b)	42.8	24.2	19.6	40.4
Average R&D intensity	0.0089	0.0273	0.0832	0.0000
Average 3-factor beta coefficients				
Mkt-Rf	1.0838	1.1018	1.2072	0.9104
SMB	0.0768	0.0352	0.0949	-0.0624
HML	-0.5000	-0.3188	-0.3457	-0.0893

7.2 Appendix B

Table 6. Regression results of the relation between the R&D intensity variable and abnormal returns.

R&D Direct Expensed Relative to Sales			
	Coefficient	*t*-statistic	P-value
Panel A: Statistics of the relation in the CAPM Model			
First year after portfolio formation	0.0117	1.2619	0.2182
Second year after portfolio formation	0.0113	1.3653	0.1838
Third year after portfolio formation	0.0156	1.8996	0.0686
Average annual alpha over 3-year period after portfolio formation	0.0128	3.8785	0.0006
Panel B: Statistics of the relation in the 3-Factor Model			
First year after portfolio formation	0.0107	1.0156	0.3192
Second year after portfolio formation	0.0179	2.0895	0.0466
Third year after portfolio formation	0.0133	1.6115	0.1191
Average annual alpha over 3-year period after portfolio formation	0.0137	3.4650	0.0019

Table 7. Regression results of the relation between the R&D intensity variable and abnormal returns.

R&D Direct Expensed Relative to Market Cap			
	Coefficient	*t*-statistic	P-value
Panel A: Statistics of the relation in the CAPM Model			
First year after portfolio formation	0.0406	1.3022	0.2043
Second year after portfolio formation	0.0885	2.9517	0.0066
Third year after portfolio formation	0.0672	2.4715	0.0203
Average annual alpha over 3-year period after portfolio formation	0.0474	3.1575	0.0040
Panel B: Statistics of the relation in the 3-Factor Model			
First year after portfolio formation	0.0299	0.8864	0.3835
Second year after portfolio formation	0.1022	3.5795	0.0014
Third year after portfolio formation	0.0580	2.1177	0.0439
Average annual alpha over 3-year period after portfolio formation	0.0493	3.0306	0.0055

Table 8. Regression results of the relation between the R&D intensity variable and abnormal returns.

R&D Amortized Relative to Sales			
	Coefficient	*t*-statistic	P-value
Panel A: Statistics of the relation in the CAPM Model			
First year after portfolio formation	0.0070	0.6343	0.5315
Second year after portfolio formation	0.0100	0.9002	0.3763
Third year after portfolio formation	0.0230	2.3143	0.0288
Average annual alpha over 3-year period after portfolio formation	0.0143	3.0549	0.0051
Panel B: Statistics of the relation in the 3-Factor Model			
First year after portfolio formation	-0.0008	-0.0622	0.9509
Second year after portfolio formation	0.0152	1.2972	0.2060
Third year after portfolio formation	0.0162	1.5343	0.1370
Average annual alpha over 3-year period after portfolio formation	0.0151	3.1382	0.0042

Table 9. Regression results of the relation between the R&D intensity variable and abnormal returns.

R&D Amortized Relative to Market Cap			
	Coefficient	*t*-statistic	P-value
Panel A: Statistics of the relation in the CAPM Model			
First year after portfolio formation	0.0558	1.6392	0.1132
Second year after portfolio formation	0.0745	2.1804	0.0385
Third year after portfolio formation	0.0622	1.9919	0.0570
Average annual alpha over 3-year period after portfolio formation	0.0452	3.1631	0.0039
Panel B: Statistics of the relation in the 3-Factor Model			
First year after portfolio formation	0.0507	1.3685	0.1829
Second year after portfolio formation	0.0681	2.0108	0.0548
Third year after portfolio formation	0.0438	1.4473	0.1598
Average annual alpha over 3-year period after portfolio formation	0.0481	3.1249	0.0043