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L'IMPATTO DELLA RICERCA E SVILUPPO SUL VALORE DELLE IMPRESE IN EUROPA

(The impact of R&D on firm value across Europe)

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Abstract

In this thesis the impact of R&D expenditures on firm market value and stock returns is examined. This is performed in a sample of European listed firms for the period 2000-2009. I apply different linear and GMM econometric estimations for testing the impact of R&D on market prices and construct country portfolios based on firms' R&D expenditure to market capitalization ratio for studying the effect of R&D on stock returns.

The results confirm that more innovative firms have a better market valuation, investors consider R&D as an asset that produces long-term benefits for corporations. The impact of R&D on firm value differs across countries. It is significantly modulated by the financial and legal environment where firms operate. Other firm and industry characteristics seem to play a determinant role when investors value R&D. First, only larger firms with lower financial leverage that operate in highly innovative sectors decide to disclose their R&D investment. Second, the markets assign a premium to small firms, which operate in hi-tech sectors compared to larger enterprises for low-tech industries.

On the other hand, I provide empirical evidence indicating that generally highly R&D-intensive firms may enhance mispricing problems related to firm valuation. As R&D contributes to the estimation of future stock returns, portfolios that comprise high R&D-intensive stocks may earn significant excess returns compared to the less innovative after controlling for size and book-to-market risk. Further, the most innovative firms are generally more risky in terms of stock volatility but not systematically more risky than low-tech firms. Firms that operate in Continental Europe suffer more mispricing compared to Anglo-Saxon peers but the former are less volatile, other things being equal. The sectors where firms operate are determinant even for the impact of R&D on stock returns; this effect is much stronger in hi-tech industries.

1. Introduction

The aim of this Ph.D. dissertation is to study the impact of research and development expenditures (hereafter R&D) on stock market value, on the overall and systematic risk of this type of investment and on firm stock returns for a sample of European firms. In the last 30 years this topic has attracted the attention of numerous scholars all over the world.

The benefits of innovation in terms of sales growth, market value increase are drawn by the seminal work of Schumpeter (1934, 1942). He introduced the term “creative destruction” and postulated that the economic change revolves around innovation, entrepreneurial activities and market power and sought to prove that the innovation-originated market power could provide better results than the invisible hand & price competition. Schumpeter argued that technological innovation often creates temporary monopolies, allowing abnormal profits that would soon be competed away by rivals and imitators; these temporary monopolies are necessary to provide the incentive necessary for firms to develop new products and processes (Schumpeter, 1942).

Other studies in the following of the past century posit that knowledge management activities are fundamental for guarantying firm survival in the long term. Firms’ success depends on the availability of specific knowledge which is not possessed and difficult to be accomplished by other competitors (Nelson and Winter, 1982; Sicca, 1998; Sobrero and Torrisi, 2007). Firms’ intangible assets are superior to tangible ones because they contain the necessary requisites (knowledge) in order to have a sustainable advantage in the long term (Gabrielli, 2006). The key role of the intangibles for firms has inspired the *knowledge based theory* (Zack, 1999) which identifies in the creation, accumulation and use of knowledge the main functions of the modern firm (Krogh et al. 2000).

Drawing on these theories there is a large body of research which considers knowledge management inside the firm as a key success factor which creates competitive advantage, and boosts firm performance. Many empirical studies have tried to capture the relation between innovation which is powered by knowledge and growth at a micro or a macro level. Firm growth is influenced or influences a set of other specific performance indicators like firm productivity, firm value and firm earnings.

R&D is the main activity inside the firm which contributes to the creation and preservation of innovation. Hence, it’s the main input indicator that has been used in the literature for testing the link between innovation and growth or innovation and firm performance. If we consider R&D as an input in the innovation creation process inside the firm, then there must be other output indicators that can be related and influenced by it. Prior research has individuated different firm level variables that can assume this role. These can be scientific publications from members of firm R&D department (Oriani, 2004); number of registered patents (Hall et al. 2000), number of citations on the registered patents (Bloom and Van Reenen, 2002); new products or processes, firm productivity or firm economic or financial performance.

Griliches (1981) was one of the first authors that tried to measure the link between R&D as a proxy for innovation and firm performance by introducing a closed form model, the so-called *hedonic model*. It permitted to capture the value relevance of R&D, which creates intangible capital for the firm and thus positively impacts firm value. After Griliches (1981) several empirical studies have found that investors consider R&D expenditures as value relevant for the firm, which means that, when R&D is disclosed, it is associated with investors' valuation of the firm and has a significant effect on firm's stock price or firm performance (Wyatt, 2008). This literature in turn, includes two main strands: one focusing upon the impact of R&D on productivity (Griliches, 1995, Mairesse and Mohen, 1996; Hall, 2009) and the other on market valuation (Cockburn and Griliches 1988; Chauvin and Hirschey, 1993; Hall, 1993b; Sougiannis, 1994; Stark and Thomas, 1998; Toivanen et al. 2002; Conolly and Hirschey, 2005; Pindado et al. 2010).

There is another research mainstream which has emphasized a significant relationship between R&D and expected stock returns (Lev and Sougiannis, 1996; Chan et al. 2001; Chambers et al. 2002; Dedman et al. 2009). This correlation has been attributed to a possible mispricing effect due to the failure of investors to correctly estimate the effects of R&D on the future firm cash flows or secondly, to a different risk-pattern of the investments in R&D compared to tangible assets.

The difficulty in evaluating the present value of R&D investments can be due to different factors. R&D-intensive firms generally have few tangible assets, the future benefits from R&D programs are far from assured and cash flows from these projects are difficult to evaluate (Aboody and Lev, 2000; Chan et al. 2001; Kothari et al. 2002). This may lead to a problem of undervaluation of the net value of these expenditures if long term benefits of R&D are not considered exhaustively, or overpricing, if investors inflate the market value of R&D-intensive firms being too optimistic about firm growth related to R&D activity (Al-Horani et al. 2003; Chiao et al. 2008). Second, under U.S. and International GAAP, R&D costs are completely expensed in the year when they are incurred, unless a clear connection between part of these costs and a hypothetic future product for sale can be demonstrated[1]. Investors can erroneously produce high multiples of these firms if they fail to correct accounting variables for long term benefits of R&D. They can also be misled by the past performance of stocks assigning excessive preference to past winners which can suffer momentum reversals in the future (Lakonishok et al. 1994; Chan et al. 2001).

The risk-pattern approach draws from the seminal work of Fama and French (1992), which suggest that measures of firm size and book-to-market ratio (BM) are able to capture part of the firm's risk that the CAPM is not able to explain. Other authors have evidenced in successive research that the overall predictive power of the Fama and French model increases when a R&D variable is added to it (Lev and Sougiannis, 1996). R&D projects may contribute sensibly to firm business risk or systematic risk in a way that may not be totally attributed to size and book-to-market ratio; hence, adjusting realized returns only for the former factors is unlikely to completely control for firm risk (Chambers et al. 2002a).

Recently, several contributions in the literature have tried to assess how the effect of the national financial and legal environment affects the market value of R&D investment. Innovation projects are the main drivers for firm growth, and the way they are financed and valued by investors may depend on the predominance of a direct or indirect intermediation model. The results on this topic are still not conclusive. Bae and Kim (2003) notice that the R&D impact on market value is stronger for a sample of Japanese firms compared to US firms, perhaps due to a "corporate myopia" typical of a market-based country where stock markets value positively short-term earnings compared to a bank-based country like Japan. However, Booth et al. (2006) provide evidence that the link between R&D and market value is stronger when the portion of equity financing in a country exceeds bank loan financing, and usually this happens in market-based intermediation systems.

[1] IAS 38 for European countries and SFAS 2 for the US.

The novelties of this study are mainly three: First, there is scarcity of research examining the effect of R&D on firm value for Continental Europe firms. The last two decades have witnessed a sensible growth of the number of firms which invest in R&D expenditures in these countries. Research and development is perceived as a strong value driver by European Institutions, local policy makers and corporations[2]. In 1995 the EU published the *Green Paper on Innovation*. It stressed the necessity that institutions in Europe should increment their capacity to invest in research and development. Moreover, the book enhanced the role of innovation for sustainable economic growth in the long term.

In March 2010 the European Commission presented its ten-year strategy by promoting smart and sustainable growth for the Community members, *Europe 2020*. It followed the *Lisbon Agenda* (2000) whose adoption did not yield the desired outcomes. The new agenda puts innovation in the center of all economic policies for economic growth. All country members have agreed to raise the *EU* R&D ratio to *GDP* up to 3% for that year and to increase efforts for promoting R&D by private owned corporations. Actually, *OECD* statistics show that this ratio is below 2% in *EU* countries against 2.8% for the US and 3.4% for Japan. Many countries including Italy actually invest less the 1.5% of their *GDP* in R&D, with a very low incidence of R&D from non-state owned corporations (Table 1 and 2 in the Appendix).

Second, I show in Section 4.1 that there exists a strong connection between R&D, sector R&D intensity, firm size and firm market value. Previous research has generally tested the impact of R&D on market value at the firm level after controlling for firm size and industry dummies (Chauvin and Hirschey, 1993; Booth et al. 2006). I follow a different approach, as I study the effect of industry on the value relevance of R&D by sorting firms in three groups according to their propensity to innovate. This variable is often used in the entrepreneurship literature for dividing industrial sectors in two regimes; the former is guided by creative destruction while the latter by creative accumulation. The first is characterized by technologies with high opportunities, low appropriability and low cumulativeness (Breschi et al. 2000). Industries subjected to this regime tend to have low barriers and new firms dominate the innovation activities of the industry. The other type is

[2] Lisbon Strategy (European Union agenda for promoting innovation, “learning economy” and social and environmental renewal in the EU)

characterized by creative accumulation technology. The experienced incumbent and larger firms have innovative comparative advantages compared to new entries.

I hypothesize that investors take into consideration the industry sector in a similar pattern when they have to assess the value relevance of innovation activities, which is indirectly related to the industry level of R&D intensity. Moreover, it seems that firm size modulates this relationship because smaller firms are more able to reap benefits from innovation in determinate sectors, while larger firms have more advantages in others. As far as I know, this issue had not been tackled in the previous literature.

Third, to the best of my knowledge, this the first study that examines the impact of R&D on stock returns in European financial markets. I apply different models for testing whether in these countries there is a potential mispricing of R&D and whether this is due to systematic risk not accounted by other empirical models.

The correct valuation of the R&D impact on stock returns across Europe can help investors to designing future investment strategies. It can also give managers and regulators useful insights on the long term benefits of R&D on stock prices and returns, which can be translated in more macroeconomic growth e social allocative efficiency. Moreover, the relationship between innovation and price variability is investigated together with the possibility that excess returns are due to industry sectors.

In order to explore the impact of R&D in market value, in this study I adopt an accounting based model based on Edwards-Bell-Ohlson residual income model (Ohlson, 1989). I extend this model for capturing various firm and country characteristics in order to analyze the relationship between R&D firm expenditures and the market value. The mispricing of R&D investment and the presence of excess returns in more innovative firms are studied by the Fama and French (1992, 1993) risk models which are also used for assessing the importance of R&D in predicting stock volatility.

The results show that R&D is positively related to firm value, although this relationship is modulated by different firm and country factors like firm size, the industrial sector where firms operate and the legal and financial environment of the country of domicile. On the other hand I find that more R&D intensive firms experience generally higher returns in the future, higher variability which indicates that R&D investment is perceived as more risky by investors. However the results are not homogeneous across different countries.

The thesis is structured as follows: in Section 2 several issues related to firm R&D activity are explained. In section 3 the theoretical background for the different approaches is evidenced. In sections 4 and 5 the two main methodologies together with sample description and empirical evidence are presented. Conclusions and final remarks follow.

2. Considerations about research and development activities at the firm level

2.1 Definition and delimitation of R&D activity

Many authors have offered definitions and have tried to set some boundaries of R&D activity inside the firms. However, many of these definitions have proved to be questionable and arbitrary. For example, Gambardella (1995) considers R&D as the firm function which is specialized in the generation, development and experimentation of technological innovation. He focuses in the innovation process and assigns this function only to the R&D function inside the firm. However, there also other divisions inside the firm which can innovate and secondly, innovation is not merely technological (Piccaluga, 1996).

Actually, researchers refer to the *Frascati Manual* for R&D definition. It was published in 1964 e periodically revisited by the *OECD*. The manual contains recommendations about gathering data on R&D activity in *OECD* country members. According to this manual, R&D comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications. The term R&D covers three activities: basic research, applied research and experimental development. Basic research is experimental or theoretical work which is undertaken primarily to acquire new knowledge of the underlying foundation of the phenomena and observable facts, without any particular application or use in view. Basic research can be further on subdivided in pure basic research and oriented research. The former is carried out for the advancement of knowledge, without seeking long-term economic or social benefits or making any effort to apply the results to practical problems or to transfer the results to sectors responsible for their application. Oriented research is carried out with the expectation that it will produce a broad base of knowledge likely to form the basis of the solution recognized or expected, current or future problems or possibilities.

Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific practical aim or objective. Applied research is undertaken either to determine possible uses for the findings of basic research or to determine new methods or ways of achieving specific and predetermined objectives. It involves considering the available knowledge and its extension in order to solve particular problems. In the business enterprise sector, the distinction between basic and applied research is often marked by the creation of a new project to explore promising results of a basic research program.

The results of applied research are intended primarily to be valid for a single or limited number of products, operations, methods or systems. Applied research gives operational form to ideas. The knowledge or information derived from it is often patented but may be kept secret.

Experimental development is systematic work, drawing on existing knowledge gained from research and/or practical experience, which is directed to producing new materials, products or devices, to installing new processes, systems and services, or to improving substantially those already produced or installed. R&D covers both formal R&D in R&D units and informal or occasional R&D in other units. In the social sciences, experimental development may be defined as the process of translating knowledge gained through research into operational programs, including demonstration projects undertaken for testing and evaluation purposes.

Although the manual tries to set definite boundaries to different forms of research, it is difficult in practice for firms to correctly delimitate activities comprised in basic research and activities that can be defined as applied research. Small firms encounter difficulties in splitting costs and assigning them to the R&D voice. These can be payroll, overhead costs and costs for materials. These issues can influence the disclosure of R&D expenditures and the correct adoption of the accounting rules to them.

2.2. The accounting regime of R&D expenditures

Current economic literature considers R&D as a long-term investment that may generate benefits over multiple years. Hence, R&D should be treated as investment in plant and long-term equipment, capital expenditures (Lev and Sougiannis, 1999). However, it seems that this is not the rationale for accounting treatment of R&D in the USA, where, from 1974 it has been compulsory to write off all R&D expenses according to GAAP accounting rules, and also to completely disclose them for the benefit of investors. This is due to the fact that regulators have the belief that the benefits deriving from R&D activity are highly uncertain and no bank would accept them as collateral in a borrowing contract like they normally do for tangible assets like plant and equipment (Damodaran, 2009).

In Europe, the situation until 2004 has been somewhat more varied. The accounting rules were differentiated mainly between basic research on the one side and development expenses on the other. The former investments were generally expensed, whereas for development projects capitalization were allowed if certain conditions were met; these basically concerned the possibility that the firm could demonstrate a link between the expenses and a marketable product or service.

Accounting systems in Europe are different from one another and inspired by different social and historical foundations. France and Germany practice code-law and have a “macrouniform, government-driven and tax-dominated” accounting system (legal compliance model), whereas the accounting system in the UK is more “micro, fair, judgmental and commercially driven” (Zhao, 2002). Empirical studies have provided evidence that accounting earnings have higher quality in common-low than code-law countries (Ball et al. 1998).

R&D accounting in Germany is inspired by a desire for prudential accounting, which is related to the importance of banks in the German system. Banks are major stakeholders in almost every big listed corporation. The law does not require the disclosure of R&D, but only “recommends” it. German tax authorities are very reluctant to permit R&D capitalizing even when future benefits could be clearly defined, as they are inspired by a prudential accounting policy.

In Sweden, companies rarely disclosed R&D expenditures before the 1990s. However, under strong pressure from trade unions the situation changed during the last years of the 20th century, when most firms began to disclose their investment in R&D. The accounting rules in Sweden are driven by a strong commitment to taxation policy, so capitalization is strongly discouraged, except under stringent and almost impossible conditions.

In the UK there was no requirement until 1989 for companies to disclose their expenditures in R&D, so many did not. After 1985 a general debate took place concluding with the adoption of the SSAP 13 in 1989. This accounting principle recommended the disclosure of R&D for firms meeting certain size thresholds. Stoneman and Toivanen

(2001) provide evidence that the adoption of SSAP 13 produced a large increase in the disclosure of R&D expenditures for all classes of firms. The accounting treatment of R&D requires the complete expensing of basic research and permits capitalization of development expenditure if certain circumstances are met.

Since 2005, all European listed firms have adopted the *IAS - IFRS* accounting principles for their financial statements, in an effort towards harmonization of accounting treatments across the continent. Under this perspective, there have been few changes for basic research costs, which continue to be totally expensed. Development expenditures can still be capitalized, but now this rule is somewhat more detailed, as the firm should provide proof that this expense creates an intangible asset that will produce specific goods or services available for sale (IAS 38.57). Due to the difficulty of the application of this rule, there is evidence that listed firms completely expense R&D in the year it is incurred (Damodaran, 2009). Disclosure has still not become compulsory (Hall and Oriani, 2006).

3. Theoretical background

3.1. The impact of R&D on firm market value, the hedonic model

The hedonic model stems from the seminal works of Griliches (1981) and others. The main advantage of the model is that it doesn't require for researchers to directly measure the benefit of the investment in R&D in terms of economic performance (earnings growth) or a specific output (firm total productivity). This could be difficult in practice because first, data would not cover a long enough time in order to enable precise measurement of the total effect. Second, occasionally long and uncertain lags between the investment in innovation and its output would mean that a researcher might have to wait a certain amount of time to see the effects in firm productivity (Hall, 2000). Instead, the model relates the valuation placed by the financial markets on a firm's assets to its R&D expenditure. This relies on the fact that listed companies are considered bundles of assets (tangibles and intangibles), whose values are determined every day by financial investors. In equilibrium, the market valuation of any asset results from the interaction between firms' demand for investment and the market supply of capital for that specific asset (Hall and Oriani, 2006). The market value can be represented as a linear function of its assets:

$$V_{it} = V(A_{it}, K_{it}, I_{it}) \tag{1}$$

where A_{it} is the book value of tangible assets, K_{it} is the replacement value of the firm's technological knowledge and I_{it} is the replacement value of the other intangible assets. If we consider assets as purely additive, the market value of the firm can be expressed as a linear function of these assets:

$$V_{it} = q_t(A_{it} + \gamma K_{it} + \lambda I_{it})^{\sigma} \tag{2}$$

where q_t is the average market valuation coefficient of a firm's total assets (reflecting the differential risk and monopoly position of the firms in the sample) and sigma are returns to scale (which usually are assumed equal to one). So the hedonic model treats the firm as a good whose characteristics are its tangible and intangible assets. In the log form the previous model can be expressed as:

$$\log(\frac{V_{it}}{A_{it}}) = \log q_t + log(1 + \gamma\, K_{it}/A_{it} + \lambda\, I_{it}/A_{it}) \qquad (3)$$

The ratio V_{it}/A_{it} can be assumed as a proxy for Tobin's q, the ratio of the market value of tangible assets to their physical value (Hall and Oriani, 2006). This equation permits to value the impact of a euro invested in innovation on the market value of the firm at a certain point in time.

The initial empirical results from adopting this approach were originated from US data. This was due to the fact that US accounting principles from 1974 required a complete expensing and disclosure of R&D investment, so there exists a broad database and highly efficient financial markets that have permitted highly significant inference. The seminal work of Griliches (1981) was followed by other contributions like Pakes (1985) which finds that unexpected changes in R&D are associated with large changes on the market value of the firm. Jaffe (1986) evidences that firms that invest intensively in R&D, experience greater benefits in terms of market value if they operate in sectors which are also R&D intensive. Cockburn and Griliches (1988) show an interaction between effectiveness measures of the innovation appropriability regime and the market valuation of the firm's R&D share, confirming that it significantly affects the expected returns from the R&D activity. Hall (1993a and 1993b) finds that the effect of R&D on stock market value fell sharply during the decade 1980-1990 due to different factors like the fall of private rate of return to R&D capital, the increase of the depreciation rate of R&D assets, more myopic financial markets which discounted R&D at a much higher rate or the takeover era which took place during the '80ies. Chauvin and Hirschey (1993) provide evidence that R&D and advertising have positive and consistent influence on the market value of the firms especially for high-tech firms. Megna and Klock (1993) continue the exploratory analysis of Cockburn and Griliches (1988), looking for complementary information to determine whether the measures of intangible capital contribute significantly to the change in Tobin's q. They focus on the semiconductor segment of the electronics industry and the strategic importance that intangible capital assumes in this area. Their findings, analyzing eleven registered companies in the Compustat database for the period 1972-1990, suggest that intangible capital contributes to the change in Tobin's q, but substantial differences remain in the q ratio in the reference field, as shown by the firm-specific effects. The stock of R&D and the stock of patents have a positive and significant impact.

Outside the US this model has been used for British data because even in the UK from 1989 accounting rules imposed firm to expense R&D in the year it was incurred with few exceptions for development expenditures (Stark and Thomas, 1989). Stoneman and Bosworth (1994) estimate a model very similar to that of Hall (1993b) using a balanced panel of 180 UK companies over the period 1984-1992. The main difference is the omission of advertising expenses and the use of the variables for patents and investment in physical capital. The results suggest that R&D and patents have a positive impact on market value, in general, with R&D affecting it more strongly than patents. Toivanen et al. (2002) realize a cross-section and panel analysis of a set of UK listed companies for the period 1989-1995. The two techniques show a positive and statistically positive coefficient for the R&D expenditure, but it widely varies without a specific trend from year to year, in contrast to what was observed by Hall (1993b) for U.S. firms.

Blundell et al. (1999) examine the relationship between technological innovations, market share and market value of 340 listed companies in the United Kingdom from 1972 to 1982. They find a positive and significant effect of market share on the number of commercialized innovations and patents, although they note that more competition in the industry tends to stimulate innovative activity. In addition, they find that the innovation impact on market value is greater for firms with higher market shares.

Hall and Oriani (2006) adopt the hedonic model for a cross-country comparison of the market valuation of R&D. The results evidence a positive and a robust valuation of R&D by the stock market for the German and French samples although the valuation of the R&D investments in the cross section is substantially greater for UK firms. From the perspective of the financial investors, this means that a currency unit spent in R&D by a company in the United Kingdom has on average an impact whose magnitude is nearly three times bigger than in France and Germany. However the paper evidences how the markets value R&D less than the unity and the trend has been decreasing over time.

3.2 The impact of R&D on firm market value, the accounting-based model

The accounting-based model derives from the contributions of Ohlson (1989, 1995) and others. It is based on the classical valuation model which reveals equity price to be the present value of future abnormal earnings (Rees, 1997). According to this model:

$$MV_{i,t} = BV_{i,t} + \sum_{\tau=1}^{\infty} E\left(RI_{i,t+\tau}\right) / \prod_{n=1}^{\tau}(1 + k_{i,t+n}) \tag{4}$$

Where $MV_{i,t}$ is the market value of firm i at time t, $BV_{i,t}$ is the book value of firm i at time t, $RI_{i,t+\tau}$ is the residual income of firm i at time $t+\tau$, $k_{i,t+n}$ is the risk-adjusted cost of capital for firm i at time $t+n$ and $E\ (\ .\ )$ is the expectations operator. The main novelty of the model is that the present market value is a function of current book value plus the present value of expected abnormal income (Green at al. 1996). As expectations about residual income are formed at time t, we have:

$$RI_{i,t} = (\pi_{i,t} - k_{i,t} BV_{i,t-1}) \tag{5}$$

Where $\pi_{i,t}$ is a measure of income (operating earnings after taxes usually). After assuming that future residual incomes can be modeled as declining at a rate $\delta > 0$, we can model them as:

$$\sum_{\tau=1}^{\infty} E\left(RI_{i,t+\tau}\right) / \prod_{n=1}^{\tau}(1 + k_{i,t+n}) = \frac{1-\delta}{k+\delta} RI_{i,t} \tag{6}$$

This is consistent with competitive markets where the initial advantage which permits in the beginning earning rates superior to the cost of capital k, is eroded at a fixed rate.

The right hand of equation (4) expresses the value in excess of book value of assets in place. Previous research has evidenced that the impact of R&D on market value can be reflected indirectly through earnings (Sougiannis, 1994). Past R&D expenditures have a significant effect in explaining residual income because they influence the tangible investments made by the firm. Only current R&D expenditures influence the present firm market value once we include in the equation the residual income variable. The latter captures the effect of past R&D expenditures that are currently producing benefits for the firm via the existing assets. These arguments suggest a modification of the basic residual income model:

$$MV_{i,t} = BV_{i,t} + \beta RI_{i,t} + \gamma RD_{i,t} + \varepsilon_{i,t} \tag{7}$$

Usually all variables in the above model are scaled by a size variable like the replacement value of total assets in order to avoid heteroskedasticity problems (Pindado et al. 2010). Other deflators have also been used like sales (Hirschey, 1985), number of shares (Rees 1997), opening market value (Lo and Lys, 2000), closing market value (Stark and Thomas, 1998). Rearranging, the final residual income model would be the following:

$$(MV_{i,t} - BV_{i,t})/BV_{i,t} = \beta RI_{i,t}/BV_{i,t} + \gamma RD_{i,t}/BV_{i,t} + \varepsilon_{i,t} \tag{8}$$

Further extensions of the model by other researchers have substituted the residual income variable with earnings before exceptional and extraordinary items. Dividends have also been added due to their signaling role (Bhattacharya, 1979). Akbar and Stark (2003) introduce the concept of net shareholders cash flows which comprise net dividends to shareholders and capital contributions from them. So, a new version of the accounting-based model after deflating all variables by closing book value of assets in order to reduce heteroskedasticity would be the following (Hughes, 2008):

$$(MV_{i,t} - BV_{i,t})/BV_{i,t} = \beta_1 E_{i,t}/BV_{i,t} + \beta_2 RD_{i,t}/BV_{i,t} + \beta_3 D_{i,t}/BV_{i,t} + \beta_4 CC_{i,t}/BV_{i,t} + \varepsilon_{i,t} \tag{9}$$

Where $E_{i,t}$ are earnings of firm i at time t, $D_{i,t}$ are firm dividends for year t, $CC_{i,t}$ are capital contributions from shareholders and stock buybacks.

Previous research has applied these models mainly on UK data. Green et al. (1996) collect data for UK listed firms for years 1990, 1991 and 1992. The results do not show a convincing significance of the R&D variable on firm market value. The R&D coefficient is positive and significant at the 5% level for 1990 and significant at the 10% level for 1991 and 1992. Stark and Thomas (1998) provide stronger evidence; they do not restrict the sample as Green et al. (1996) only to firms which report R&D expense. The results are much more positive in favour of the value relevance of R&D expense, with the coefficients on all the annual cross-sections and the pooled data being positive and significant at the 5% level. Furthermore, the actual increases in explanatory power associated with the addition of R&D expense into the firm value equation are sizeable enough to be noticed not merely statistically.

Akbar and Stark (2003) use all non-financial UK firm-year observations for which data is available from 1990 to 2001. Estimates of the R&D loading in pooled cross-section regressions are significant for all deflators (book value, sales, number of shares and opening book value). The empirical results support the hypothesis that the capital markets treat R&D expenditures as a long term investment.

Hughes (2008) uses a sample of UK firms for the period 1990-2005. She finds a significant positive effect of R&D on firm market value after correcting the model for endogeneity problems which are relevant in panel data. Dedman et al. (2009) confirm the previous results with respect to the value relevance of research and development. The coefficients for R&D are positive and significant. They are also robust to the choice of the deflator.

Booth et al. (2006), Pindado et al. (2010), Duqi et al. (2011) and Appolloni et al. (2011) offer some preliminary evidence that R&D can be considered value-relevant even in Continental Europe. They use sample of European firms and modulate the R&D effect by control variables like firm size, firm free cash flows, growth rate of equity and loan markets. The empirical results show that the R&D effect is always positive and strongly significant.

3.3 The potential mispricing effect of R&D on stock returns

Although the aforementioned contributions evidence that R&D is value relevant there are also many studies which report that R&D is often mispriced by investors. They fail to correctly price the benefits of R&D on stocks' future cash flows causing a share over- or undervaluation.

The mispricing effect can be due to the failure by investors to correctly value the long term benefits of R&D or to their failure to correct their discount rate when valuing these expenditures. The first error mainly is due to accounting rules while the second concerns the non-diversifiable risk pattern of R&D.

Under U.S. and International GAAP, R&D costs are completely expensed in the year when they are incurred, unless a clear connection between part of these costs and a hypothetic future product for sale can be demonstrated. The potential mispricing role of different accounting regimes has been subject of a long debate among researchers. This issue followed the compulsory disclosure and complete expensing of R&D in the US from 1974 and in the UK from 1989. As pointed out before, it is common belief that parts of R&D should be capitalized due to their similarity with long term assets. Following this approach some studies have suggested that financial reporting can be improved in favour of a less conservative policy that requires R&D costs to be capitalized (Lev and Zarowin, 1999). This policy change, it is argued, would make summary accounting measures such as earnings and net assets more comparable across R&D-intensive and non-R&D-intensive firms, and therefore more useful to investors.

Empirical evidence from US and UK firms suggest that capitalizing and amortizing does help in explaining share prices. Aboody and Lev (1998) examine accounting options in the US software industry which permit the capitalization of some costs. They report that these capitalized costs are correlated with equity values conditional on other elements of reported earnings and book values, again suggesting that managers may use their discretion to improve financial reporting. However their results are not conclusive as, they find that only 25% of software development costs are capitalized.

Lev and Sougiannis (1996) report that, after controlling for reported accounting numbers, incremental R&D asset and amortization expense measures constructed from the publicly available history of R&D expenditures are cross-sectionally correlated with observed share prices. Chambers et al. (2002b) find that capitalizing and amortizing R&D costs is capable in principle of producing economically significant financial reporting benefits. Their results also suggest that realizing these benefits will require granting substantial discretion to managers over the choice of costs to be capitalized and the rate at which these costs are expensed. As a result, these benefits will depend on the extent to which managers have incentives to use this discretion opportunistically, and the ability of corporate governance mechanisms and the audit process to place reasonable bounds on such behavior.

Kothari et al. (2002) find that R&D investments generate more uncertain future benefits compared to capital expenditures. The coefficient on current R&D expenditures is about three times that of the coefficient in current capex. Givoly and Shi (2008) observe that capitalization is associated with lower underpricing of the stock on the first day of trading. The authors interpret this as evidence that capitalizers are subject to less uncertainty about the success of their software investments.

Oswald (2008) studies how the choice of capitalizing versus expensing is associated with the value-relevance of book value and earnings for a sample of UK. He adjusts firm accounting earnings to reflect what they would have been if capitalization of development expenditures had been adopted. The results suggest that firms' exercise of discretion over the accounting treatment of development expenditures are consistent with the notion that firms acted to increase the value relevance of earnings and book value.

Reassuming, many authors have tried to assess if investors consider R&D expenditures as an asset or a simple annual cost. Sougiannis (1994), Lev and Sougiannis (1996), Hall (2000) among others point out that this is the case. The question whether there is mispricing or not due to annual expensing remains an opened question. Chambers et al. (2002b) suggest that permitting more discretion allows managers to give more information to the market thus allowing better allocation efficiency. However, the evidence by now does not permit to say that capitalizers perform better in terms of market share than expensers. Moreover, there is some recent research that evidences how the choice to capitalize or expense is due to the R&D growth rate relative to firm profitability (Lev et al. 2005). They find that companies with a high growth rate of R&D relative to their profitability (typically, early life-cycle companies) report conservatively (expense R&D), while firms with a low R&D growth rate relative to profitability (mature companies) tend to report aggressively (capitalize R&D). The authors find misevaluation evidence which is consistent with well-established behavioral finance findings and, in particular, with the heuristic of representativeness that makes investors view patterns in reported data as representative about future patterns and thus overreact.

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The risk-pattern approach draws on the seminal work of Fama and French (1992). Their paper aimed to test the validity of the Capital Asset Pricing Model (CAPM) of Sharpe (1964), Lintner (1965) and Black (1972). The authors begin with assessing that this model does not explain stock returns and it contains several contradictions. The first one is the size effect first indicated by Banz (1981). He finds that market equity (*ME*) adds to the explanation of the cross section of average returns provided by market βs. It seems that returns on small stocks are too high given their β estimates, while returns on large stocks are too low. Bhandari (1988) reports that average returns are related to leverage too, although this source of risk should be captured by market β. Stattman (1980), Rosenberg et al. (1985) and Chan et al. (1991) find that average returns on US and Japanese stocks are positively related to the ratio of a firm's book value of common equity to its market value. Basu (1983) show that earnings price ratios (E/P) help explain the cross section of average returns on US stock even when size and β are included in the regression.

Drawing from these "anomalies" of the CAPM, Fama and French (1992) build an empirical model for capturing different sources of risk that are not captured by β estimates for years after 1963. They include in this model a proxy for size (Market capitalization, *ME*), book-to-market ratio (*BM*), earnings to price ratio (E/P) and leverage *(Assets to book-value of equity, A/BE).* After offering empirical evidence that beta cannot explain stock returns when stocks are grouped by pre-ranked betas, they show that the new added variables are strongly significant in predicting share returns. So, size negatively impacts stock returns as bigger firms usually are less risky than smaller ones. The book-to-market ratio captures the distress risk of the firm and is strongly related to firm economic fundamentals. High *BM* firms (a low share price relative to book value of equity) tend to have low and persistent earnings on assets, while low *BM* firms are associated with high earnings.

After Fama and French (1992), a broad literature is developed which aims to test size and especially the book-to-market ratio as predictors for future returns assuming that if assets are priced rationally, variables like those must proxy for sensitivity to common risk factors in returns. Fama and French (1993) bring forward this approach and identify three main factors that are able to explain the future excess stock returns, i.e., a market factor

(β), a size variable (*SMB*) and a book-to-market variable (*HML*). Firms with high *BM* ratios tend to have low and persistent earnings on assets.

The book-to-market effect is also related to value and growth investing strategies. There is evidence that value strategies (based on high *BM*, low *E/P* stocks) outperform growth strategies (low *BM*, high *E/P* stocks). This is carried out by “contrarian” investors which bet against “naïve” strategies that tend to overreact to good news and bad news. Naïve investors tend to get overly-excited about stocks that have done very well in the past so these glamour stocks get overpriced (De Bondt and Thaler, 1985). Lakonishok et al. (1994) offer more empirical support to this point of view. They use a sample of US firms from 1963 to 1990 and find that value stocks outperform growth stocks due to a persistent overestimation of future earnings of glamour stock by investors relative to value stocks. They do not find any different risk pattern among the two classes of stocks.

Fama and French (1995, 1996) provide an economic foundation to their three factor model. The rationale is that if stocks are priced rationally then size and book-to-market patterns in returns must be explained by the behavior of earnings. They find that high *BM* firms tend to be distressed and they have low ratios of earnings to book values of equity for at least 11 years around portfolio formation. Low *BM* stocks instead, are associated to strong and persistent earnings. Again, the authors offer evidence that the “contrarian” model offer by Lakonishok et al. (1994) can be explained by the three factor model (Fama and French 1996).

Following these contributions, a number of subsequent studies examine the effect of the *BM* ratio on stock prices even outside the US. The results are not univocal. Kothari and Schanken (1997) find a positive link in a time-series pattern between *BM* and future stock returns. Pontiff and Schall (1998) find that the predictive ability of the book-to-market ratio is related to the ability of book value to forecast future cash flows. They assess that the *BM* ratio can be a proxy of a discount rate. Same results are evidenced by Clubb and Naffi (2007) for the UK market. However Gregori et al. (2001) provide evidence for the UK that when portfolios are formed in a two-way classification (size and *BM*) the Fama and French (1993) model does not explain all the variation in cross-section returns.

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The evidence offered mainly for US and UK data suggests that the CAPM alone cannot explain several anomalies observed in stock returns. Size and book-to-market ratio seem to add strength to predictive models; investing strategies based on underperforming stocks like high *BM* stocks seem to gain abnormal returns not justified by the classic market model. Inspired by the new risk-approach introduced by Fama and French (1992, 1993) other authors have opened a new point of view based on intangibles and especially R&D. These studies assess that introducing a measure of R&D in the Fama and French model helps in predicting future stock returns. The main reason seems to be that R&D is a new non-diversifiable source of risk and if investors do not consider it properly, stock prices could be under or overvalued. In their seminal paper, Lev and Sougiannis (1996) find that when a measure of R&D stock is included in the Fama and French model, the model's overall predictive ability of future stock returns greatly increases. The authors give an interesting explanation of this fact in Lev and Sougiannis (1999). It seems that the book-to-market ratio, which is a corner stone in Fama and French (1992, 1993) captures all the firm growth options, and thus it might be substituted by a measure of R&D stock, which is a primary driver of innovation and thus, firm growth. Low *BM* companies usually are R&D intensive and high *BM* ones have low R&D investment. The return premium that investors ask is sensibly higher for basic research, which is more risky than development expenditures, indicating a clear compensation for higher risk in R&D projects.

Chan et al. (2001) consider a sample of US firms for the period 1975-1995 and they find no evidence of mispricing for high-R&D firms compared to low-tech ones. Their results do not support a direct link between R&D spending and future stock returns. However when they measure R&D intensity relative to the market value of equity, the most innovative stocks perform significantly better than the less innovative. The authors argue that this performance may be due to the fact that *RD/ME* highly ranked stocks generally tend to be past losers, whose managers are optimistic about the firm's future prospects. Financial markets tend to be sluggish in revisiting their past expectations.

The mispricing pattern is defended also by papers which study unexpected changes in R&D investment or new R&D program announcements. Chan et al. (1990) study the stocks' response to 95 announcements of increased R&D. High-technology firms that announce increases in R&D spending experience positive abnormal returns on average, whereas announcements by low-technology firms are associated with negative abnormal returns. Moreover, in cross-sectional analyses they find that firms with higher R&D intensity than the industry average experience larger stock-price increases only for high-tech industries. Eberhart et al. (2004) examine a sample of US firms in the period 1951-2001, which unexpectedly increase their R&D expenditures by a significant amount. The authors find consistent evidence of a misreaction, as manifested in the significantly positive abnormal stock returns that the sample firms' shareholders experience following these increases. They also find consistent evidence that sample firms experience significantly positive long-term abnormal operating performance following their R&D increases. These results suggest that R&D increases are beneficial investments, and that the market is slow to recognize the extent of this benefit which is proof of investor under-reaction.

Chambers et al. (2002a) admit that there exists a potential mispricing of R&D expenditures but this occurs because investors fail to correctly value long term benefits of R&D. R&D intensive firms have excess returns that persist over time after controlling for size and *BM* ratio; these returns have a higher level of variability compared to firms that are not R&D intensive. The investors do not take into consideration the different riskiness of R&D firms.

Outside the US, the correct valuation of R&D has been studied for the UK market by Al-Horani et al. (2003) and Dedman et al. (2009). The former present evidence that the cross-section of UK expected stock returns is positively related to R&D activity, after controlling for size and *BM* effect. Dedman et al. (2009) extend the work of Al-Horani et al. (2003) studying the three-factor model of Fama and French (1993) in cross-industry portfolios. The effect of the R&D variable has a positive effect on stock returns for 13 out of 20 industrial portfolios, evidencing that it can be a useful factor in pricing assets. They also confirm that investors are not misled by the fact that R&D expenditures are expensed in the year when they are incurred, because they consider R&D as an asset. Moreover, the *RD/ME* ratio can subsume the *BM* ratio as Lev and Sougiannis (1999) predict.

Recently, Ciftci et al. (2011) take into consideration a very large sample of US stocks with positive R&D from 1979 through 1997. They sort firms in two groups according to their R&D industry benchmark intensity, low R&D-intensive and high R&D-intensive

firms. First, they find that high R&D firms have lower return variability. This is consistent with the fact that top innovators mitigate the risk of research by diversifying their R&D investments even through joint ventures and alliances (Szwejczewski et al. 2006). Second, high R&D-intensive firms earn excess returns in the short term, whereas low R&D firms do not. In the long term returns of both groups converge, reflecting common business and information risk factors. This indicates a mispricing problem for the top group. In summary, high industry-adjusted R&D intensive firms suffer from undervaluation in the short term, but they can mitigate this pattern if managers decide to disclose sensible information about the long term benefits of R&D projects.

Xu and Zhang (2004) and Nguyen et al. (2010) find no evidence of abnormal returns related to R&D effect for Japanese firms; they find no undervaluation of R&D investments except for the post-bubble period (1993-2000). Chiao and Hung (2005) and Chiao et al. (2008) study the Taiwan stock market; they highlight an evident mispricing of R&D expenditures, which persists for up to three years, especially for firms operating in the electronics sectors.

3.4 The moderating role of other variables in the market valuation of R&D

The market valuation of R&D can be modulated by several firm and country characteristics. For example, prior literature has always assessed the importance of a firm's size in performing innovation and in the market valuation of R&D investment. This coincides with the Schumpeterian view suggesting that larger firms are more able to perform R&D investment for several reasons (Schumpeter, 1939). R&D projects are risky and larger firms are more able to secure funds for financing these projects because size is related to internally generated cash flows (Schumpeter, 1942). Moreover, larger firms can better diversify their activities and can spread the risk over a large number of R&D projects, they can benefit from greater access to capital markets (Scherer and Harhoff, 2000) or they have the possibility of achieving a long-run competitive advantage due to greater market power (Galbraith, 1952; Arrow, 1962).

More recently, several authors have related the modulating effect of firm size to the impact of R&D on firm value. R&D should be better appreciated by financial markets for larger firms as they can reap benefits from innovation more successfully than SME-s (Toivanen et al. 2002; Connolly and Hirschey, 2005).

There are also contributions in the literature which cast doubts on the Schumpeterian view. They notive that among performers of R&D, the number of innovation outputs such as number of patents or amount of innovation per dollar of R&D decline with firm size (Bound et al. 1984; Pavitt et al. 1987; Acs and Audretsch, 1990, 1991; Van Dijk et al. 1997). A very low rate of hierarchical governance structure and a less bureaucratic environment allow a higher responsiveness to innovative opportunities by small firms and new entrants in the market (Link and Bozeman, 1991).

Firm market share is hypothesized to be another important factor for moderating the effect of R&D on firm value but this relationship remains controversial. Blundell et al. (1999) posit that dominant firms tend to have higher rates of R&D and innovate more. Firms with higher market share tend to commercialize more innovative products, thus benefiting more of the innovation process in terms of a better market valuation. Pindado et al. (2010) confirm these results; the higher the market share of the firm, the more effective the R&D spending and, therefore, the higher the market valuation. The authors justify this with the fact that R&D spending yields some supranormal profits for each dollar sold; hence, the overall benefits will be greater as the market share rises. However Toivanen et al. (2002) for a sample of UK firms find no evidence that firms with higher market share can better internalize the gains from R&D.

The industrial sector is another relevant key variable when we deal with innovation and firm size. Some industries should take advantage of small firm innovation, while others foster innovation activity in large corporations (Ortega-Argilés et al. 2009). Cohen and Klepper (1996) suggest by theoretical and empirical evidence a modulating effect of the sector where firms operate for the R&D – size relationship. They posit that this relation is weaker for industries where innovations are more saleable, more product-driven than process-driven, and where prospects for rapid growth due to innovation are stronger.

Other authors study this phenomenon from the point of view of technological trajectories (Nelson and Winter, 1982; Malerba and Orsenigo, 2000). Technological opportunities and appropriability conditions affect the dynamics of market structure and innovation investment (Levin et al. 1985; Cohen et al. 1990). It is thus plausible that larger firms can better benefit from innovation in sectors with high entry barriers and lower technological opportunities, while smaller firms can succeed in entrepreneurial sectors (Ortega-Argilés et al. 2009). Acs and Audretsch (1991) find that hi-tech firms show no increasing returns to firm size in generating innovative output. They relate their results to the fact that firms operating in these sectors can benefit from small increments to existing knowledge in order to produce innovative output, while low-tech firms should invest in a substantial addition to the existing knowledge.

Another strand of research draws from the seminal work of Himmelberg and Petersen (1994). In this paper, the authors offer empirical evidence that sector innovativeness is crucial even when firms' financial constraints for investing in R&D are investigated. Small firms operating in hi-tech sectors are more likely to rely mainly on internal finance because they face financial constraints from outside investors. Bond et al. (1999) examine the cash flow sensitivity of investment in fixed capital and R&D for firms located in UK and Germany. They find that cash flow is not significant in explaining the propensity to invest in R&D in both countries. In the UK cash flow does matter more for the investment decisions in fixed capital for non-R&D firms than it does for R&D firms. These results indicate that hi-tech UK firms face a higher wedge between the costs of internal and external finance than German firms. UK firms experience more financial constraints when they have to finance long-term investments in R&D. In the same spirit, other important contributions study this topic for European countries (Bah and Dumontier, 2001; Muller and Zimmerman, 2008; Ughetto, 2008; Torluccio, 2008).

In the literature, there have been few contributions which have connected the impact of R&D on market value with firm sector; these papers have concentrated on non-European data. Chauvin and Hirschey (1993) test R&D value relevance for US firms belonging to three commonly accepted hi-tech sectors and to three low-tech sectors. The results show that R&D coefficients are higher for the former group. Chiao and Hung (2005) find that electronics firms gain abnormal returns, compared to non-electronics firms, in the Taiwan context in the three-year period that follows new R&D announcements.

The results from the contributions listed above show that the industry where firms operate is important when several issues related to firm R&D are investigated, such as the optimal firm size, in order to have the greatest benefits in the sector or financial constraints related to highly innovative corporations. I extend this body of research by introducing the concept of sector innovativeness even for the market valuation of R&D expenditures. Some sectors are commonly considered as hi-tech by investors, regulators and policy makers. Firms that operate in these industries should invest heavily in R&D in order to operate competitively, because the sector R&D intensity is a threshold for firms' efforts in this sense. I hypothesize that the impact of R&D on market value should be greater for these firms, compared to firms that operate in sectors that require a low rate of R&D intensity and low level of innovation. Firm size is connected to the industry as smaller firms should evidence a greater advantage in terms of a better market valuation of their R&D expenditures when they operate in hi-tech industries, while larger firms should be more able to benefit from R&D investment in low-tech sectors.

The legal and financial environment where firms operate is another factor that may affect the stock market valuation of R&D expenditure. First, the role of equity and debt financing of R&D has been studied by different authors. Yosha (1995) and Bhattacharya and Chiesa (1995) argue that financial arrangements matter in R&D spending because of the potential for information leakage may lead to differences in the stock market's response to R&D expenditures. Boot and Thakor (1997) posit that firms that rely on more complex technologies have more to gain from the feedback role of market prices and, therefore, should prefer financial markets, implying that the stock market reaction to R&D spending should be influenced by the characteristics of the financial system.

Second, Demirgừc-Hunt and Maksimovic (2002) show that the more developed a country's loan and equity markets are, the stronger its growth will be. La Porta et al. (1998, 2006) indicate that countries with a solid legal background and a high protection level of minority shareholders experience a more significant expansion of stock and credit markets. Empirical contributions supporting the agency theory problem point out that the R&D investment creates high information asymmetries that may encourage the expropriation of minority shareholders (Aboody and Lev, 2000). The presence of majority shareholders may induce investors to undervalue R&D projects (Hall and Oriani, 2006). On the other hand, Tylecote and Ramirez (2006) find evidence that the presence of large and liquid shareholders such as pension funds, which are able to diversify in order to minimize risk, typical of market-based countries like UK and USA, makes investors biased towards short-term earnings. This might imply a bigger risk premium for projects with high R&D spending that rely on more distant cash flows. In the same direction, Munari et al. (2010) find that widely-held firms in market-based countries such as the UK undertake less investment in R&D because they fear a negative market valuation.

Booth et al. (2006) build from these assumptions and conjecture that the way that equity investors value R&D expenditures depends not only on the extent to which the financial system in which the firm operates is developed but also on the relative importance of bank and public equity financing within the system. Financial investors are more prone to suffer information asymmetries about firm's activities in the bank-based system than they are in the market-base one. Both systems are influenced by the degree of the legal environment as La Porta et al. (1998, 2006) evidence. The empirical results show that the market valuation of R&D is stronger when equity financing in a country increases compared to loan bank financing.

R&D investment has a high degree of information asymmetries; insiders have usually more information about its potential outcomes in the long term (Aboody and Lev, 2000). These difficulties arise in countries where insiders can control big stakes of shares like in Continental Europe and where the private benefits of control are higher (Dyck and Zingales, 2004). Previous evidence for the US shows that generally investors are not able to correct their valuation of high R&D intensity stocks thus, generating abnormal returns, mispricing should be more pronounced in Europe where disclosure is more problematic due to accounting rules and practices. Investors in Europe could suffer information risk more than in Anglo-Saxon markets, because it increases in presence of relevant inside information and low disclosure. There is evidence that information risk significantly impacts asset pricing because uninformed investors will require a higher rate of return for holding stocks with higher rate of private information (Easley and O'Hara, 2002, 2004; Ciftci et al. 2011).

We would expect that the stock variability of firms that invest more in R&D for Continental European firms is higher than non-R&D firms but lower than innovative firms domiciled in the UK other things being equal, because in Anglo-Saxon economies institutional investors put more pressure on managers and are more unwilling to accept short term losses which are frequent in hi-tech sectors (Tylecote and Ramirez, 2006). They might suffer from a so-called “myopic” view, which forces them to overreact by selling loser stocks and buying winners. In bank-based countries, inside shareholders are more inclined to accept long-term investments; they do not tend to calibrate frequently their portfolios following periodical information from firm managers, hence the stock volatility should be lower. Sias (1996) and Bushee and Noe (2000) provide empirical evidence that higher institutional ownership is associated with higher stock return variability.

There is some evidence that in some European countries it may exist a size and book-to-market effect but the results are still non conclusive. Fama and French (1998b) find that their model can explain stock returns in cross-country evidence even for European markets. Value stocks with high *BM* ratio outperform growth stocks in twelve out of thirteen international markets. Similar results are found for France by Lajili-Jarjir (2007), and Chahine (2008). Malin and Veeraraghavan (2004) do not reach the same outcomes comparing the UK with France and German markets. They evidence a small size effect in France and Germany, but no value effect for the markets investigated.

Previous research have pointed out that mispricing of R&D could derive from a failure of investors to control for a non-diversifiable source of risk intrinsic of this asset that cannot be captured by other factors. The modulating effect of R&D in the Fama and French model (1993) for Continental European firms should not be different to that observed in the US or UK, due to similar risk characteristics of highly innovative firms in US and Western Europe.

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The economic rationale deriving from the contributions listed in these sections supports the view that research and development should have a significant and positive effect on firm value and stock returns. This is hypothesized by the hedonic model that considers the firm as a bundle of tangible and intangible assets. The Tobin’s Q ratio is approximated by a log-linear function of these assets. The residual income model draws from the dividend discount model assumptions. The abnormal earnings are originated by the growth options that are entangled in current investments in innovation. This relationship is differently modulated by several firm characteristics like size, industry, market share, cash flow, firm age, firm growth and other features related to the financial environment where firms operate like corporate governance, loan and equity market development.

The effect of R&D on stock returns is somehow a more opened question. R&D investments are considered more risky than other firm tangible investments. Sometimes, investors fail to correctly price the benefits of these investments. This is reflected on underreaction or overreaction to new R&D announcements, mispricing in a short term or long term perspective, excess returns for R&D intensive stocks. This can be due to the investors' inability to correctly control for extra risk in R&D projects or to the difficulty related to the accounting treatment of R&D.

4. The effect of R&D on firm value; the models, descriptive statistics and empirical results

4.1 The residual income model

A. The model, research questions and variables

In order to test whether R&D positively impacts firm value we use two accounting based models which are drawn from the seminal works of Ohlson (1989), Green et al. (1996), Stark and Thomas (1998). The models imply a linear approximation of firm value by a measure of earnings which reflects the profit deriving from the assets in place and a measure of the future growth opportunities for the firm which is represented by the current outlays in R&D. Earnings can be substituted by the residual income in a first version of the model or by operating profits in a second version. The latter comprises some important variables which can help improve its predictive power and will be explained below.

In the residual income model used in the present section, the firm value (*FV*) is related linearly to its book value (*BV*), residual income (*RI*), and R&D expenditure (*RD*). Generally, the book value of the year in progress (*BV*) is used as a deflator to permit the reduction of the scale effect. Other variables have been used in literature as deflators, such as sales, number of shares or opening book value (Hirschey, 1985; Rees, 1997; Lo and Lys, 2000). The basic model specification used is the following:

$$FV_{i,t} = \beta_0 + \beta_1\left(RI_{i,t}/BV_{i,t}\right) + \beta_2\left(RD_{i,t}/BV_{i,t}\right) + \beta_3 Ln\_Sales + \beta_4 MKTSHARE + \beta_5 LEV + \varepsilon_{i,t} \qquad (10)$$

where $FV_{i,t} = (MV_{i,t} - BV_{i,t})/BV_{i,t}$.

Similarly to Sougiannis (1994), Green et al. (1996), Toivanen et al. (2002), and Akbar and Stark (2003), only research and development costs that appear in the current year are considered; it is assumed that past expenditures have already produced tangible assets and are therefore reflected in the remuneration of these assets by the residual income.

In accordance with previous studies (Green et al. 1996), firm market value of equity and debt at time *t* ($MV_{i,t}$), is usually measured six months after the end of the financial (calendar) year. This choice has the advantage of identifying the level of market value when the financial statement has for some time been deposited and been available to investors, who will consequently have already absorbed the information in this document and acted on the stock market based on the various expectations created. The book value ($BV_{i,t}$) is determined as the sum of the book value of equity plus reserves plus the firm's debt value, which usually corresponds to its market value.

The surplus profit or residual income is computed as the difference between the firms' operating income and the book value of their assets multiplied by the cost of capital. The weighted average cost of capital *(WACC)* is calculated using as the risk-free rate the yield to maturity of Government bonds for each country. The rate of return of Government bonds with roughly an expiry date closest to 10 years was used as the risk-free rate of return. The research and development costs ($RD_{i,t}$) are identified by the annual expenditure declared in each firm's financial statement.

Our main hypothesis supports the leading view in nowadays economic theory. R&D should positively influence firm value in European countries. As many contributions in the literature have highlighted, the relation between R&D and market value can be modulated by different firm features. We insert in the basic model some of these variables which have been used in prior research and whose role is supported by economic theories.

The first variable is the companies' market share, *MKTSHARE*. It is measured as the ratio between the sales of the company in year *t* (net sales) and net sales of firms in the same sector[3]. Blundell et al. (1999) have evidenced the positive impact that market share has in the market valuation of R&D. Firms with high market share should innovate more because the market share helps the leading firm to create entry barriers in the sector which enhance its market value (Pindado et al. 2010). I expect that the market share should have a positive effect on the market valuation of R&D.

I include a control variable that I call *LEV* to control for firms' financial structure. It is calculated as the ratio of the long and short-term debt to equity market value. Previous empirical evidence shows that financial leverage should not be preferred by firms that have a high propensity to innovate, as debt is more suitable for stable cash flows (Hall, 1992). High R&D-intensive firms should have highly volatile earnings, and intangible investments are not suitable for collateral in lending agreements with banks. The level of

[3] The industrial sectors were defined using the ICB sectors of the Industry Classification Benchmark from the FTSE - LSE Group UK

debt strongly influences the decision to finance innovative projects, especially for younger or smaller enterprises. In general, more innovative firms make more recourse to risk capital insomuch as the greater weight of intangibles entails more risks for external borrowers in terms of information asymmetries and moral hazard (Myers and Majluf, 1984; Himmelberg and Petersen, 1994).

The firm's size effect is captured by including *Ln_Sales* which is the natural log of net sales. As already pointed out, firm size is considered a key point for the firm's propensity to innovate and R&D intensity (Munari et al. 2010). According to economic theory and previous empirical outcomes, larger firms should experience a stronger effect of R&D on firm value.

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The financial and legal environment of firms' country of domicile has always attracted the attention of the researchers in economics because it is considered as one of the drivers that can boost or obstacle firm's growth (Franks and Mayer, 1990; Hall and Soskice, 2001; Hoskinsson et al. 2002; Booth et al. 2006; Munari et al. 2010; etc.). These studies address the question of different types of shareholder and firm performance but do not concentrate on the association between innovation, national differences in financial and legal systems and firm value. However other papers have tried to shed some light in the connection between country characteristics and economic growth (Demirgùc-Hunt and Maksimovic, 2002). I test here whether investors differently value R&D in countries with different legal and financial background. The relation between market or bank-based financial systems and R&D has proved to be controversial. As I highlighted above, banks should not prefer to lend to high R&D intensive firms so in a bank-based system the impact of R&D on market value should be lower. However, market-based systems suffer somehow from a myopic view, they prefer short-term profits. Investors in these countries should consider high R&D expenditures as more risky and should negatively value the R&D impact on stock prices.

Moreover, in countries like Germany, banks are key stakeholders in corporations; they do not have the emergency of short-term earnings like mutual funds typical of Anglo-Saxon economies. The former might appreciate R&D investment because it could guarantee long-term benefits and leadership (Hall and Oriani, 2006). However, the legal environment is a key driver for permitting a better disclosure of corporate information especially for sensible data like R&D projects. According to many authors (La Porta et al. 1998, 2006 among others) this is more guaranteed in Anglo-Saxon financial markets which encourage transparency more than bank-based economies.

The legal environment is represented by a variable constructed by La Porta et al. (1998). This is a measure of shareholders' protection, called *ANT_DIR*, which takes values from 1 to 6 according to a particular country, 6 being the best protection possible. This index is a combination of different variables: the first equals one if the country's commercial laws give the opportunity to shareholders to vote by proxy; the second is equal to one if shares are required to be deposited before the shareholders' meeting. The third variable equals one if in a country cumulative and/or proportional voting for directors is allowed. This should permit minority shareholders to put their representatives in the board. The fourth variable equals one if shareholders are granted certain rights to pursue directors in courts, or other measures which permit minority shareholders to tackle perceived oppression by directors. The fifth variable protects shareholders from dilution effects, giving them the option to buy new issues of stock before other interested investors. The sixth variable equals one if the percentage of share capital needed to call an extraordinary shareholders' meeting is not too high (below 10 %).

The level of financial development is captured by a variable constructed by Levine (2000). This is measured by the natural log of the product between the value of domestic equities traded on domestic exchanges divided by countrie's *GDP* and the value of deposit money bank credits to the private sector as a share of *GDP*. I call this variable *FIN_ACT*. *RD/BV* is interacted with these categorical dummies in order to investigate whether or not they influence the impact of R&D on firm value.

Finally, a dummy variable is included for considering the change in international accounting rules with the adoption of *IAS-IFRS* standards from 2005 onwards. This dummy, which I call *IFRS,* takes the value of 1 for observations in years 2005-2007 and 0 otherwise. If the interaction of R&D with this dummy is significant, then the new rules can help in improving the market valuation of R&D.

I extend the basic model for testing the importance of country variables. As usual, the closing book value of assets is used as a deflator. The model will be the following:

$$FV_{i,t} = \beta_0 + \beta_1\left(RI_{i,t}/BV_{i,t}\right) + \beta_2\left(RD_{i,t}/BV_{i,t}\right) + \beta_3 RD * ANT\_DIR + \beta_4 RD * FIN\_ACT + \beta_5 RD * IFRS + \sum_{j=6}^{12}\beta_j YEAR + \sum_{j=13}^{16}\beta_j COUNTRY + \varepsilon_{it} \quad (11)$$

YEAR and *COUNTRY* comprise a set of time and country dummies for time and country specific effects, while ε_{it} is the error term. Then, I perform a different set of regressions via panel FE estimation, in which the interaction between *RD/BV* and firm market share is tested. In this case, the new interaction variable is named *RD*MKTSHARE*. The model will have the following pattern:

$$FV_{i,t} = \beta_0 + \beta_1\left(RI_{i,t}/BV_{i,t}\right) + \beta_2\left(RD_{i,t}/BV_{i,t}\right) + \beta_3 RD * MKTSHARE + \beta_4 LEV + \sum_{j=5}^{10}\beta_j YEAR + \sum_{11}^{14}\beta_j COUNTRY + \varepsilon_{it} \quad (12)$$

Finally the important role of the industry is considered by dividing the whole sample into three groups according to the sector innovativeness. This variable is incorporated in the model by three dummies, *Dummy_hitech*, *Dummy_medtech* and *Dummy_lowtech*. Industry sectors were sorted and divided into three groups based on R&D intensity over the period 2001-2007 (Table 3). Then, a dummy was assigned to every group.

I include an interaction variable between *RD/BV* and *Ln_Sales* to the model (10) that I call *RD_Sales,* and run this model for every group-sector in order to verify a potential different modulating impact of firm size over the value relevance of R&D for different industries:

$$FV_{i,t} = \beta_0 + \beta_1\left(RI_{i,t}/BV_{i,t}\right) + \beta_2\left(RD_{i,t}/BV_{i,t}\right) + \beta_3 RD\_Sales + \beta_4 LEV + \sum_{j=5}^{10}\beta_j YEAR + \sum_{11}^{14}\beta_j COUNTRY + \varepsilon_{it} \quad (13)$$

B. Sample selection

The dataset comprises a sample of non-financial listed firms domiciled in Europe that operated continuously from 2001 to 2007. The firms under consideration performed research and development investment in each year. The initial data for R&D investment was provided by Eurostat statistics[4] on the R&D expenditures of the Top 1000 firms in the EU area that invested the largest sums in R&D in the reported years (2001-2007).

The European countries considered in this study are the UK, Germany, France, Sweden and Italy. I concentrated only on these countries because, in the annual survey carried out by the EU Industrial Scoreboard, the capitalization of companies listed in these nations constituted around 80% of the entire sample and the investment in R&D from these firms covered almost 75% of the total R&D expenditures. In order to have a more homogeneous sample, companies that were delisted or were subject to IPOs in that period were not considered. The missing data was integrated with other information extracted from Datastream and two other databases provided by Bureau van Dijk (OSIRIS, AMADEUS). Research on the firms' financial statements was carried out for a final check. Finally, the sample was corrected for the presence of outliers by elimination of observations with negative values for the deflated variables, with the exception of the residual income which can be lower than zero.

At the end of this process, the final sample comprised 416 companies: 136 of them were domiciled in the UK, 122 were German, 75 French, 53 Swedish and 30 Italian; with a total of 2884 firm-year observations distributed over the five countries.

C. Descriptive statistics and empirical results

In Table 1 descriptive statistics are exhibited for the most important variables across countries. There is a high variability of data, although some of the variables have been deflated to correct for the size effect. The dependent variable's mean values are similar for French, German and UK firms (18.53, 20.5 and 16.93 respectively), showing a not dissimilar market capitalization for firms domiciled in these countries. On the other hand, Swedish firms' stock values are higher on average, while the Italian ones are somewhat

[4] The 2008 EU Industrial R&D Investment Scoreboard.

smaller. Median values are, however, more similar, even for *RI/BV* and *RD/BV* in each country, indicating a high skewness in sample distribution. *RI/BV* ranges from 0.27 for Italy to 0.59 for the German sample; *RD/BV* ranges from 0.09 for Italy to 0.29 for Sweden, indicating little R&D spending for Italian firms, other things being equal. Considering that *Ln_Sales* median values are very similar for every country sample (the range is 12.54 to 14.71), it may be the case that the capitalization of the Swedish firms benefits from very high price-to-book ratios compared to other firms in the sample. Previous contributions that have used the same model show smaller values for the same variables. For example, Green et al. (1996) consider a UK sample for years 1990-1992, and their median values for *FV*, *RI/BV* and *RD/BV* are respectively 0.82, 0.04 and 0.03 respectively.

Table 1 - Descriptive statistics by country, years 2001-2007

This table provides descriptive statistics for main variables across countries for years 2001-2007. The number of firms is shown at the bottom of the table. *FV = (MV-BV)/BV* is the dependent variable. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RI* is the firm residual income measured as $RI_{i,t} = (Ebit_{i,t} - k_{i,t}BV_{i,t-1})$. *RD* is the year firm expenditure in research and development. *MKTSHARE* is firm's market share. *LEV* is the debt to equity ratio. *Ln_Sales* is the natural log of sales at the end of fiscal year.

	France				**Germany**				**Italy**				**Sweden**				**United Kingdom**			
Variable	Mean	P5	Med.	P95	Mean	P5	Med.	P95	Mean	P5	Med.	P95	Mean	P5	Med.	P95	Mean	P5	Med.	P95
FV	18.53	0.37	3.41	90.53	20.6	0.38	4.17	108.9	10.9	0.23	2.39	56.77	67.61	0.68	7.07	398.1	16.93	0.16	3.3	69.48
RI/BV	1.49	-0.18	0.4	7.97	2.09	-0.24	0.59	12.88	0.75	-0.14	0.27	3.72	4.38	0	0.29	26.03	1.74	-0.27	0.37	10.06
RD/BV	1.68	0	0.16	8.72	1.18	0.01	0.28	6.02	0.33	0	0.09	1.82	4.79	0.01	0.29	30.56	1.37	0	0.15	6.22
MKTSHARE	0.15	0	0.02	0.73	0.12	0	0.01	0.48	0.04	0	0	0.2	0.33	0	0.04	0.77	3.6	0	0.01	0.29
LEV	2.11	0.02	0.63	5.31	17.39	1.54	41.68	299	18.47	0.01	0.37	103.3	6.63	0.06	3.63	16.43	3.15	0.01	0.51	6.18
Ln_Sales	13.77	9.21	13.74	17.61	13.39	9.92	13.16	17.7	13.75	10.9	13.32	17.74	14.66	10.97	14.71	18.27	12.61	8.5	12.54	16.69
Obs.	**75**				**122**				**30**				**53**				**136**			

In Table 2 a correlation matrix between the main variables is shown. There is a significant correlation between *FV* and the principal independent variables *RD/BV* and *RI/BV* (68.7% and 65.8%, respectively). Even *RD/BV* and *RI/BV* are well-correlated with each other (46.9%). The other variables show a weak correlation with one another and with *FV*, with the exception of *Ln_Sales* and *MKTSHARE* which are closely correlated (56.22%).

Table 2 – Pearson correlation coefficients

This table presents the coefficients of correlation for main variables. The sample consists of 416 non-financial firms. *FV = (MV-BV)/BV* is the dependent variable. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RI* is the firm residual income. *RD* is the annual firm expenditure in research and development. *MKTSHARE* is firm's market share. LEV is the debt to equity ratio. *Ln_Sales* is the natural log of sales at the end of fiscal year.

		1	**2**	**3**	**4**	**5**	**6**
1	FV	1					
2	RD/BV	0.687*	1				
3	RI/BV	0.658*	0.469*	1			
4	Ln_Sales	-0.151*	-0.158*	-0.075*	1		
5	MKTSHARE	-0.011	-0.011	-0.012	0.562*	1	
6	LEV	-0.015	-0.012	-0.015	0.031	-0.002	1

Notes: * indicate 5% level of significance

In Table 3 a breakdown of firm-year observations divided per sector for the period 2001-2007 is presented. The most innovative industries are marked by a higher RD/Sales ratio. Theoretically, a higher R&D intensity implies higher innovation opportunities for the industry (Lin and Huang, 2008). In this sample, hi-tech firms have a R&D intensity rate that ranges from 8.77% for Technology Hardware & Equipment to 3.75% for Leisure Goods. The middle group R&D intensity ratio ranges from 3.71% to 1.40%. Finally, the less innovative firms have a maximum R&D intensity of 1.32% and a minimum value of 0.12%. The hi-tech group comprises 1435 firm-year observations, the medium tech 916, and the low tech has only 513 observations during the period 2001-2007. This is due to the Industrial Scoreboard Survey which concentrates only on R&D performing firms that are more likely to pertain to highly innovative industries. The cut-off values for creating the sub-samples were chosen in order to have significant firm-year observations and also a significant number of industries for every group.

Table 3 – Distribution of firm-year observations per industry and for the period 2001-2007
All firms for the total sample have been sorted in three groups based on sector innovativeness which is captured by R&D intensity. R&D intensity is the ratio of total R&D expenditures for the period 2001-2007 to total sales for the specific sector. ICB code and ICB sector are the industry classifications adopted by the FTSE-LSE Group (see Table 3 in the Appendix for sectors description).

ICB Code	ICB Sector	Firm-year obs.	R&D intensity
Hi-tech			
9570	Technology Hardware & Equipment	126	8.77%
4570	Pharmaceuticals & Biotechnology	347	7.83%
2710	Aerospace & Defense	98	5.99%
2730	Electronic & Electrical Equipment	287	5.96%
3350	Automobiles & Parts	161	3.97%
9530	Software & Computer Services	403	3.81%
3740	Leisure Goods	13	3.75%
Medium-tech			
4530	Health Care Equipment & Services	105	3.71%
1350	Chemicals	147	3.64%
2750	Industrial Engineering	287	3.45%
3720	Household Goods & Home Construction	112	2.91%
2720	General Industrials	56	2.80%
5330	Food & Drug Retailers	21	2.72%
3760	Personal Goods	70	2.28%
3570	Food Producers	70	1.67%
5550	Media	48	1.40%
Low-tech			
6530	Fixed Line Telecommunications	48	1.32%
2350	Construction & Materials	56	1.26%
2790	Support Services	70	1.23%
570	Oil Equipment Services & Distribution	31	1.19%
1750	Industrial Metals & Mining	50	1.14%
2770	Industrial Transportation	35	1.14%
1770	Mining	32	1.07%
5370	General Retailers	42	0.85%
7530	Electricity	41	0.71%
530	Oil & Gas Producers	35	0.32%
7570	Gas Water & Multiutilities	35	0.28%
3530	Beverages	23	0.17%
5750	Travel & Leisure	35	0.12%

In order to test the value relevance of R&D an analysis via panel fixed-effects (FE) estimation is performed for every country (Table 4). All the models have been corrected for the presence of the heteroskedasticity of residuals, by running robust regressions (White, 1980). I decided to winsorize by 1% the top values for the main variables. As many variables are rightly skewed it would make little sense to winsorize even the bottom observations. A similar approach is followed by Dedman et al. (2009) for testing the value relevance of R&D in the UK market.

Table 4 – Panel FE estimates of the relationship between FV and independent variables

This table presents evidence between the dependent variable *FV = (MV – BV) / BV* and most important independent variables for every country sample. The number of observations for each country is listed at the bottom of the table. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RI* is the firm residual income. *RD* is the year firm expenditure in research and development. *MKTSHARE* is the firm's market share. *LEV* is the debt to equity ratio. *Ln_Sales* is the natural log of sales at the end of the fiscal year. T-tests are shown in brackets below the parameter estimates. Year dummies have been included in every regression for time effects. R-squares and adj. R-squares are listed at the bottom of the table.

	FR	**GR**	**IT**	**SW**	**UK**
RI/BV	3.624***	3.248***	4.904***	10.09**	4.780***
	[6.55]	[10.50]	[4.79]	[2.40]	[10.16]
RD/BV	1.934***	7.908***	-6.230*	8.923**	2.005***
	[3.51]	[10.05]	[-1.95]	[2.27]	[3.73]
Ln_Sales	-3.645***	-0.681	0.531	10.19	-1.074
	[-3.52]	[-0.31]	[0.37]	[0.77]	[-0.95]
MKTSHARE	-10.69	-0.449	-3.664	27.02	-0.268
	[-0.87]	[-0.03]	[-0.64]	[0.57]	[-0.02]
LEV	0.019	1.086	-0.867	8.423	0.004
	[0.57]	[1.37]	[-1.40]	[1.01]	[0.06]
Intercept	86.46***	15.00	1.066	-161.5	25.4
	[4.19]	[0.34]	[0.04]	[-0.57]	[1.18]
N	527	853	210	371	923
R-sq	0.312	0.435	0.264	0.198	0.344
Adj. R-sq	0.168	0.42	0.226	0.184	0.247

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

I opted for the use the FE panel data regression, as this approach has certain advantages over the simpler OLS models in cross-section. It corrects for unobserved effects which in OLS regression would produce biased estimators. As the study focuses on different countries, FE panel models seem preferable, given that the non-observable effects are inherent to a specific country and it is unlikely that the environmental conditions changed during the period of study[5]. In the basic model only a few variables are considered.

The residual income is a reliable factor for increasing firm market performance. The estimators are all significant at the 5% level and positive, with higher levels for the Swedish sample, which confirms the specificity of Swedish firms ($\beta_{1,\,SW}$ = 10.09, *t-test* = 2.40). The main variable, *RD/BV*, exhibits positive and significant evidence for the UK, Germany, France and Sweden while it is negative for Italy. German and Sweden coefficients are obviously bigger than others ($\beta_{2,GR}$ = 7.908, $\beta_{2,\,SW}$ = 8.923). It seems that R&D expenditures have a greater impact on market value for firms operating in countries other than the UK, other conditions being equal.

For all countries except Italy, investing one euro in research and development has a more than proportional impact on a firm's market value, with an even more pronounced effect for Swedish and German firms. Results regarding UK data are in line with previous studies (Hughes, 2008). I also find similarities with studies on Continental Europe data. In Hall and Oriani (2006) there is positive evidence of R&D effect on the market value of US, UK, German and French companies, albeit less significant than in the present study. Furthermore, they did not find significant evidence for Italian data, for which I find a negative correlation, confirming the possibility that the Italian Stock Exchange does not consider R&D expenses as value relevant. In Bae and Kim (2003) the coefficient for R&D in the German sample is about 11.847, showing a comparable strong effect of this variable on market value.

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The relevance of country indicators is tested by three new regressions in panel FE for the full sample. First of all, I add three new interacting variables in regressions (1), (2) and (3) in Table 5, which aim to control for a potential effect of legal and financial environment on the impact of R&D on firm value: *RD*ANT_DIR* for anti-director rights effect, *RD*FIN_ACT* for the development of the stock market and private sector loan market effect, and *RD*IFRS* for the effect of the new accounting rules from 2005. The results confirm the positive effect of a strong legal protection for shareholders and well-

[5] The Hausman test offers robust evidence to support fixed effects compared with random effects.

developed financial markets for the market valuation of innovation. The effect of R&D on firm market value is positive and strongly significant in each regression. The country variables go in the expected direction: *RD*ANT_DIR* is positive and significant (β_3 = 1.066, *t-test* = 4.35), indicating that a high level of shareholders' protection increases the valuation of R&D by investors.

*RD*FIN_ACT* is significant, too (β_4 = 2.534, *t-test* = 3.92). The development of loan and equity markets is a key factor for a better valuation of assets especially when they have long-term benefits and a high level of information asymmetries such as R&D expenditures. Booth et al. (2006) reach similar conclusions for a sample of firms domiciled in OECD country members. The interaction between *RD/BV* and the *IFRS* dummy is not significant. This means that the change in the accounting standards from 2005 has not brought any sensible modification in the market valuation of R&D.

In regression (4) in Table 5 the effect of firm market share is tested by interacting *RD/BV* with a variable which accounts for market share (*MKTSHARE*). I find that it has no significance over the effect that R&D has on market value. However, previous research has not reached a conclusive opinion about the importance of market share on innovation activities and firm value, either. Blundell et al. (1999) and Pindado et al. (2010) provide evidence of a positive influence while Toivanen et al. (2002) do not find any significant effect for UK firms. The debt-to-equity ratio is not significant, either, indicating little attention from investors to this variable in the R&D valuation context.

In order to test the importance of firm size and industry I sort the entire sample into three macro-sectors according to their level of R&D intensity as in Table 3. The most innovative sectors are commonly defined as hi-tech, medium-tech (i.e. the middle group), and low-tech (i.e. the less innovative corporations). I apply model (13) and regress the dependent variable $FV_{i,t}$ via panel FE for each sub-sample. Firm, country and time fixed effects are added in each regression. Results are presented in Table 6.

The residual income (*RI/BV*) is positive and significant, but the effect is stronger in non-hi-tech industries ($\beta_{1,\ Low\text{-}tech}$ = 7.101, *t-test* = 12.08; $\beta_{1,\ Hi\text{-}tech}$ = 1.305, *t-test* = 1.99), indicating that for these firms it is more important to have a stable stream of cash flows rather than preforming R&D investment.

Table 5 – Panel FE estimates for testing the relationship between the dependent variable *FV = (MV-BV)/BV* and different sets of independent variables

This table presents evidence of the relationship between the dependent variable and different sets of independent variables for the full sample. The number of observations is 2884 for all years. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RI* is the firm residual income. *RD* is the year firm expenditure in research and development. *MKTSHARE* is the firm's market share. *LEV* is the debt to equity ratio. *ANT_DIR* and *FIN_ACT* measure the legal and financial environment in each country. *RD*ANT_DIR, RD*FIN_ACT, RD*IFRS* and *RD_MKTSHARE* are interactions between *RD/BV* and the other 4 variables. T-tests are shown in brackets below the parameter estimates. Year and country dummies have been included in every regression for time and country effects. R-squares and adj. R-squares are listed at the bottom of the table.

	(1)	**(2)**	**(3)**	**(4)**
RI/BV	3.693***	3.364***	3.458***	3.432***
	[10.45]	[9.58]	[9.84]	[9.78]
RD/BV	5.786***	2.703**	2.256***	1.927***
	[6.41]	[2.07]	[5.99]	[5.03]
RD*ANT_DIR	1.066***			
	[4.35]			
RD*FIN_ACT		2.534***		
		[3.92]		
RD*IFRS			0.199	
			[0.86]	
RD_MKTSHARE				-2.006
				[-0.42]
LEV				0.018
				[0.40]
YEAR	YES	YES	YES	YES
COUNTRY	YES	YES	YES	YES
Intercept	23.72	23.8	23.74	24.06
	[0.57]	[0.57]	[0.57]	[0.58]
N	2884	2884	2884	2884
R-sq	0.376	0.474	0.569	0.64
Adj. R-sq	0.372	0.366	0.477	0.580

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

For hi-tech firms, it is imperative to invest in R&D, and financial markets do appreciate this investment ($\beta_{2,\ Hi\text{-}tech}$ = 8.732, *t-test* = 4.02). *RD/BV* is negative and significant for low-tech firms. The interaction between *RD/BV* and *Ln_Sales* is particularly interesting. For hi-tech and med-tech firms the loadings on *RD_Sales* are negative and significant ($\beta_{3,\ Hi\text{-}tech}$ = -0.503, t-test = -4.34; $\beta_{3,\ Med\text{-}tech}$ = -0.409, *t-test* = -3.62). The interacting effect of R&D and Sales is positive and significant for low-tech firms ($\beta_{3,\ Low\text{-}tech}$ = 0.304, *t-test* = 2.36).

A joint interpretation of the coefficients therefore allows a strengthening of the hypothesis that in high innovation industries it is necessary to maintain significant R&D investment in order to have an advantage in terms of market value. In other industries, earnings are more highly valued.

Table 6 – Panel FE estimates for testing the relationship between the dependent variable *FV = (MV-BV)/BV* and independent variables

This table presents evidence of the relationship between the dependent variable and independent variables. The full sample has been divided into three groups based on the propensity to innovate of firms' industry sectors. The number of observations is listed at the bottom of the table. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RI* is the firm residual income. *RD* is the year firm expenditure in research and development. *LEV* is the debt to equity ratio. *RD_Sales* is the interaction between *RD/BV* and *Ln_Sales.* T-tests are shown in brackets below the parameter estimates. Year and country dummies have been included in every regression for time and country effects. R-squares and adj. R-squares are listed at the bottom of the table.

	Hi-tech	Med-tech	Low-tech
RI/BV	1.305**	6.798***	7.101***
	[1.99]	[20.62]	[12.08]
RD/BV	8.732***	5.424*	-7.781**
	[4.02]	[1.87]	[-2.56]
RD_Sales	-0.503***	-0.449***	0.304**
	[-4.34]	[-3.62]	[2.36]
LEV	-0.007	0.002	0.039
	[-0.06]	[0.06]	[0.35]
YEAR	YES	YES	YES
COUNTRY	YES	YES	YES
Intercept	22.89**	6.393	3.923
	[2.19]	[1.10]	[0.54]
N	1176	1021	687
R-sq	0.36	0.433	0.29
Adj. R-sq.	0.223	0.251	0.333

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

In a similar perspective, firm size not only impacts negatively on R&D intensity for firms operating in these industries as previous theoretical approaches and empirical evidence have demonstrated (Lundvall and Johnson, 1994; Cohen and Klepper; 1996). It is closely related to the market valuation of R&D expenditures by investors. In some sectors, mostly hi-tech ones, small firms are more successful in generating tangible outputs from innovation, they are more productive than larger firms (Acs and Audretsch, 1988), and they are appreciated by investors. The impact of the interaction between firm size and R&D is positive for larger firms in low tech sectors because size helps firms to spread the costs of innovation on more projects, and to take advantage of economies of scale, high concentration and higher appropriability conditions (Lin and Huang, 2008).

Firm size is closely correlated to market share as it can be observed by the correlation matrix in Table 2. Larger firms normally have a higher market share, other things being equal. This might explain why there is no evidence of a market share effect on the value relevance of R&D. As most firms operate in the hi-tech sectors, size has a negative impact on the market valuation of R&D and market share should impact firm value in a similar direction.

No predictive power is assigned to leverage; the effect of this variable remains controversial. Previous research has also failed to give definitive results on this topic.

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In order to assure the validity of the previous assumptions I performed various robustness checks, first, by using a different dependent variable, the firm's market value deflated by sales. There are a number of contributions in the literature where sales are used as a deflator for similar models, as in Hirschey (1985) in the U.S. context, and in Stark and Thomas (1998) for UK firms. I perform in this case only a panel analysis for every country, I include in the model only the most relevant variables: *RI /Sales* and *RD/Sales*, and I control for firm size, market share, and leverage. The results are presented in Table 7. It seems that the hypotheses concerning R&D are verified in all countries except Italy, confirming the peculiarity of the Italian stock market. The coefficients are strongly significant and positive for France, Germany, UK and Sweden. The *RI* effect is positive for all countries. The impact of size remains negative and significant throughout the entire sample. Most of the firm-year observations belong to the hi-tech and medium-tech sectors, so it is not surprising that size is negatively valued by the markets. The other variables do not seem to add additional predictive power to the model, thus confirming the results of the previous regressions. The overall predictive power of the model seems adequate, with R-squares above 0.35 for all countries.

Second, I perform a robustness check for correcting a potential endogeneity problem that might afflict the R&D variable in the basic model (10). Firm value and R&D expenditures can influence each other as higher R&D investment boosts firm value and the latter helps to increase firms' investment in R&D. I try to alleviate this problem by instrumenting the R&D variable by its lags up to three years.

Table 7 – Panel FE estimates of the relationship between *(MV-BV) / Sales* and most important independent variables

This table presents evidence of the relationship between the dependent variable and most important independent variables for every country sample. Annual sales are used as a deflator for a robustness check. The number of observations is listed at the bottom of the table for each country. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RI* is the firm residual income. *RD* is the year firm expenditure in research and development. *MKTSHARE* is the firm's market share. *LEV* is the debt to equity ratio. *Ln_Sales* is the natural log of sales at the end of the fiscal year. T-tests are shown in brackets below the parameter estimates. Year dummies have been included in every regression for time effects. R-squares and adj. R-squares are listed at the bottom of the table

	FR	**GR**	**IT**	**SW**	**UK**
RI/BV	6.135***	0.249***	1.919***	8.305**	3.673***
	[193.48]	[27.07]	[2.81]	[-2.32]	[-10.92]
RD/BV	3.934***	2.711***	-0.115	9.346***	0.767***
	[7.97]	[10.56]	[-0.20]	[2.94]	[4.96]
Ln_Sales	-3.446***	-1.020***	-0.473**	-1.938***	-1.646***
	[-6.15]	[-4.98]	[-2.48]	[-3.47]	[-11.58]
MKTSHARE	52.22	0.256	0.256	1.197	-0.558***
	[0.88]	[0.19]	[0.42]	[0.74]	[-3.36]
LEV	-0.033	0.019	-0.143**	0.573**	-0.345
	[-0.21]	[0.26]	[-2.18]	[1.99]	[-0.43]
Intercept	-7.527***	21.29***	10.97***	42.86***	32.13***
	[-6.64]	[5.15]	[2.79]	[3.59]	[11.80]
N	527	853	210	371	923
R-sq	0.791	0.589	0.449	0.578	0.371
Adj. R-sq	0.689	0.569	0.314	0.49	0.256

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

In this case, the former values of R&D may indirectly influence firm value but are not influenced the other way around. The results are presented in Table 8. For reasons of space, I report only the results of the basic model for each country.

The results offer robust evidence that R&D have a positive effect on firm value. This is confirmed for every country with the exception of Italy. The Hansen J-tests support the validity of the instruments. The null hypothesis that the instruments are valid is not rejected. The other variables are mostly not significant and have little predictive power on the dependent variable.

Table 8 IV-GMM estimates of the relationship between *FV* and most important independent variables
This table presents evidence of the relationship between the dependent variable and most important independent variables for every country sample. The number of observations is listed at the bottom of the table for each country. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RI* is the firm residual income. *RD* is estimated by three annual lags of the same variable for correcting endogeneity bias. *MKTSHARE* is the firm's market share. *LEV* is the debt to equity ratio. *Ln_Sales* is the natural log of sales at the end of the fiscal year. T-tests are shown in brackets below the parameter estimates. Year dummies have been included in every regression for time effects. R-squares and adj. R-squares are listed at the bottom of the table. Hansen J-tests perform tests of overidentifying restrictions of the instruments.

	FR	**GR**	**IT**	**SW**	**UK**
RI/BV	1.764***	4.591***	-3.5	2.072**	3.526
	[3.83]	[6.58]	[-0.38]	[2.03]	[1.53]
RD/BV	8.403***	9.212***	43.7	2.054**	5.358**
	[5.81]	[4.64]	[1.35]	[2.11]	[2.28]
Ln_Sales	-2.323**	-0.303	2.567	13.81	-0.515
	[-2.25]	[-0.27]	[1.32]	[0.62]	[-0.58]
MKTSHARE	-29.01	4.698	-5.959	93.39	-22.8
	[-1.32]	[0.61]	[-0.65]	[0.96]	[-1.45]
LEV	-0.747	0.963	-0.402	-13.92	0.027
	[-0.72]	[0.81]	[-0.27]	[-0.56]	[1.16]
Intercept	58.65***	6.78	-57.69	-253.8	16.38
	[2.82]	[0.28]	[-1.36]	[-0.54]	[0.99]
Hansen	2.03	1.29	2.41	2.72	0.53
	(0.36)	(0.52)	(0.29)	(0.25)	(0.76)
N	300	488	120	212	528
R-sq	0.606	0.705	0.494	0.42	0.533
Adj. R-sq	0.595	0.700	0.329	0.416	0.525

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

4.2 The accounting based model

A. The model, research questions and variables

The extension of the residual income model has been recently proposed by Stark and Thomas (1998), Akbar and Stark (2003) and Hughes (2008). Its assumptions follow the seminal work of Ohlson (1989). The model hypothesises that the market value of a firm can be represented by a linear function of five variables: Book Value of Equity, R&D, Dividends, Earnings, Capital Contributions and other information. By now, it has been tested only on UK data. The reason I propose this extension is to evidence that R&D expenditures may have a signalling role for investors. R&D can convey information about the goodness of future earnings together with dividends, earnings and capital contributions from shareholders.

As previous empirical research shows, a deflator should be used for all variables in order to reduce multicollinearity and other problems deriving from scale (Dedman et al. 2009). We use the closing book value of equity as a deflator and thus, the estimated model is the following:

$$\frac{MV_{i,t} - BV_{i,t}}{BV_{i,t}} = \beta_1 \frac{RD_{i,t}}{BV_{i,t}} + \beta_2 \frac{D_{i,t}}{BV_{i,t}} + \beta_3 \frac{E_{i,t}}{BV_{i,t}} + \beta_4 \frac{CC_{i,t}}{BV_{i,t}} + \alpha_i + \lambda_t + \varepsilon_{i,t} \qquad (13)$$

Where $MV_{i,t}$ is the market value of the firm *i* at time *t*; $BV_{i,t}$ is the book value of the firm *i* at time *t*; $RD_{i,t}$ is the research and development expenditure of firm *i* at time *t*; $D_{i,t}$ is the amount of dividends paid by the firm *i* during year *t*; $E_{i,t}$ are the earnings of the firm *i* at time *t* and $CC_{i,t}$ are the capital contributions of the firm *i* at the same period *t*. Then firm individual effects (α_i), time effects (λ_t) and an error term ($v_{i,t}$) are added. I expect that the effect of the independent variables on firm value is positive following the results of previous contributions.

In a further specification of the model I address more exhaustively different hypotheses which concern investor protection and the quality of legal and financial environment in each country. In this case the model would be the following:

$$\frac{MV_{i,t} - BV_{i,t}}{BV_{i,t}} = \beta_1 \frac{RD_{i,t}}{BV_{i,t}} + \beta_2 \frac{D_{i,t}}{BV_{i,t}} + \beta_3 \frac{E_{i,t}}{BV_{i,t}} + \beta_4 \frac{CC_{i,t}}{BV_{i,t}} + \sum_{i=5}^{10} \beta_i RD * INV.PROT + \alpha_i + \lambda_t + \varepsilon_{i,t} \qquad (14)$$

The market value of equity is calculated as the year-end market price multiplied by the number of shares outstanding. The book value is measured as the sum of the share capital plus reserves. Cash Dividends paid indicates the total cash dividends paid to different classes of shares (ordinary, preference and savings shares) during the fiscal year. Earnings are measured as the bottom-line earnings figure as reported in the financial statements, plus research and development expenses incurred during the year. The capital contributions represent the net revenues from the shares' purchase and sale. It includes amounts received from the conversion of bonds or preference shares into ordinary shares, from the exchange of shares with bonds, from the sale of own shares and income from stock options.

Research and development expenditures represent all direct and indirect costs associated with the creation and development of new processes, techniques, applications and products with commercial possibilities.

INV.PROT are the legal and financial variables inspired by the paper of La Porta et al. (1998, 2006) and Levine (2000). The "disclosure" variable positively depends on the level of transparency of the communication prospects offered by listed firms to investors and analysts. The "anti-director rights" variable takes values from 0 to 6 where 6 is the highest protection for minority shareholders. The "creditor rights" variable is an index which aggregates creditor rights and takes values from 0 to 4. These rights comprise rights of creditors during reorganization procedures, rights to get collateral in case of reorganization, creditor consent in order to permit managers reorganizing the distressed firm and creditors' power to change management in case of reorganization.

It can be seen that the variables used in this case include more issues related to the legal environment of the country of domicile and thus, give a better framework of it. The *FIN_ACT* variable accounts for the development of the local equity and loan markets. As in the previous section these variables are interacted with *RD/BV* in order to verify their moderating effect in the market valuation of R&D.

B. Sample selection

The second model is tested for a sample of European firms. The annual accounting data for each company were extracted from Datastream. Initially, financial and accounting data related to listed companies domiciled in 14 EU countries for the period 2000-2009 were collected. The initial sample consisted of 6,921 listed companies divided into 14 European countries. However, the number of firms which have positive R&D is considerably low for many countries. Disclosure of R&D is one of the main issues which influence empirical studies on innovation, as it is not compulsory outside the US. I decided to concentrate only on five countries out of 14, where there were a sufficient number of firms disclosing R&D outlays. This would prevent the analysis from producing biased results.

Companies were divided according to the classification adopted by *ICB* (Industry Classification Benchmark) in 10 industries; all financial firms were excluded (ICB Code: 8000 FINANCIALS). The ICB classification code is adopted by the FTSE Group – London Stock Exchange and has become an international well-known system for sorting firms based on their main operating industry (See Table 3 in Appendix, for a description of the sectors). In order to be included in the final dataset each firm had to meet two conditions: the book value and market value had to present no missing values in each year, and the book value should assume a positive value in order to use it as a deflator. After this first selection individual observations for each firm that had extreme values and outliers were eliminated. This was done by implementing different statistics tests on the sample such as “*dfbeta*” for data leverage, or “Cook’s distance”. These statistics measure the distance that a particular regression coefficient would shift when a potential outlier is included or excluded from the regression. In some countries it is common to have two classes of shares like A or B in Sweden or UK. The shares grant different voting rights to different groups of shareholders, or different dividend rights. In this case I dropped all B shares, as they would have produced duplications in all accounting items such as R&D expenditures, sales etc. (As the firm is the same, there would be two observations per year with identical accounting data and two different stock prices, A and B).

At the end of the process the selected countries were Finland, France, Germany, Sweden and UK with 756, 2849, 2603, 1155 and 4050 firm – year observations respectively for the years 2000-2009.

C. Descriptive statistics and empirical results

First, in Tables 9 and 10 some descriptive statistics for the key variables for each country are displayed. The number of firm – year observations for which R&D is bigger than zero or not missing ranges from 430 for Finland to 1643 for UK. In percentage, Finnish firms invest or declare more R&D (56.87%) compared to other countries. It can be observed that the dependent variable has a similar mean value for Finland, France and Germany and it's bigger for Sweden and UK. This indicates that firms in Sweden and UK sample have greater capitalization other things being equal. As it can be expected, the median values are smaller than mean values for every country as the number of small firms is usually higher. The independent variables are somehow more homogeneous across countries.

Table 9 – R&D firm-year observations and total firm–year observations per country over the years 2000-2009

Country of domicile	R&D firm-year observations	Total observations	R&D % on total
FINLAND	430	756	56.87%
FRANCE	973	2849	34.15%
GERMANY	1108	2603	42.56%
SWEDEN	485	1155	41.99%
UK	1643	4050	40.56%

Mean values for *RD/BV* are 0.060 for Finland, 0.043 for France, 0.050 for Germany, 0.065 for Sweden and 0.067 for the UK. Earnings are on average smaller for UK firms while dividend rates seem to higher for Finnish firms.

The empirical analysis begins by testing the relationship between R&D activities, dividends, earnings, capital contributions and firm value. The analysis is performed by panel data for a period of 10 years. The models used are different. First, I apply OLS estimators and panel regression with fixed effects. The benefits of the fixed effects methodology were highlighted in Section 4.1.C. Stark and Thomas (1998) and Dedman et al. (2009) have used a similar methodology for UK samples. The superiority of the fixed effect estimator over the random effect is assured by applying the Hausman test. Results are exhibited in Table 11.

Table 10 – Descriptive statistics by country, years 2000-2009

(MV-BV)/BV is the dependent variable. *MV* is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *DIV* are total cash dividends paid to different classes of shares. *RD* is the year firm expenditure in research and development. *CC* are capital contributions which represent the net revenues from the shares' purchase and sale. *E* are earnings which are measured as the bottom-line earnings figure reported in the financial statements, plus research and development expenses incurred during the year.

		Mean	**Std. Dev.**	**1% %tile**	**Median**	**95% %tile**
FINLAND	(MV-BV)/BV	1.570	1.703	0.027	1.066	4.632
	RD/BV	0.060	0.147	0.000	0.010	0.285
	DIV/BV	0.080	0.090	0.000	0.059	0.242
	CC/BV	0.029	0.194	0.000	0.000	0.129
	E/BV	0.105	0.361	-1.275	0.136	0.417
FRANCE	(MV-BV)/BV	1.756	2.348	0.014	1.075	5.841
	RD/BV	0.043	0.139	0.000	0.000	0.240
	DIV/BV	0.042	0.061	0.000	0.029	0.135
	CC/BV	0.035	0.166	0.000	0.000	0.202
	E/BV	0.111	0.227	-0.824	0.127	0.393
GERMANY	(MV-BV)/BV	1.650	2.061	0.023	0.987	5.696
	RD/BV	0.050	0.103	0.000	0.000	0.230
	DIV/BV	0.040	0.078	0.000	0.027	0.122
	CC/BV	0.020	0.094	0.000	0.000	0.108
	E/BV	0.090	0.313	-1.204	0.121	0.417
SWEDEN	(MV-BV)/BV	2.204	2.919	0.025	1.373	6.870
	RD/BV	0.065	0.154	0.000	0.000	0.332
	DIV/BV	0.053	0.069	0.000	0.038	0.181
	CC/BV	0.055	0.188	0.000	0.000	0.384
	E/BV	0.095	0.279	-0.809	0.136	0.421
UK	(MV-BV)/BV	2.374	5.974	0.021	1.208	7.131
	RD/BV	0.067	0.714	0.000	0.000	0.226
	DIV/BV	0.068	0.351	0.000	0.044	0.177
	CC/BV	0.064	0.632	0.000	0.002	0.347
	E/BV	0.062	1.161	-1.861	0.126	0.464

The results support the assumption that R&D expenditures have a positive effect over firm value. The *OLS* and the *FE* estimators are generally positive and significant. If the panel *FE* regression is considered, it seems that investors assign more value relevance to R&D in Sweden and UK (β_{SW} = 2.611, β_{UK} = 3.290). The other variables have all the expected sign, they are positive and significant. Although there is not a clear economic theory behind, dividends should influence positively firm value (Fama and French, 1998; Rees, 1997; Hand and Landsman, 2005; Hughes 2008). This effect might be explained by differentials in tax rates, information asymmetry between insiders and outsiders (Hughes, 2008). Different legislators might tax differently dividends compared to capital gain. For example, in the US the tax rate on dividends was higher for a certain period.

Table 11 - Pooled cross section estimates and panel *FE* estimates for testing the relationship between the dependent variable *(MV-BV)/BV* and different independent variables

MV is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RD* is the year firm expenditure in research and development. *DIV* are total cash dividends paid to different classes of shares. *CC* are capital contributions which represent the net revenues from the shares' purchase and sale. *E* are earnings which are measured as the bottom-line earnings figure as reported in the financial statements, plus research and development expenses incurred during the year. T-tests are shown in brackets below the parameter estimates. Year dummies have been included in every regression for time effects. The number of observations, Hausman tests and adj. R-squares are listed at the bottom of the table.

	FIN		FR		GER		SW		UK	
	OLS	FE	OLS	FE	OLS	FE	OLS	FE	OLS	FE
RD/BV	4.077***	1.361***	1.308***	1.156***	0.213	1.332**	3.498***	2.611***	3.195***	3.290***
	[5.22]	[3.00]	[2.74]	[2.78]	[0.42]	[2.50]	[4.02]	[2.91]	[7.55]	[27.71]
E/BV	1.019***	1.148***	1.429***	1.318***	0.406**	0.291**	0.242	1.013***	1.516***	1.433***
	[2.86]	[5.59]	[2.92]	[5.67]	[2.19]	[2.13]	[0.45]	[2.61]	[4.31]	[17.09]
DIV/BV	5.052***	5.166***	6.100***	3.493***	1.648***	1.003**	5.977***	3.489**	2.649***	2.498***
	[8.19]	[7.20]	[3.87]	[3.66]	[2.60]	[2.14]	[3.17]	[2.25]	[3.50]	[11.51]
CC/BV	1.586**	1.496***	1.456***	1.003***	1.834***	0.749**	2.282**	0.863*	2.190***	1.589***
	[2.48]	[4.65]	[4.23]	[3.77]	[3.26]	[2.01]	[2.26]	[1.90]	[4.09]	[9.36]
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Intercept	1.402***	1.516***	2.462***	2.804***	2.159***	2.283***	2.154***	2.340***	3.758***	3.925***
	[3.49]	[8.08]	[8.64]	[20.42]	[10.25]	[20.58]	[6.16]	[9.56]	[5.76]	[15.13]
N	601	601	2151	2151	1933	1933	973	973	3047	3047
Adj. R2	0.29	0.15	0.13	0.28	0.31	0.48	0.34	0.45	0.36	0.27
Hausman		66.54		96.70		85.54		92.00		64.46
test		(0.00)		(0.00)		(0.00)		(0.00)		(0.00)

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

In this case investors should negatively react to new dividends. The signalling approach is also used to explain why dividends have an effect on corporate value. They convey information to investors about future profitability. Firm managers are not very keen to rapidly change the dividend rate every year. They tend to keep it stable (Litner, 1956). Hence, dividend payments are interpreted as a signal about future stable earnings (Baker et al. 2001).

It might be possible that the R&D variable in the previous regression might suffer from endogeneity problems. This should happen if it is correlated with the error term. The R&D variable is a candidate for endogeneity because investment in innovation is influenced by firm size, and thus firm value.

Table 12 – Instrumental variable estimates via 2SLS and GMM methodology for testing the relationship between the dependent variable *(MV-BV)/BV* and different independent variables

MV is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RD* is the year firm expenditure in research and development. *DIV* are total cash dividends paid to different classes of shares. *CC* are capital contributions which represent the net revenues from the shares' purchase and sale. *E* are earnings which are measured as the bottom-line earnings figure as reported in the financial statements, plus research and development expenses incurred during the year. T-tests are shown in brackets below the parameter estimates. Year dummies have been included in every regression for time effects. The number of observations, Hansen-Sargan tests for misspecification of instruments and adj. R-squares are listed at the bottom of the table.

	FIN		FR		GER		SW		UK	
	2SLS	GMM	2SLS	GMM	2SLS	GMM	2SLS	GMM	2SLS	GMM
RD/BV	4.251***	4.533***	1.981***	1.691***	-0.341	-0.574	5.458***	5.207***	0.993	2.775**
	[9.81]	[5.15]	[4.09]	[2.83]	[-0.57]	[-0.96]	[5.61]	[4.20]	[0.85]	[2.16]
E/BV	0.491***	0.552**	1.009***	1.195**	0.23	0.212	-0.237	0.0283	1.681***	1.477***
	[2.60]	[2.13]	[3.81]	[1.97]	[1.29]	[0.77]	[-0.39]	[0.03]	[20.21]	[3.96]
DIV/BV	6.627***	6.614***	6.083***	5.460***	1.634***	1.626**	5.512***	5.531***	2.553***	2.434***
	[10.64]	[10.72]	[8.42]	[2.62]	[3.16]	[2.56]	[3.30]	[3.69]	[16.38]	[4.29]
CC/BV	0.807***	0.835**	1.041**	0.987**	1.826***	1.623**	0.751	0.754	5.042***	1.862
	[2.61]	[2.04]	[2.49]	[2.36]	[3.70]	[2.16]	[0.80]	[0.69]	[2.58]	[0.83]
YEAR	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Intercept	0.515***	0.483***	0.523***	0.540***	1.095***	1.107***	0.930***	0.921***	0.926***	1.069***
	[3.17]	[3.49]	[4.25]	[4.42]	[7.83]	[9.92]	[3.11]	[4.38]	[4.24]	[5.37]
N	377	377	1258	1258	1175	1175	552	552	1881	1881
Adj. R2	0.41	0.41	0.13	0.13	0.21	0.21	0.35	0.34	0.50	0.61
Hansen -	3.07	2.13	2.16	1.51	1.23	1.77	1.50	0.81	5.06	5.60
Sargan test	(0.38)	(0.54)	(0.53)	(0.67)	(0.74)	(0.62)	(0.68)	(0.84)	(0.16)	(0.17)

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

Larger firms tend to invest more in R&D because they have more resources. Firms that have a better valuation of their R&D projects may decide to increment the amount invested because of this favorable valuation by the market causing reverse causality. Fixed effects panel estimators and *OLS* estimators would produce biased results in this case. I correct this problem instrumenting *RD/BV* with its lags up to 4 years in the past (Lag 1 to lag 4). By doing this, R&D lags will influence the future firm market value via the current expenditure in R&D but they will not be influenced by the dependent variable. Results are exhibited in Table 12.

In table 12 a 2SLS estimator and a GMM one are estimated. The 2SLS regression assumes that the errors are *i.i.d.* When this is not the case, it may produce consistent but not efficient estimates. The GMM estimator corrects this problem. The results show positive loadings for *RD/BV* for all countries with the exception of Germany. The 2SLS estimator and the GMM are similar for Finland, France and Sweden indicating a normal distribution of the disturbances for these samples. The coefficients of the other variables do not change considerably when I opt for the GMM approach. The loadings on *RD/BV* even in this model are less strong for UK just like in the Section 4.1 supporting the view that in Continental Europe countries R&D has a stronger impact on firm value.

The Hansen-Sargan test is not rejected showing that the instruments used for estimating the current value of R&D are valid and they are not correlated with the error term.

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The results I present in the previous regressions may suffer a problem of selection bias which is related to the choice the firms make when they decide whether to disclose or not R&D investments. The missing values of this variable in the sample derive from no R&D investment during the year or may be subject of the desire of the firm's managers to not display this type of investment. In this second case, what we see from the above regressions is only the effect of R&D on firm value for the firms that disclose this information; if the other group is not considered the coefficients on *RD/BV* might be biased and not consistent. The problem of selection bias in social sciences was studied by Heckman (1979) who introduced a new estimator for estimating the probability that a certain variable is observed or not before inserting it in the main equation where it acts as an independent variable in an *OLS* regression.

In order to check the robustness of previous results to a potential selection bias related to R&D disclosure, I build a sample selection model, where the main model is jointly estimated with a *Probit* model for the probability of reporting R&D. As previously described, this can be a relevant issue for European firms, as disclosure of R&D is not compulsory (Hall and Oriani, 2006). I decided to adopt a Heckman estimator with maximum likelihood for estimation. Its main advantages over the simpler two-step estimator rely on its better capabilities to have asymptotic efficient estimators in finite samples. The two-step estimator has proved to be consistent but not efficient especially for model estimates with heteroschedastic errors. It is more used for finding starting points before running the ML estimator (Greene, 2003).

This Heckman correction first, estimates the probability that R&D is disclosed, by an indicator variable: *YES R&D* or *NO R&D*, depending on whether the firm *i* for year *t* has reported R&D or not. Afterwards, a second model is estimated where the inverse of the Mills ratio (lambda) from the selection regression is added as an additive independent variable. This is the ratio of the probability density function to the cumulative distribution function for a variable. It permits to correct the selection bias for non-observing the qualities of firms that decide to not disclose R&D. When it is added in the main regression, this will produce unbiased estimates for the independent variables (if lambda is significantly different from zero).

Three new variables are included in the selection model: *Ln_sales* as a proxy for firm size, *RD_sector* which is the mean value of R&D investment for every industrial sector and *FIN_LEV* which is the debt-to-equity ratio for every firm. The rationale behind the choice to add size is that usually larger firms should report and thus invest more in R&D in absolute terms. Variables from the main equation are not included in the selection one in order to avoid multicollinearity issues.

The R&D sector is an important driver for modulating an optimal level of investment in innovation for all the firms in that sector. It acts as a benchmark for managers and investors which compare firm R&D intensity to the R&D intensity level of its competitors. A relevant mismatch can be reflected in good or bad market performance.

Table 13 – Heckman probit regression for estimating the probability that reported R&D is positive and OLS regression for estimating the impact of R&D on firm value including the effect of the Heckman coefficients.

MV is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RD* is the year firm expenditure in research and development. *DIV* are total cash dividends paid to different classes of shares. *CC* are capital contributions which represent the net revenues from the shares' purchase and sale. *E* are earnings which are measured as the bottom-line earnings figure as reported in the financial statements, plus research and development expenses incurred during the year. *Ln_Sales* is the log of annual firm sales. *RD_Sector* is the average value of R&D expenditure in a certain year for a certain industry. *FIN_LEV* is the firm debt-to-equity ratio. T-tests are shown in brackets below the parameter estimates. Year dummies have been included in every regression for time effects. The number of observations and the lambda test which measures the correlation between the two error terms is listed below.

	FIN	FR	GER	SW	UK
Main eq.					
RD/BV	3.782***	1.085***	0.0931	3.162***	2.419***
	[9.82]	[3.04]	[0.22]	[5.13]	[28.36]
E/BV	1.023***	1.339***	0.375**	0.423	1.244***
	[4.54]	[5.76]	[2.49]	[1.13]	[17.21]
DIV/BV	1.772***	1.686***	1.855***	2.407***	1.837***
	[5.26]	[5.66]	[4.09]	[4.70]	[36.00]
CC/BV	4.119***	5.660***	1.475***	5.120***	2.019***
	[6.32]	[7.47]	[2.71]	[3.72]	[13.25]
YEAR	YES	YES	YES	YES	YES
Intercept	0.812***	1.291***	1.615***	1.592***	0.0931
	[7.69]	[17.00]	[22.59]	[11.97]	[1.01]
Selection eq.					
Ln_Sales	0.0219	0.163***	0.103***	0.150***	0.022***
	[0.71]	[11.97]	[7.25]	[5.79]	[3.71]
RD_Sector	1.376***	0.064***	-0.095	0.0107	0.015***
	[3.80]	[2.64]	[-1.41]	[1.59]	[3.48]
FIN_LEV	-0.489***	-0.386***	-0.416***	-0.851***	-0.065***
	[-11.37]	[-21.74]	[-22.09]	[-14.17]	[-7.90]
Intercept	0.980**	-0.736***	0.113	0.152	0.084
	[2.48]	[-4.39]	[0.65]	[0.53]	[1.28]
N	756	2849	2603	1155	4050
Lambda test	11.60	12.04	9.81	9.07	14.22
(λ=0)	(0.02)	(0.00)	(0.001)	(0.003)	(0.00)

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

Hence it is more common that firms invest in and report R&D activity if they operate in sectors where R&D is considered as a value driver (Chauvin and Hirschey, 1993). According to the information asymmetry theory, firms with high R&D intensity should be penalized by a higher debt. This type of asset is usually financed by equity (Bhattacharya and Chiesa, 1995). Hence, the probability of disclosing or performing R&D should be negatively influenced by the financial leverage. The results are presented in Table 13.

The variables used for the selection equation seem to be important. The possibility of disclosing and reporting R&D increases when firms get bigger (*Ln_Sales* is positive and significant for all countries with the exception of Finland. Firms that operate in sectors with high R&D intensity have a greater probability of reporting R&D. This is true for Finland, France and UK and not different from zero in the other two countries. The *D/E* ratio has a negative effect on the disclosure of R&D for every country as expected.

The empirical evidence show however, that for all countries, the correlation of the error terms in the two equations is not significantly different from zero (lambda test), which implies that there is no bias arising from sample selection in the estimates of main equation. The conclusion from the sample selection estimation is that although R&D is observed for only a subset of firms in the Finnish, French, German, Swedish and UK economies, it is still possible to have consistent estimates of the effect of R&D on firm value.

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At the end of this section I present estimates of an OLS regression with the inclusion of R&D with some country level variables like those in Section 4.1. The analysis is performed on the overall sample which comprises all firms from the 5 selected countries. The new variables are inspired by the seminal paper of La Porta et al. (1998) and La Porta et al. (2006). They measure the level of transparency in the market, the protection of investors and creditors and also the development level of loan and equity markets in the country. For a description of the variables, the readers can refer to Section 4.2.A. I interact *RD/BV* with each one of these variables. If the interaction effects are positive, then there is evidence that the impact of R&D on firm value is modulated by the legal and financial framework of the country of domicile. Results are shown in table 14.

Table 14 – OLS estimates of the impact between some firm and country indicators and the dependent variable *(MV-BV)/BV.*

MV is the firm market value measured 6 months after the end of every financial year. *BV* is the firm book value of assets measured at the end of the financial year. *RD* is the year firm expenditure in research and development. *DIV* are total cash dividends paid to different classes of shares. *CC* are capital contributions which represent the net revenues from the shares' purchase and sale. *E* are earnings which are measured as the bottom-line earnings figure as reported in the financial statements, plus research and development expenses incurred during the year. *Disclosure, ANT_DIR, FIN_ACT, CRED_RIGHTS* are country indicators that measure market transparency, shareholder protections, development of loan and equity markets and creditor rights respectively. T-tests are shown in brackets below the parameter estimates. Year and country dummies have been included in every regression for time effects. Adj. R-squares and number of observations are listed below.

	A	**B**
RD/BV	3.118***	6.074**
	[8.21]	[2.05]
E/BV	1.405***	1.441***
	[4.68]	[4.60]
DIV/BV	2.788***	2.748***
	[3.54]	[3.57]
CC/BV	2.076***	2.103***
	[4.73]	[4.51]
RD*Disclosure		2.80***
		[2.87]
RD*ANT_DIR		3.454***
		[3.83]
RD*FIN_ACT		0.784*
		[1.72]
RD*CRED.RIGHTS		1.407*
		[1.80]
YEAR	YES	YES
COUNTRY	YES	YES
Intercept	2.716***	2.762***
	[10.43]	[10.54]
N	8705	8705
Adj. R-sq	0.297	0.303

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

It can be observed that the impact of R&D on firm value is influenced by these variables. The interactions between *RD/BV* and the four country indicators are significant. It seems that a robust financial markets enhances the positive valuation of R&D (β_{RD*FIN_ACT} = 0.784). The other three variables are positive and significant as well, following approximately the impact of *RD*ANT_DIR* in the section 4.1.C.

Conclusions

In this chapter the impact of R&D on firm value for a sample of European firms was investigated. This topic has been studied by many scholars in the last 20 years which have concentrated mainly in US and UK firms given the availability of data and a reasonable level of efficiency of financial markets in these countries. I investigated this phenomenon for Continental Europe firms listed in 5 countries and I included a sample of UK firms for a comparison. The results confirm that the investors consider R&D as an asset for the firm even when national accounting standards force companies to expense this investment in the year it is incurred. The impact of R&D on firm value measured by firm market capitalization is always positive with the exception of Italian firms; this is confirmed by previous research.

However, the empirical analysis shows that the impact of R&D changes across countries. It is stronger in bank-based countries like Germany; this might supports the view that shareholders in these economic systems are more able to value the long-term benefits of innovative projects rather than investors in Anglo-Saxon economies who may be more interested in short-term capital gains (Tylecote and Ramirez, 2006). There are other firm characteristics which can remarkably change the way R&D is valued by the markets. In particular firm size and the industry where firms operate seem to significantly modulate this relationship. If the industry is considered as highly R&D- intensive with a high propensity to innovate, then investors assign much more importance to the effort in R&D that the single firm undertakes. On the other hand, R&D is not particularly appreciated in sectors where it is not a strong driver for growth. Firm size is related to the sector. In mature sectors with low growth rates size positively impacts the value relevance of R&D. In hi-tech sectors it has a negative effect. Other firm fundamentals like firm financial leverage or market share do not have sensible effects on the market valuation of R&D. In the second part of the chapter the positive effect of R&D on firm market performance is confirmed together with dividends, earnings and capital contributions. I find that the probability that firms invest and declare R&D depends positively from firm size, sector R&D intensity and negatively from the debt-to-equity ratio. If we consider the economic system of the country of domicile, it seems that R&D is more valued when financial markets are well developed and assure a reasonable level of efficiency to the investors.

5. The effect of R&D on stock returns; the model, descriptive statistics and empirical results

5.1 The model, research questions and variables

As previously highlighted, the valuation of R&D expenditures and their effective benefits for the firm in terms of future cash flows are difficult to evaluate for investors and analysts and may suffer mispricing problems. This can be due to extended information asymmetries between insiders and other stakeholders, the latters have always less information about the reliability of data that managers decide to disclose to the markets. Mispricing can be generated even by the accounting regime of R&D expenditures.

Studies on the impact of R&D on the market performance of Continental European firms have been hampered by national accounting rules which still do not require the total disclosure of these outlays as in the US case. Moreover, only in the last 15 years has there been a significant effort for the harmonization of rules, the adoption of international best practices and for the real integration of different markets, making them more efficient even in terms of asset pricing. All listed firms in European markets have adopted the *IASB* financial reporting standards from 2004 in an effort towards harmonization of financial information to investors[6]. On the other hand, the number of firms that have increased their investment in R&D and/or disclosed it to the investors has grown constantly.

The corporate governance of Continental European countries is remarkably different from that of US and UK firms. There is a huge presence of insider shareholders which may control more than 50% of the voting rights (Faccio and Lang, 2002; Tylecote and Ramirez, 2006). This could be a bank as in Germany, the State as in France or family shareholders as in Italy. The Nordic countries lie somewhere in the middle between Germany and the UK with a strong presence of insiders as well as institutional investors.

Prior studies using European datasets have highlighted a positive and significant effect of R&D on market value confirming the evidence found in the US that investors consider it as an asset which has long-term benefits on firm value (Hall and Oriani, 2006; Pindado et

[6] The IAS 38.52 describes the activities that have to be grouped as research and development expenditure. Basic research has to be expensed in the year when it is incurred. Development expenditures can be capitalized but under strict requirements.

al. 2010; Munari et al. 2010). However, the positive outcomes of R&D investment can be remarkably modulated by firm specific characteristics like size, corporate governance, cash flows, firm growth or country specific characteristics (Toivanen et al. 2002; Pindado et al. 2010). The presence of different types of investors which have different investment horizons (Bae and Kim, 2003; Munari et al. 2010), or different market legal and financial frameworks (Hall and Oriani, 2006) can influence the market valuation of R&D (Booth et al. 2006).

R&D investment contains a high degree of information asymmetries; insiders have usually more information about its potential outcomes in the long-term (Aboody and Lev, 2000). These difficulties arise in countries where insiders can control big stakes of shares like in Continental Europe and where the private benefits of control are higher (Dyck and Zingales, 2004). Previous evidence for the US shows that generally investors are not able to correct their valuation of highly R&D-intensive stocks thus, generating abnormal returns. Mispricing should be more pronounced in Europe where disclosure is more problematic due to accounting rules and practices. Investors in Europe could suffer information risk more than in Anglo-Saxon markets, because it increases in presence of relevant inside information and low disclosure. There is evidence that information risk significantly impacts asset pricing because uninformed investors will require a higher rate of return for holding stocks with higher degree of private information (Easley and O'Hara, 2002, 2004; Ciftci et al. 2011).

We would expect that the stock variability of firms that invest more in R&D for Continental European firms be higher than non-R&D firms but lower than innovative firms domiciled in the UK other things being equal, because in Anglo-Saxon economies institutional investors put more pressure on managers and are more unwilling to accept short term losses which are frequent in hi-tech sectors (Tylecote and Ramirez, 2006). They might suffer from a so-called "myopic" view, which forces them to overreact by selling loser stocks and buying winners. In bank-based countries, inside shareholders are more inclined to accept long-term investments; they do not tend to frequently calibrate their portfolios following periodical information from firm managers, hence the stock variability should be lower. Sias (1996) and Bushee and Noe (2000) provide empirical evidence that higher institutional ownership is associated with higher stock return variability.

There is evidence that in several Continental European countries it may exist a size and book-to-market effect but the results are still inconclusive. Fama and French (1998b) find that their model can explain stock returns in cross-country evidence even for European markets. Value stocks with high *BM* ratio outperform growth stocks in twelve out of thirteen international markets. Similar results are found for France by Lajili-Jarjir (2007), and Chahine (2008). However, Malin and Veeraraghavan (2004) do not reach the same results comparing the UK with France and German markets. They evidence a small size effect in France and Germany, but no value effect for the markets investigated.

Previous research have also offered an alternative explanation of R&D mispricing suggesting that it could derive from a failure of investors to control for a non-diversifiable source of risk intrinsic of this asset that cannot be captured by other factors. The modulating effect of R&D in the Fama and French model (1993) for Continental European firms should not be different to that observed in the US or UK, due to similar risk characteristics of highly innovative firms in US and Western Europe.

In order to detect the mispricing of R&D on the stock market and a potential impact of R&D on stock returns, I initially follow the approach of Lev and Sougiannis (1996, 1999). I regress in cross-section for each country future stock returns on R&D expenses or R&D capital after controlling for market beta, firm size and firm market-to-book ratio. The model is the following:

$$R_{i,t+6} = \alpha_0 + \alpha_1 Ln(RD/ME)_{i,t} + \alpha_2 beta_{i,t} + \alpha_3 Ln(ME)_{i,t} + \alpha_4 Ln(BM)_{i,t} + \varepsilon_{i,t+6} \qquad (15)$$

Where:

$R_{i,t+6}$ is the stock return of firm *i* 6 months after financial statements for year *t* have been disclosed to the market. This usually happens at the end of June of every year. Firm betas have been calculated following the approach of Fama and French (1992) on 24 to 60 monthly returns in the 5 years before end of June of year *t*. $RD_{i,t}$ is the annual R&D expenditure for firm *i* in year *t*. $ME_{i,t}$ is the market capitalization of firm *i* at the end of year t. $BM_{i,t}$ is the book-to-market ratio for firm *i* in year *t*. Then monthly regressions from 1999 to 2010 are run following the Fama and MacBeth (1973) model.

In the second step of the analysis I check for abnormal excess returns of high R&D stocks. Previous methods which consist in controlling for size and book-to-market effects are applied (Chan et al. 2001; Chambers et al. 2002). Each stock is assigned to a control portfolio based on its size and *BM* ratio. At the end of June of year *t*, 25 control portfolios are created, by sorting all stocks in 5 *ME* and then 5 *BM* groups based on the market capitalization and *BM* ratio of previous year. Then one year and two year excess returns for each stock are calculated after assigning them to one of 25 portfolios. Then, all firms are sorted in 4 groups based on their *RD/ME* ratio and non-RD firms are grouped in a separate portfolio. One year and two year average excess returns for the five groups are then measured.

Following this step, I control whether there is a potential mispricing of R&D stocks deriving from a systematic source of risk that the three factor model of Fama and French (1993) cannot capture. *SMB* and *HML* portfolios following Fama and French (1993) are constructed. Then all firms are sorted on the *RD/ME* ratio and divided in 5 groups. If there is a significant stock mispricing, the regression intercept should be different from zero. The time series equation for each portfolio *i* is the following:

$$r_{i,t} - r_{f,t} = \alpha_i + \gamma_1\left[r_{m,t} - r_{f,t}\right] + \gamma_2 SMB_t + \gamma_3 HML_t + \varepsilon_{i,t} \qquad (16)$$

Where $r_{i,t}$ is the stock return of firm *i* at the end of time *t*; $r_{f,t}$ is the 1 month risk free rate of return on treasury bonds observed in month *t*; $r_{m,t}$ is the market rate of return at the end of month *t*, SMB_t and HML_t are size and book to market portfolios as in Fama and French (1993) for each month *t*. (A list of risk free rates and stock indexes per country which were used for calculating the above variables is presented in the Table 4 and 5 in the Appendix).

Finally, the stock volatility is analyzed in order to value whether more innovative stocks incorporate more business risk and whether this valuation differs across countries. Following Chan et al. (2001), I estimate the effect of R&D on stock variability and control for size and *BM* ratio. The economic rationale of the R&D impact is that more R&D intensive firms should be more risky in terms of returns' variability other things being equal. A cross-section regression model via the Fama and McBeth (1973) approach is used:

$$\sigma_{i,t+6} = \beta_0 + \beta_1 Ln(ME)_{i,t} + \beta_2 Ln(BM)_{i,t} + \beta_3 RD/ME_{i,t} + \varepsilon_{i,t+6} \qquad (17)$$

The sample comprised all listed firms of four EU countries: Finland, France, Germany and Sweden for years 1999-2009[7]. Financial data for these firms were downloaded from Datastream. I decided to concentrate only on these countries because the number of listed companies and the number of firms that declared R&D activity for other EU countries was not significantly high, hence slope coefficients for regressions would have been seriously biased. A sample of UK firms was added for comparison purposes as the UK stock exchange comprises the highest number of listed stocks in Europe with a high percentage of R&D intensive firms. Afterwards, all financial, insurance and real estate firms were dropped from the sample as the financial statements of these firms differ sensibly from manufacture companies in terms of leverage, R&D activity, intangibles etc. Firms with negative price and book value of equity were eliminated and extreme outliers were excluded by winsorizing from above at the 99% level the main variables which are rightly-skewed. Dedman et al. (2009) use a similar approach for their UK sample. A final check was performed in other databases like Bureau Van Dijk in order to find missing data, especially for R&D expenditures.

At the end of this process the final sample comprised 12911 firm-year observations, from which only 4755 observations reported R&D activity. The selected stock markets and indices for every country are reported in the Appendix.

5.2 Descriptive statistics and preliminary empirical results

In Table 15 the distribution of firms per country of domicile is presented. It can be observed that the number of firms that on average performed R&D or disclosed it during these years is almost never bigger than 55% of the sample for each country.

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[7] Stock prices and returns go up to July 2010

Table 15 - Number of firm-year observations per country of domicile.
In column 1 the number of firm-year observations with positive *RD/ME* over time is reported. Column 2 comprises the total number of firm-year observations and Column 3 the percentage of positive *RD/ME* firms over the total sample for each country.

Country of domicile	R&D firm-year observations	Total firm-year observations	R&D % on total
FIN	460	857	53.68%
FRA	866	2954	29.32%
GER	1186	3143	37.73%
SWE	521	1337	38.97%
UK	1722	4620	37.27%

It was stressed above that the disclosure of R&D is not compulsory across Europe. Firms that declare positive R&D ranges from 29.32% of the sample for France to near 38% for the UK and Germany and Sweden, and only Finland exceeds 50% perhaps, because the Finnish market has less listed firms than others. Larger countries have also the highest number of listed firms in the sample.

In Table 16 descriptive statistics for R&D and non-R&D firms are presented. For every country I calculate average measures of *Ln(ME)*, the natural logarithm of market capitalization, which accounts for firm size, the *BM* ratio, the earnings ratio (Earnings/Price) and a measure of leverage (Total Debt/Equity) across years 1999-2009. It can be observed that R&D firms are larger compared to non-R&D for every country. This evidences that R&D disclosure is related to size (Hall and Oriani, 2006). The book-to-market ratio of R&D firms is lower; innovative firms tend to be growth stocks. Sweden and UK firms have the lowest *BM* ratio (0.390 and 0.469 respectively). The leverage ratio is higher for non-R&D firms. French and German firms are the most leveraged, while UK firms use more equity. High *D/E* ratios are common in bank-based countries. Firms finance their activities with debt more than their competitors in Anglo-Saxon markets. The fact that non-R&D firms use more debt is in line with economic theories which demonstrate that R&D activity presents high risks of moral hazard and information asymmetries so it’s preferable to finance it by equity (Williamson, 1988; Hall, 2002). Earnings ratio seems to be higher on average for non-R&D firms.

Table 16 - Descriptive statistics for firms that performed R&D over the period 1999-2009 compared with non-R&D firms.

Ln(ME) is the natural log of market capitalization. *BM* is the book-to-market ratio. *E/P* is the earnings-to-price ratio. *D/E* is the total debt-to-equity ratio.

	Ln(ME)		BM		E/P		D/E	
Country of domicile	R&D	Non R&D	R&D	Non R&D	R&D	Non R&D	R&D	Non R&D
FINLAND	13.454	11.073	0.601	0.723	0.048	0.166	0.809	1.162
FRANCE	12.743	11.419	0.639	0.656	0.063	0.066	0.661	0.667
GERMANY	13.832	12.148	0.575	0.631	0.061	0.073	0.859	1.348
SWEDEN	13.434	13.063	0.390	0.691	0.050	0.084	1.117	1.395
UK	12.475	11.154	0.469	0.727	0.050	0.054	0.807	0.678

In Table 17 all firms are classified based on their main sector of operations. As usual, I adopted the ICB industrial classification. Firms are not sorted on a country level for not having only a few corporations per sector. Moreover, firms' value drivers are usually compared by investors and analysts with firm competitors in different markets, not only in firms' country of domicile.

All sectors are sorted on their average *RD/ME* ratio; for each sector I also present its *BM* ratio and *Ln(ME)* that accounts for average size. The most innovative sectors are the same evidenced by previous research on innovation; automobile and parts, technology & hardware & equipment, pharmaceuticals & biotech, etc. This is reported for US markets by Chan et al. (2001) or Japan by Nguyen (2010). Book-to-market ratios per sector and market capitalization are not significantly different; there is not a clear trend across sectors.

Last, in Table 18 descriptive statistics for average firms' *RD/ME* for each country of domicile are provided. The mean values are not remarkably different; this is due to the deflative effect of *ME*. The other statistics show a strong value asymmetry; i.e., the median is close to zero for almost all countries, much lower than the average values. *RD/ME* values show the highest levels of variability for France and the lowest for the UK. French and German firms have the highest levels of *RD/ME* in absolute values; the UK firms on average invest less compared to their market value of equity.

Table 17 - Mean values of *RD/ME, BM* and size per industry.
All firms have been classified based on the main sector of operations and then sorted by *RD/ME*. The ICB industry classification was adapted.

Sector	RD/ME	BM	Ln(ME)
Automobiles & Parts	13.31%	0.44	20.12
Software & Computer Services	12.18%	0.61	17.78
Technology Hardware & Equipment	10.66%	0.47	18.68
Leisure Goods	9.69%	0.56	18.32
Pharmaceuticals & Biotechnology	9.46%	0.66	19.07
Health Care Equipment & Services	9.24%	0.59	18.66
Electronic & Electrical Equipment	8.34%	0.70	17.72
Chemicals	7.13%	0.90	19.56
Industrial Engineering	7.04%	0.72	18.66
Aerospace & Defense	6.99%	0.94	20.09
Oil Equipment, Services & Distribution	4.77%	0.77	20.34
Support Services	3.77%	0.82	18.57
Household Goods & Home Construction	3.65%	0.80	18.52
Alternative Energy	3.34%	0.62	18.43
General Industrials	3.10%	0.78	19.45
Food Producers	2.90%	0.87	19.12
General Retailers	2.87%	0.81	19.10
Construction & Materials	2.21%	0.88	19.31
Industrial mining & metals	2.20%	0.91	19.98
Media	2.19%	0.84	18.92
Personal Goods	2.03%	0.72	18.39
Forestry & Paper	1.88%	0.89	20.08
Beverages	1.50%	0.70	18.49
Fixed Line Telecommunications	1.19%	0.76	21.33
Mining	1.05%	0.91	19.56
Electricity	0.92%	0.82	20.81
Industrial Transportation	0.78%	0.68	18.61
Travel & Leisure	0.62%	0.95	19.30
Mobile Telecommunications	0.49%	0.76	21.19
Tobacco	0.41%	0.74	23.00
Gas, Water & Multiutilities	0.37%	0.87	21.21
Food & Drug Retailers	0.34%	0.84	21.30
Oil & Gas Producers	0.32%	0.83	21.12

In order to examine whether R&D is a significant factor for explaining future stock returns beyond firm beta, size and *BM* ratio I apply model (15) and regress monthly returns on the three variables.

Table 18 - Descriptive statistics of *RD/ME* for the period 1999-2009.
Firms have been grouped by country of domicile. The 1% and 95% are the 1 percentile and 95 percentile of each sample distribution.

Country of domicile	Mean	Std. Dev.	1% percent	Median	95% percent
FINLAND	0.026	0.061	0.000	0.003	0.122
FRANCE	0.028	0.104	0.000	0.000	0.147
GERMANY	0.032	0.090	0.000	0.000	0.163
SWEDEN	0.028	0.074	0.000	0.000	0.142
UK	0.022	0.071	0.000	0.000	0.105

The regression is run monthly from June 2000 to June 2010 following the methodology of Fama and MacBeth (1973). Previous research for US markets (Lev and Sougiannis, 1996; 1999) has evidenced that the introduction of a measure of R&D helps improving the significance of the basic model introduced by Fama and French (1992). If the impact of R&D on stock returns is significant, there exists a potential mispricing effect of R&D expenditures.

As previously discussed, stock returns for firm *i* start six months after the end of the previous fiscal year. Six months are necessary for investors to incorporate in their expectations accounting information from previous year’s financial statements. Empirical results are presented in Table 19.

The results indicate that the market model has not a significant predictive power for future stock returns. Firm beta is never significant and close to zero for all countries for the period considered. Fama and French (1992) evidence that the relationship between beta and stock returns disappears in the US markets during the 1969-1990 period. I confirm here this result for European markets for years 1999-2009. Firm size has a negative and significant effect at the 1% level on returns only for Germany and the UK (β_{GER} = -0.003, t-test = -3.69, β_{UK} = -0.003, t-test = -4.06). It is not significant for Sweden and France and only significant at the 10% level for Finland.

Table 19 - Cross-sectional regressions of monthly future stock returns on *RD/ME*

The sample period goes from July 2000 to July 2010. *Ln(ME)* is the natural log. of market capitalization. Beta is estimated from the market model using past 60 month returns. *Ln(BM)* is the natural log of book-to-market ratio. T-statistics are in parenthesis.

	FIN	FRA	GER	SWE	UK
β	-0.005	-0.001	0.000	0.002	0.000
	[-0.98]	[-0.45]	[-0.01]	[0.42]	[0.03]
Ln(ME)	-0.002*	0.001	-0.003***	0.002	-0.003***
	[-1.82]	[1.62]	[-3.69]	[1.41]	[-4.06]
Ln(BM)	0.007*	0.004	0.007**	0.011**	0.008***
	[1.74]	[0.89]	[2.01]	[2.59]	[3.72]
Ln(RD/ME)	0.002	-0.001	0.003***	-0.002	0.002**
	[0.70]	[-0.63]	[3.17]	[-0.82]	[2.54]
Intercept	-0.040*	-0.032*	-0.052***	-0.065*	-0.054***
	[-1.67]	[-1.74]	[-2.80]	[-1.77]	[-3.04]
N	4032	7559	10320	4566	16024
R2	0.38	0.31	0.20	0.46	0.37

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

The *BM* ratio is positive for all countries but significant at the 5% level only for Germany, Sweden and UK. The R&D variable helps in improving the predictability of the model only for Germany and UK (β_{GER} = 0.003, t-test = 3.17, β_{UK} = 0.002, t-test = 2.54). The overall R^2 is not considerably high for all countries.

The loadings on the R&D are similar to those evidenced by Lev and Sougiannis (1999) for the US market. The empirical results evidence that R&D can be a good predictor for future stock returns, but not for all European countries. Previous evidence for size and *BM* effect in the UK is confirmed.

5.3 R&D and portfolio abnormal returns

In the previous section,I showed that there is a positive relationship between R&D and future stock returns for two out of five countries under observation. I test in the following whether investors correctly price firm shares or there is evidence that confirms a possible mispricing of R&D investment across Europe. In order to detect average excess returns the procedure described in Fama and French (1993) is followed. At the end of June of each year *t* in the period 1999-2009, stocks for each country sample are allocated to five size portfolios using stock capitalization breakpoints (*ME*). Then, stocks in each size quintile are sorted in five *BM* portfolios using the book-to-market ratio of the end of year *t-1*.All portfolios are annually rebalanced. Every stock is matched to a "benchmark" portfolio which has similar size and book-to-market ratio. Buy-and-hold abnormal returns are calculated in June of every year for the next one or two years as the difference between every stock's returns and the returns of its matched portfolio. At the end, stocks are ranked in four groups based in their *RD/ME* ratio and average one year and two year excess returns are calculated for each group. Non-R&D firms are grouped separately.

Table 20 reports average abnormal returns for roughly four equal groups based on the ratio of R&D to ME, where group one is the less R&D-intensive and group four the most innovative. In row one and two of Table 20, abnormal returns for one year and two year buy-and-hold portfolios are presented.

The results generally reveal that portfolio excess returns increase with respect to *RD/ME*. They are superior to their matched size and book-to-market portfolios for the first and second year after portfolio formation and this is confirmed for every country. The top R&D-intensive groups have the highest excess returns for every country. The highest returns are observed for Finland (18.33% and 6.11% respectively in year 1 and 2), and France (18.45% and 9.14%) and Germany (10.99% and 7.79%). In these three countries mispricing seems to be persistent because it is strengthened in the second year. In the other two countries we observe overvaluation for the lowest R&D groups especially in the Sweden case, but the trend reverses in the second year. The mispricing of top R&D groups for UK firms is lower compared to the other countries (0.52% for the first year and 1.05% for the second). Non-R&D firms do not have a clear pattern across different markets. Generally they are undervalued compared to top-R&D firms with the exception again of Sweden and UK.

Generally, these results confirm a pronounced undervaluation of R&D stocks, especially for the top-quintile R&D groups in France, Finland and Germany and a potential overvaluation for Sweden in the first year after portfolio formation.

Table 20 - Excess returns for R&D-sorted portfolios

Firms are ranked and sorted in four portfolios in July of each year *t* based on the *RD/ME* ratio of year *t-1*. Non-R&D firms are grouped separately. Buy-and-hold abnormal returns are calculated for the first and second year after portfolio formation and averaged. Size and *BM* control portfolios are created in each July of year *t* splitting each country sample in five quintiles on market capitalization and then five quintiles of *BM* ratio. *BM* is the average book-to-market ratio of equity for each portfolio. *Ln(ME)* is market capitalization (logged). *E/P* is the earnings-to-price ratio.

	Non-R&D	Q1 (low)	Q2	Q3	Q4 (high)
FIN					
1 year excess returns	5.51%	-6.49%	-3.79%	2.87%	18.33%
2 year excess returns	4.03%	-2.71%	0.48%	1.27%	6.11%
BM	0.656	0.749	0.703	0.668	0.557
Ln(ME)	18.286	21.184	20.001	19.486	18.253
E/P	6.65%	7.43%	6.37%	5.20%	4.89%
FRA					
1 year excess returns	5.54%	-0.85%	3.27%	10.20%	18.45%
2 year excess returns	2.90%	1.34%	2.12%	7.63%	9.14%
BM	0.797	0.660	0.620	0.643	0.597
Ln(ME)	18.587	21.615	20.253	19.870	19.113
E/P	11.15%	6.46%	6.92%	6.11%	5.95%
GER					
1 year excess returns	2.89%	-15.68%	1.53%	-1.31%	10.99%
2 year excess returns	0.49%	-8.26%	7.14%	-1.55%	7.79%
BM	0.764	0.879	0.601	0.591	0.524
Ln(ME)	18.018	21.093	20.459	19.764	19.366
E/P	8.68%	6.73%	6.47%	6.24%	5.31%
SWE					
1 year excess returns	-16.28%	-14.94%	-4.24%	-7.49%	-1.06%
2 year excess returns	-12.68%	-2.58%	1.88%	2..78%	2.49%
BM	0.573	0.745	0.540	0.433	0.322
Ln(ME)	18.067	20.787	20.393	19.624	18.294
E/P	5.42%	6.14%	6.02%	4.91%	3.56%
UK					
1 year excess returns	2.50%	-0.71%	-0.19%	-0.24%	0.52%
2 year excess returns	3.85%	-5.44%	-2.93%	-1.48%	1.05%
BM	0.661	0.805	0.669	0.476	0.465
Ln(ME)	18.778	21.069	19.512	18.757	17.843
E/P	7.59%	6.93%	6.13%	5.79%	5.25%

We do not observe a significant mispricing in UK. This can enforce the view that in Continental Europe more innovative firms can suffer mispricing due to high information asymmetries compared to value stocks. Investors in these countries find it difficult to correctly adjust their expectations about future cash flows related to R&D investment. In the UK mispricing is much lower due to higher transparency of financial statements and lower information risk. It can be observed that mispricing is low even for Sweden firms. Sweden financial and legal environment and corporate governance is similar to that of other Continental Europe countries i.e. Germany. Nevertheless, it has some peculiarities in terms of voluntary disclosure towards investors that make it more transparent compared to other Continental European Countries. Cooke (1989) and Grey and Skogsvik (2004) have evidenced that listed firms in Sweden opt for voluntary disclosure to give positive signals to the markets about their future performance. This is more pronounced in sectors like Pharmaceuticals where the R&D intensity is higher. Hence, disclosure helps investors to assess conservative measurement biases in the accounting numbers and facilitates predictions of future cash flows, reducing stock mispricing.

In rows three to five of Table 20 average values for key variables across *RD/ME* quintiles are presented. Generally, top-R&D firms have lower market capitalization; this is confirmed for all countries of the sample. Firm *BM* ratios are lower for most innovative stocks. The economic literature has shown that growth stocks with low *BM* ratios are usually those that innovate more than others; this is reflected in high stock prices compared to book value of equity (Lakonishok et al. 1994; Chan et al. 2001). The same rationale seems to guide to *E/P* ratio which is inversely proportionate to the *RD/ME* across all countries.

The results highlighted in Table 20 indicate a potential mispricing for most innovative stocks in Continental Europe. Investors tend to overvalue firms with a lower *RD/ME* ratio, but seem to have lower expectations on future cash flows for highly innovative firms. In this case undervaluation is common across all countries, although it is weaker for the UK and Sweden. These outcomes indirectly support previous research which has evidenced that in Continental Europe information asymmetries are higher; mispricing is more pronounced for highly innovative firms in these countries as they should suffer more from this issue.

5.4 R&D expenditures and systematic risk

In the previous section it can be noticed that stock mispricing is positively influenced by R&D intensity across different countries. It might be possible that this non correct valuation by investors reflects an additional source of risk for R&D expenditures not exhaustively captured by the *BM* or the size effect. To address this issue, I use the multi-factor model of Fama and French (1993) after sorting each country's sample by a measure of R&D intensity.

At the end of June of each year from 2000 to 2010, every country sample is sorted by market capitalization and stocks are allocated to two size groups (small and big, S and B) based on whether firm market equity is below or above the median. Stocks are also allocated independently from the first sort in three book-to-market groups, low (L), median (M) and high (H). Six portfolios are created from the intersection of size and *BM* groups (S/L, S/M, S/H, B/L, B/M, B/H) and value-weighted returns are calculated from July of year *t* till June of year *t+1*. Portfolios are rebalanced in June of each year *t*, so the book-to market of year *t-1* is known (Fama and French, 1993). The *SMB* portfolio is the simple monthly average between returns on S/L, S/M, S/H portfolios and returns on B/L, B/M, B/H portfolios. It attempts to measure the effect of size since the *BM* effect should be nullified from the difference. In the same way, *HML* is the monthly average of the difference between returns of S/H, B/H and returns of S/L and B/L portfolios. It represents the book-to-market risk factor.

The country samples are then sorted by *RD/ME* and divided in 4 groups (1 being the less R&D intensive and 4 the top quartile). Non-R&D firms are allocated to a separated portfolio. Portfolios are created every June of year *t*, and returns are calculated for the next 12 months. Then Fama and French (1993) model is applied. I recall it here for convenience:

$$r_{i,t} - r_{f,t} = \alpha_i + \gamma_1\left[r_{m,t} - r_{f,t}\right] + \gamma_2 SMB_t + \gamma_3 HML_t + \varepsilon_{i,t}$$

Where $r_{i,t}$ is the average monthly return for portfolio i; $r_{f,t}$ is the one month risk-free rate of return for each country in month t, $r_{m,t}$ is the market value-weighted return for month *t*[8]. For each country I have 128 monthly observations spanning from 1999 to July 2010. This model should capture all variations in firm excess returns. If the intercept is significantly different from zero, there is a high possibility that R&D might actually induce a not correct valuation of firm stock returns due to firms' systematic risk. The results are presented in Table 21.

[8] Risk free rates and market indices used in this section are listed in the Appendix.

Table 21 – Risk-adjusted returns on portfolios sorted on *RD/ME*

Portfolios are created in each July of year *t* and rebalanced every year based on accounting information of previous year. R_m is the return on the value-weighted market index. R_f is the risk-free rate of return. R_m-R_f is the monthly excess return of the specified market index. *SMB* and *HML* are the monthly returns on the two portfolios which proxy for size and *BM* risk. The sample period goes from July 2000 to June 2010 (128 months). Non-R&D firms are grouped separately for each country. The risk free rates and the market indexes used are listed in Table 4 and 5 in the Appendix.

	FIN				FRA				GER				SWE				UK			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Rm-Rf	0.841***	1.001***	0.915***	0.916***	0.953***	1.126***	1.064***	0.974***	1.111***	1.108***	1.184***	1.033***	0.865***	0.913***	1.023***	0.964***	0.924***	1.085***	1.015***	0.963***
	[35.97]	[23.17]	[17.28]	[12.56]	[42.47]	[31.42]	[27.83]	[20.82]	[30.59]	[35.37]	[38.95]	[27.56]	[29.62]	[40.07]	[35.11]	[23.77]	[25.31]	[24.44]	[23.02]	[14.62]
SMB	0.717***	0.523***	0.633***	0.744***	0.004	0.0676	-0.0122	0.098	0.450***	0.350***	0.580***	0.525***	0.197***	0.290***	0.215***	1.033***	0.401***	0.614***	0.738***	0.770***
	[21.19]	[9.01]	[8.90]	[7.59]	[0.09]	[0.97]	[-0.16]	[1.05]	[10.26]	[9.09]	[15.52]	[11.40]	[3.94]	[7.44]	[4.35]	[15.12]	[12.04]	[15.16]	[18.33]	[12.82]
HML	0.001	0.212***	0.128***	0.0232	-0.0016	-0.031	0.006	0.003	-0.23***	-0.036	0.371***	0.100***	0.533***	0.368***	0.214***	0.0358	-0.06**	-0.008	-0.0208	-0.0674
	[0.04]	[6.73]	[3.33]	[0.44]	[-0.08]	[-0.98]	[0.17]	[0.07]	[-5.36]	[-0.93]	[4.59]	[6.51]	[14.30]	[12.65]	[5.21]	[0.58]	[-2.08]	[-0.21]	[-0.54]	[-1.17]
Intercept	-0.07***	-0.007**	-0.006*	-0.005	-0.004	0.008**	0.004	-0.004	-0.005	-0.005	-0.001	-0.002	-0.01***	-0.006*	-0.010**	-0.007	-0.08***	-0.002	-0.002	-0.003
	[-4.15]	[-2.31]	[-1.75]	[-1.00]	[-1.55]	[2.25]	[0.97]	[-0.69]	[-1.44]	[-1.45]	[-0.42]	[-0.38]	[-2.66]	[-1.87]	[-2.56]	[-1.38]	[-3.66]	[-0.79]	[-0.60]	[-0.80]
N	128	122	122	122	122	121	122	122	121	122	122	122	122	122	121	120	122	122	122	122
Adj. R2	0.72	0.82	0.71	0.58	0.84	0.89	0.87	0.78	0.81	0.73	0.74	0.88	0.80	0.84	0.83	0.80	0.88	0.79	0.79	0.78

Non-R&D portfolios per country

	FIN	FRA	GER	SWE	UK
Rm-Rf	0.869***	0.820***	0.768***	0.873***	0.917***
	[19.02]	[30.69]	[51.83]	[50.39]	[32.71]
SMB	0.343***	-0.0843	0.675***	0.719***	0.721***
	[5.58]	[-1.57]	[37.37]	[23.92]	[27.44]
HML	0.160***	-0.009	-0.051***	-0.153***	-0.040
	[4.80]	[-0.38]	[-2.81]	[-6.84]	[-1.60]
Intercept	-0.004	-0.005	-0.01***	-0.008***	-0.009***
	[-1.24]	[-1.63]	[-7.64]	[-3.58]	[-5.23]
N	122	128	127	128	128
Adj. R2	0.77	0.89	0.77	0.78	0.84

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

The results evidence that the three factor model explains a high proportion of the time series variation in returns for all five portfolios. Adjusted R-squares are indeed very high. They are never lower than 70% with the only exception of the top quartile in the Finland sample. The loading for the market factor is generally high and close to unity across countries and R&D portfolios. It is always significant at the 1% level. Abnormal returns are not so common across the results. We observe negative and significant intercepts in the lowest quartiles for Finland (α_{Q1}= -0.007, α_{Q2}= -0.006, α_{Q3}= -0.006) and Sweden (α_{Q1}= -0.011, α_{Q2}= -0.006, α_{Q3}= -0.010). This common trend can be due to the positive correlation of two Scandinavian countries (the correlation between stock returns during the period under observation for Sweden and Finland is 0.46). In the other countries we notice a significant underpricing for France Q2 portfolio (α_{Q2}= 0.008) and overpricing for the UK Q1 portfolio (α_{Q1}= -0.008). Non-R&D portfolios suffer overvaluation but this is significant only for Germany, Sweden and UK.

The overall picture seems to indicate no significant risk based excess returns for top R&D sorted portfolios for France, Germany and UK and significant albeit low overpricing for Finland and Sweden. The size portfolio carries a positive loading when significant and this is verified for all countries except France. The coefficients when positive confirm the result for every level of significance. Moreover there exists a positive trend from low R&D portfolios to top quartiles. High *RD/ME* firms have lower size and this is reflected in higher *SML* coefficients for more R&D intensive firms because they are supposed to be more risky. The book-to-market variable has not a clear trend across countries and R&D sorted portfolios. It is positive and significant for Finland (Q2, Q3), Germany (Q3 and Q4) and Sweden (Q1, Q2, Q3). It is generally not significant for France and UK. However, when significant, the *BM* factor decreases when *RD/ME* increases due to lower *BM* ratios for most innovative firms. The results for UK data confirm previous research by Al-Horani et al. (2003) and Dedman et al. (2009) which posit that the size variable has a positive effect and positive trend when *RD/ME* increases. They also find evidence that when firms are grouped by a measure of R&D intensity the *BM* impact is not straightforward. This may be due to the fact that R&D often subsumes to the *BM* risk factor (Lev and Sougiannis, 1999).

In order to perform an additional check on the risk assessment of R&D expenditures I follow Chan et al. (2001) and apply the three factor model during down and up markets separately. During the former, the market return is lower than the risk free rate, while in the second case it is higher. I aim to test whether there exist a possible over or undervaluation during different economic phases and whether this depends on firm R&D intensity.

Several authors have emphasized that value and growth stocks perform differently in bull and bearish markets. Lakonishok et al. (1994, 2004) find that value strategies outperform glamour stocks in different time periods even during recessions. This is due to an overvaluation of growth stocks; investors seem to overestimate future growth rates of these firms based on their past history as winners. Chiao et al. (2008) find that top R&D sorted portfolios earn greater abnormal returns during expansion phases and perform worse compared to low R&D portfolios during recessions. Xu and Zhang (2004) and Ngyuen et al. (2010) find that R&D firms in Japan tend to outperform low R&D firms but only in bearish markets.

The results show that in European countries the effect of the economic cycle doesn't influence under- (over-) valuation of R&D sorted portfolios. The empirical evidence is similar to that for the entire sample and I do not tabulate the results in order to save space.

5.5 Overall variability for R&D intensive firms

Prior research has provided evidence that R&D activity is generally more risky due to a high level of information asymmetries and moral hazard (Bhattacharya and Chiesa, 1995), the output of R&D investment is highly uncertain and profits are far from assured. These issues should be reflected on higher firm stock return variability. Chan et al. (2001) for the US and Zu and Zhang (2004) for Japan, have shown that the returns' variability positively depends from research and development expenditures along with a set of controlling variables. In this section I apply a similar approach to theirs and estimate a linear cross section regression of the form (model 17):

$$\sigma_{i,t+6} = \alpha_1 + \beta_1 Ln(ME)_{i,t} + \beta_2 Ln(BM)_{i,t} + \beta_3 RD/ME_{i,t} + \varepsilon_{i,t+6}$$

At the end of June of each year *t*, the stock variance for each firm for the next 12 months is calculated. All stocks per country (performing R&D or not) are included in the sample. The square root of stocks' returns variance is defined as the total risk for firm *i,* in year *t*. This variable is regressed on a measure of firm size (*Ln(ME)*), book-to-market ratio (*Ln(BM)*) and *RD/ME*. The Fama and MacBeth (1973) methodology for estimating the regression coefficients is used again. The results are exhibited in Table 22.

Table 22 - Cross-sectional regressions of monthly future stock volatility on *RD/ME*
Stock volatility is measured in July of each year *t* based on accounting information of previous year. It is the standard deviation of monthly returns for 12 months going from July of year *t* at June of year *t+1*. The sample period goes from July 2000 to July 2010. *Ln(ME)* is the natural log. of market capitalization. Beta is estimated from the market model using past 60 month returns. *Ln(BM)* is the natural log of book-to-market ratio. T-statistics are in parenthesis

	FIN	**FRA**	**GER**	**SWE**	**UK**
Ln(ME)	-0.003***	-0.010***	-0.013***	-0.020***	-0.010***
	[-8.20]	[-22.48]	[-17.49]	[-16.56]	[-38.52]
Ln(BM)	-0.013***	-0.030***	-0.018***	-0.037***	-0.020***
	[-7.48]	[-8.16]	[-4.18]	[-8.74]	[-9.14]
Ln(RD/ME)	0.122***	0.153***	0.206***	0.115***	0.230***
	[11.92]	[13.64]	[20.05]	[15.59]	[10.39]
Intercept	0.152***	0.353***	0.405***	0.636***	0.295***
	[19.09]	[36.21]	[27.76]	[21.01]	[49.40]
N	763	2611	2785	1188	4059
R2	0.27	0.33	0.43	0.41	0.40

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

As expected, the size variable negatively impacts stock variability, larger firms are also less volatile. I obtain the same results for the book-to-market ratio. Value stocks are usually firms operating in mature sectors with a low level of uncertainty which is reflected in lesser stock variability. Lakonishok et al. (1994) achieve similar outcomes for US firms. The R&D variable is positive and significant for all countries. The loadings range from 0.122 (*t-test* = 11.92) for Finland to 0.230 (*t-test* = 15.59) for the UK. These outcomes confirm the initial expectations that stock variability is positively influenced by R&D expenditures. Further, I find that Continental Europe firms are less volatile than UK firms. The greater stock variability of UK firms is consistent with previous research which has related high volatility of traded shares with the widespread presence of institutional investors among firm shareholders (Potter, 1992; Bushee and Nee, 2000). Institutions are more sensitive than other type of investors to short-term firm results with little interest in long-term capital appreciation. They could suffer firm's strong commitment to R&D investment because these companies tend to have lower earnings in the short-term. It can be observed from Table 20 that this is the case; *E/P* ratios of highly R&D intensive firms are lower than less innovative ones, other things being equal.

5.6 Robustness checks: Using a measure of R&D stock in cross section regressions

In the following, I test whether the results achieved using R&D annual expenditures are still consistent after a measure of R&D stock is used. This variable has been largely used in the literature and many authors have evidenced its impact on firm market value (Griliches, 1988; Hall and Oriani, 2006; Pindado et al., 2010). The R&D capital is created artificially because firms completely expense R&D in the year it is incurred. I construct it following the intuition of Griliches (1981). This method is based on a standard perpetual inventory equation with declining balance depreciation:

$$\mathrm{K_t} = (1-\delta)\mathrm{K_{t-1}} + \mathcal{R}_\mathrm{t} \tag{18}$$

where K_t is the end-of-period stock of R&D capital and R_t are the annual R&D expenditures during the year *t*. The depreciation rate δ is chosen to be 15 percent per year although Griliches and Mairesse (1981) found that the exact choice of depreciation rate make little difference in production function estimates. The initial stock of R&D expenditures is set equal to the value of R&D at the first year divided by the depreciation rate, summed with a growth rate of new R&D of 8% per year (Hall, 1990). Accordingly, I re-estimate regression (15) in cross-section:

$$R_{i,t+6} = \alpha_0 + \alpha_1 Ln(RDC/ME)_{i,t} + \alpha_2 beta_{i,t} + \alpha_3 Ln(ME)_{i,t} + \alpha_4 Ln(BM)_{i,t} + \varepsilon_{i,t+6}$$

The results are evidenced in Table 23. It can be observed that the slope coefficients are in line with those derived from the previous regressions where a flow variable of R&D was used.

Table 23 - Cross-sectional regressions of monthly future stock returns on the R&D capital to ME ratio
The sample period goes from July 2000 to July 2010. *Ln(ME)* is the natural log. of market capitalization. Beta is estimated from the market model using past 60 month returns. *Ln(BM)* is the natural log of book-to-market ratio. T-statistics are in parenthesis. *RDC* is the R&D capital estimated using the standard perpetual inventory method. *Ln(RDC/ME)* is the natural log of *RDC/ME* ratio.

	FIN	**FRA**	**GER**	**SWE**	**UK**
β	-0.006	-0.002	-0.002	0.013**	0.001
	[-0.38]	[-0.59]	[-0.46]	[2.20]	[0.44]
Ln(ME)	-0.004*	0.001	-0.003***	0.002	-0.003***
	[-1.69]	[1.09]	[-3.19]	[1.11]	[-3.69]
Ln(BM)	0.001	0.011**	0.009*	0.011*	0.008***
	[0.26]	[2.48]	[1.74]	[1.85]	[3.07]
Ln(RDC/ME)	0.001	0.003*	0.002**	-0.003	0.002**
	[0.09]	[1.98]	[2.02]	[-0.88]	[2.00]
Intercept	-0.064	-0.025	-0.057***	-0.076*	-0.058***
	[-1.65]	[-1.22]	[-2.70]	[-1.77]	[-3.13]
N	1647	4414	6361	2335	11728
R2	0.34	0.25	0.23	0.43	0.38

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

5.7 The modulating effect of the industry sector on R&D mispricing

In the previous sections it was evidenced how R&D can contribute to the prediction of future stock returns together with size and *BM* ratio. However, this effect is not straightforward across all countries. In the following, I check whether the propensity to innovate of firms' industry sectors can modulate this effect. Prior studies have shown that mispricing may be driven by the sector in which firms operate. Chiao et al. (2008) show that the R&D impact is more important for firms operating in the electronics industry in Taiwan compared to non-electronics firms. Al-Horani et al. (2003), offer empirical evidence for UK data that the risk premia generated by an R&D addendum in the Fama and French model is much higher for high-tech firms belonging to electronics, software and health industries. Ciftci et al. (2011) find that firms tend to earn excess returns when they have an above-the-average R&D intensity ratio compared to other competitors in the same industry sector. The aforementioned papers indicate that sector R&D intensity is the threshold for evaluating firm innovativeness. I partially follow this path as I sort all firms in the sample based on their main sector of operations. At the end of June of each year industry sectors were sorted and divided into three groups based on their R&D intensity over the period 1999-2009.

Table 24 - Cross-sectional regressions of monthly future stock returns on the RD/ME ratio per sector based on firm R&D intensity

The sample period goes from July 2000 to July 2010. At the end of July of each year *t* stocks for all countries are ranked based on the last available *RD/ME* ratio and sorted in three groups. The most R&D intensive firms are named as hi-tech. The middle group is named med-tech and the less innovative firms are included in the low-tech sample. For each group stock returns are estimated based on the accounting information of year ***t-1***. *Ln(ME)* is the natural log. of market capitalization. Beta is estimated from the market model using past 60 month returns. *Ln(BM)* is the natural log of book-to-market ratio. T-statistics are in parenthesis.

	Hi tech	**Med tech**	**Low tech**
β	0.001	-0.001	0.001
	[0.17]	[-0.28]	[0.24]
Ln(ME)	-0.003***	-0.002**	0.001
	[-3.26]	[-2.42]	[1.22]
Ln(BM)	0.005***	0.003***	0.006***
	[3.20]	[2.79]	[2.68]
Ln(RD/ME)	0.003***	0.002*	-0.001
	[3.21]	[1.68]	[-0.58]
Intercept	-0.044***	-0.033**	-0.024
	[-2.71]	[-2.01]	[-1.09]
N	17377	13821	11303
R2	0.51	0.65	0.39

Notes: * indicate levels of significance (*** pv< 1%, ** pv< 5%; * pv< 10%).

The hi-tech group comprises all firms with *RD/ME* ratio over 4.77%, the med-tech companies have a *RD/ME* ratio that ranges from 1.88% to 4.77% and the low-tech firms lower than 1.88%. The number of firms in each group is 135, 107 and 88 respectively. I decided to not split the sample at a country level as this would have produced biases results due to the low number of firms in single countries. First, the R&D predictive power is tested by applying model (13). The results are presented in Table 24.

The impact of R&D on future stock returns is positive and significant only for the hi-tech firms (*Ln(RD/ME*) = 0.003, *t-test* = 3.21), while it loses its predictive power for less innovative firms. The results show that mispricing is more likely to occur for highly R&D intensive firms.

In Table 25 excess returns for sector portfolios based on their R&D intensity are calculated. It can be observed that excess returns are higher for top *RD/ME* firms. Further, the undervaluation is more marked for highly *RD/ME* intensive sectors, while it lowers considerably when less innovative industries are considered. This enforces the view that industry sector can significantly impact R&D mispricing.

Table 25 - R&D and one year sector excess returns

In this table excess returns for one year buy-and-hold sector portfolios are evidenced. All firms are grouped in sectors based on their ICB code in July of every year. Average cumulative returns are calculated for the next 12 months after portfolio formation. Then all firms are sorted based on their *RD/ME* and divided on four groups where group one has the lowest *RD/ME* ratio and four the highest. Excess returns are then calculated as the average return of every *RD/ME* group and its sector benchmark portfolio. The *RD/ME* column indicates average *RD/ME* ratios for all sectors as in Table 17.

Sector	**RD/ME**	**1 (low)**	**2**	**3**	**4 (high)**
Automobiles & Parts	13.31%	-5.01%	-7.42%	-11.24%	3.03%
Software & Computer Services	12.18%	-37.91%	-3.54%	5.90%	19.31%
Technology Hardware & Equipment	10.66%	-61.51%	-11.45%	-3.93%	8.14%
Leisure Goods	9.69%	-18.58%	18.36%	1.11%	10.64%
Pharmaceuticals & Biotechnology	9.46%	-26.88%	-4.89%	3.28%	4.01%
Health Care Equipment & Services	9.24%	-32.41%	9.41%	6.00%	27.64%
Electronic & Electrical Equipment	8.34%	-30.97%	-6.05%	0.79%	13.18%
Chemicals	7.13%	4.28%	7.30%	-0.21%	1.32%
Industrial Engineering	7.04%	3.27%	-1.38%	-0.72%	3.39%
Aerospace & Defense	6.99%	-1.61%	0.23%	3.24%	3.17%
Oil Equipment, Services & Distribution	4.77%	-25.85%	7.94%	-5.04%	2.74%
Support Services	3.77%	0.75%	2.81%	1.75%	1.23%
Household Goods & Home Construction	3.65%	0.60%	-0.46%	5.04%	4.67%
Alternative Energy	3.34%	-20.37%	-8.46%	7.75%	3.99%
General Industrials	3.10%	-0.70%	-6.70%	2.31%	5.39%
Food Producers	2.90%	0.12%	-0.13%	6.84%	7.72%

General Retailers	2.87%	5.71%	3.30%	4.80%	4.37%
Construction & Materials	2.21%	-3.01%	-1.34%	5.79%	1.27%
Industrial mining & metals	2.20%	-17.71%	-2.36%	4.71%	5.35%
Media	2.19%	-10.70%	-9.19%	-5.89%	4.66%
Personal Goods	2.03%	-4.72%	6.53%	7.89%	5.52%
Forestry & Paper	1.88%	-14.58%	-16.61%	2.60%	2.80%
Beverages	1.50%	10.39%	-16.88%	-0.91%	5.41%
Fixed Line Telecommunications	1.19%	-37.53%	-2.23%	3.14%	
Mining	1.05%	6.14%	4.10%	5.99%	4.98%
Electricity	0.92%	9.52%	0.62%	5.39%	
Industrial Transportation	0.78%	-14.57%	3.56%		
Travel & Leisure	0.62%	-12.27%	8.55%	10.99%	
Mobile Telecommunications	0.49%	-3.99%	1.39%		
Tobacco	0.41%	16.18%			
Gas, Water & Multiutilities	0.37%	2.76%	1.00%	6.77%	
Food & Drug Retailers	0.34%	-17.09%			
Oil & Gas Producers	0.32%	2.80%			

Conclusions

In this chapter the effect of R&D on firm stock returns was examined. I investigated whether R&D can help predicting future stock returns for a sample of European firms, and whether more R&D-intensive portfolios can achieve excess returns compared to size and book-to-market benchmark portfolios. The results provide support that R&D can help investors to estimate future stock returns but only in two out of five countries, Germany and the UK. R&D-intensive firms earn substantial abnormal returns one year and two years after portfolio formation. Companies that invest more in R&D have lower market capitalization, lower *BM* ratios and lower *E/P* ratios. They are typically growth stocks.

The evidence does not permit to value any mispricing due to the non-correct valuation of systematic risk for more innovative firms. However, these firms are usually more risky in terms of overall stock volatility compared to those that invest less in R&D. Listed firms in UK seem to suffer more this issue, perhaps due to the diffused presence of institutional investors among their shareholders.

Industry sector seem to be once again a powerful driver for modulating R&D mispricing as it was in previous chapters for the market valuation of R&D. R&D can help predicting future returns but only for hi-tech firms. These groups on average achieve higher abnormal returns compared to companies that operate in less innovative industries.

Thesis conclusions and final remarks

Private firm investment in R&D has constantly grown in the last years all over the world. Similarly, theoretical and empirical research that tries to assess the effect of research and development over firm performance and stock prices has greatly increased since the 80ies. Unfortunately, prior contributions on this topic have concentrated mainly on US markets and only a few of them have tried to investigate the phenomenon for other markets. This thesis tries to partially fill this gap as I consider here Continental European firms for a recent period, 1999-2009.

The main problem that concerns the study of R&D across Europe is that firms are not required to disclose this type of information. The other issue is related to the accounting treatment of R&D in financial statements. The economic literature considers R&D as an asset which generates profits in the long term. The legislators instead, have opted for the complete expensing of all R&D outlays in the year when they are incurred since 1974 in the US and 1989 for the UK (will small exceptions in the latter case). In Continental Europe, the rules are somehow more variegated; basic research is completely expensed whereas for development research capitalization is permitted under some circumstances. Different authors have highlighted that firms usually expense all R&D due to the difficulty to correctly apply this rule.

In order to study the effect of R&D on stock prices I considered a sample of listed firms from six European Countries for the period 1999-2009. Only part of them disclosed R&D investment due the issues discussed above. In the first two chapters the effect of R&D on firm value was studied and in the last chapter the effect of R&D on stock returns was investigated.

In the first case an accounting based model introduced by Ohlson (1989) was used. The rationale of this model is that firm value can be estimated as the present value of discounted dividends. The latter can be approximated by firm book value plus expected future residual income. R&D expenditures are added in the model as they influence the technological progress which helps firms to produce future cash flows. I estimated two versions of this model by applying different econometric models which are mainly used for panel data. These models correct for fixed effects among firms and then for heteroskedasticity, autocorrelation and cross causality among dependent and independent variables. I checked also for possible selecting bias for firms that decide to disclose to the market their investment in R&D. In further specifications of the models, other control variables were added in order to capture modulating effects related to size, industry, firm leverage, financial and legal environment of the countries where firms operate etc.

I found that R&D has a positive and significant effect on firm value for almost all countries with the exception of Italian firms. This effect persists across years and across countries. These results are in line with prior research for UK markets. Firms that decide to disclose R&D are usually larger in size, operate in hi-tech sectors and have lower leverage. The market valuation of R&D is modulated by other variables. It is higher for smaller firms which operate in hi-tech sectors and larger for firms that operate in low-R&D intensity ones. I evidence that the sector has a key role in this valuation.

Firms that operate in markets with elevated disclosure and shareholders' rights have also a positive valuation of their R&D expenditures. The interaction between this variable and the dummies which represent disclosure quality and the development of financial markets is always positive and significant across Europe.

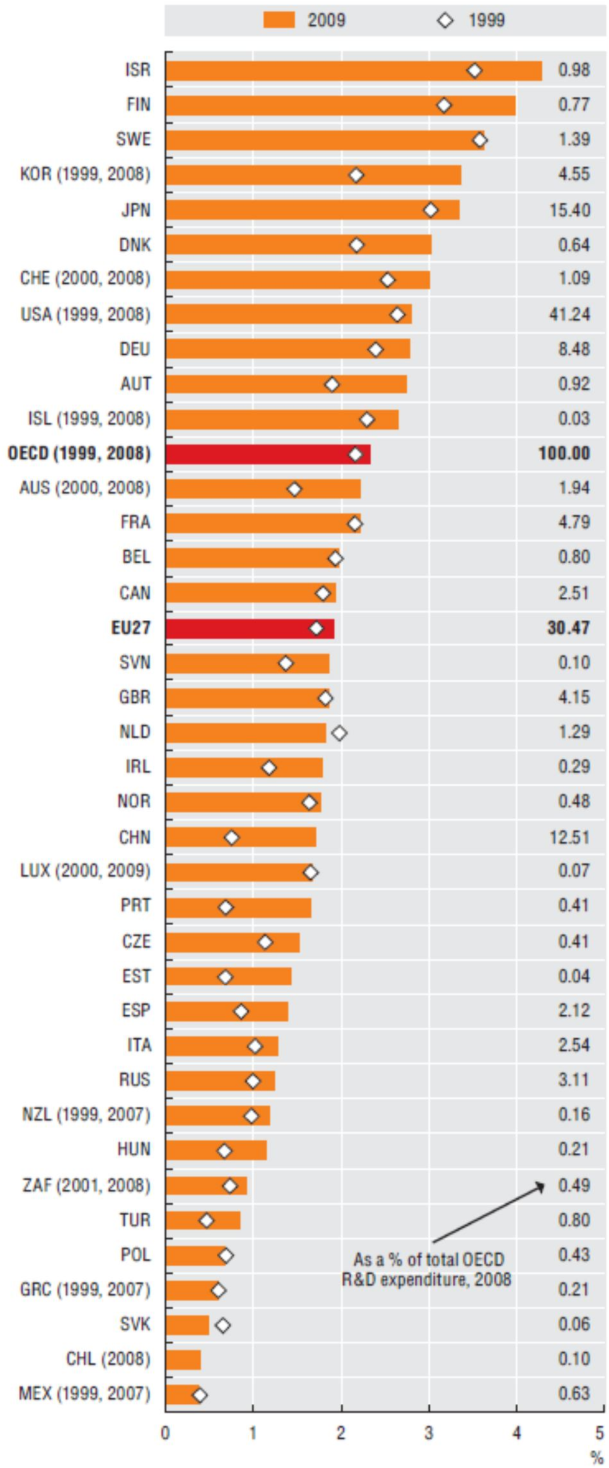
In the last chapter I test the effect of R&D on stock returns. The results indicate that R&D can help in predicting future stock returns for Continental European firms. This can be due to a potential mispricing of this asset by investors. Mispricing generates higher excess returns for highly intensive R&D sorted portfolios after controlling for size and book-to-market ratio. This is verified for all countries. I did not find empirical evidence to support the view that investors do not completely control for risk when they value R&D. When Fama and French (1993) model is tested for buy-and-hold portfolios based on their R&D intensity, little mispricing is evidenced. However, R&D firms are more risky in terms of stock volatility, which seems to be higher for UK firms compared to Continental Europe. This can be related to the presence of institutional investors among firm shareholders in the UK.

Overall, the results highlighted in the present dissertation indicate that R&D can remarkably influence firm value and this should be taken into consideration by investors when they value stocks. However, they should consider other factors at the firm and country level when comparing company performance ex-ante and ex-post their R&D

investment. Highly innovative stocks are more prone to mispricing due to over- and undervaluation because they are more risky then other firms and because investors are often misled by other firm characteristics and by the past performance of these stocks.

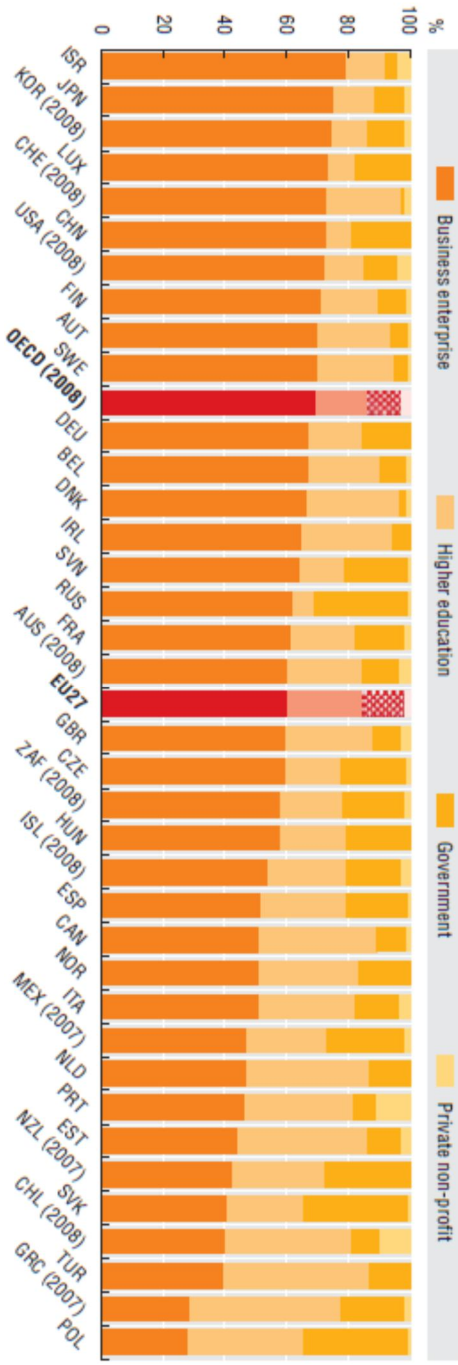
Appendix

Table 1 – Gross domestic expenditure on R&D as a percentage of GDP, 1999 and 2009. Cross-country comparison



Source: OECD, Main Science and Technology Indicators Database, June 2011

Table 2 – R&D expenditure by performing sectors as a percentage of GERD (Gross domestic expenditure on R&D), year 2009. Cross-country comparison



Source: OECD, Main Science and Technology Indicators Database, June 2011

Table 3 – ICB sector classification. Sector and Subsector breakdown

Sector*	Subsector	Definition
0530 Oil & Gas Producers	0533 Exploration & Production	Companies engaged in the exploration for and drilling, production, refining and supply of oil and gas products.
	0537 Integrated Oil & Gas	Integrated oil and gas companies engaged in the exploration for and drilling, production, refining, distribution and retail sales of oil and gas products.
0570 Oil Equipment, Services & Distribution	0573 Oil Equipment & Services	Suppliers of equipment and services to oil fields and offshore platforms, such as drilling, exploration, seismic-information services and platform construction.
	0577 Pipelines	Operators of pipelines carrying oil, gas or other forms of fuel. Excludes pipeline operators that derive the majority of their revenues from direct sales to end users, which are classified under Gas Distribution.
0580 Alternative Energy	0583 Renewable Energy Equipment	Companies that develop or manufacture renewable energy equipment utilizing sources such as solar, wind, tidal, geothermal, hydro and waves.
	0587 Alternative Fuels	Companies that produce alternative fuels such as ethanol, methanol, hydrogen and bio-fuels that are mainly used to power vehicles, and companies that are involved in the production of vehicle fuel cells and/or the development of alternative fuelling infrastructure.
1350 Chemicals	1353 Commodity Chemicals	Producers and distributors of simple chemical products that are primarily used to formulate more complex chemicals or products, including plastics and rubber in their raw form, fibreglass and synthetic fibres.
	1357 Specialty Chemicals	Producers and distributors of finished chemicals for industries or end users, including dyes, cellular polymers, coatings, special plastics and other chemicals for specialized applications. Includes makers of colourings, flavours and fragrances, fertilizers, pesticides, chemicals used to make drugs, paint in its pigment form and glass in its unfinished form. Excludes producers of paint and glass products used for construction, which are classified under Building Materials & Fixtures.
1730 Forestry & Paper	1733 Forestry	Owners and operators of timber tracts, forest tree nurseries and sawmills. Excludes providers of finished wood products such as wooden beams, which are classified under Building Materials & Fixtures.
	1737 Paper	Producers, converters, merchants and distributors of all grades of paper. Excludes makers of printed forms, which are classified under Business Support Services, and manufacturers of paper items such as cups and napkins, which are classified under Nondurable Household Products.
1750 Industrial Metals & Mining	1753 Aluminum	Companies that mine or process bauxite or manufacture and distribute aluminum bars, rods and other products for use by other industries. Excludes manufacturers of finished aluminum products, such as siding, which are categorized according to the type of end product.
	1755 Nonferrous Metals	Producers and traders of metals and primary metal products other than iron, aluminum and steel. Excludes companies that make finished products, which are categorized according to the type of end product.
	1757 Iron & Steel	Manufacturers and stockholders of primary iron and steel products such as pipes, wires, sheets and bars, encompassing all processes from smelting in blast furnaces to rolling mills and foundries. Includes companies that primarily mine iron ores.
1770 Mining	1771 Coal	Companies engaged in the exploration for or mining of coal.
	1773 Diamonds & Gemstones	Companies engaged in the exploration for and production of diamonds and other gemstones.
	1775 General Mining	Companies engaged in the exploration, extraction or refining of minerals not defined elsewhere within the Mining sector.
	1777 Gold Mining	Prospectors for and extractors or refiners of gold-bearing ores.
	1779 Platinum & Precious Metals	Companies engaged in the exploration for and production of platinum, silver and other precious metals not defined elsewhere.

2350 Construction & Materials	2353 Building Materials & Fixtures	Producers of materials used in the construction and refurbishment of buildings and structures, including cement and other aggregates, wooden beams and frames, paint, glass, roofing and flooring materials other than carpets. Includes producers of bathroom and kitchen fixtures, plumbing supplies and central air-conditioning and heating equipment. Excludes producers of raw lumber, which are classified under Forestry.
	2357 Heavy Construction	Companies engaged in the construction of commercial buildings, infrastructure such as roads and bridges, residential apartment buildings, and providers of services to construction companies, such as architects, masons, plumbers and electrical contractors.
2710 Aerospace & Defense	2713 Aerospace	Manufacturers, assemblers and distributors of aircraft and aircraft parts primarily used in commercial or private air transport. Excludes manufacturers of communications satellites, which are classified under Telecommunications Equipment.
	2717 Defense	Producers of components and equipment for the defense industry, including military aircraft, radar equipment and weapons.
2720 General Industrials	2723 Containers & Packaging	Makers and distributors of cardboard, bags, boxes, cans, drums, bottles and jars and glass used for packaging.
	2727 Diversified Industrials	Industrial companies engaged in three or more classes of business within the Industrial industry that differ substantially from each other.
2730 Electronic & Electrical Equipment	2733 Electrical Components & Equipment	Makers and distributors of electrical parts for finished products, such as printed circuit boards for radios, televisions and other consumer electronics. Includes makers of cables, wires, ceramics, transistors, electric adapters and security cameras.
	2737 Electronic Equipment	Manufacturers and distributors of electronic products used in different industries. Includes makers of lasers, smart cards, bar scanners, fingerprinting equipment and other electronic factory equipment.
2750 Industrial Engineering	2753 Commercial Vehicles & Trucks	Manufacturers and distributors of commercial vehicles and heavy agricultural and construction machinery, including rail cars, tractors, bulldozers, cranes, buses and industrial lawn mowers. Includes non-military shipbuilders, such as builders of cruise ships and ferries.
	2757 Industrial Machinery	Designers, manufacturers, distributors and installers of industrial machinery and factory equipment, such as machine tools, lathes, presses and assembly line equipment. Includes makers of pollution control equipment, castings, pressings, welded shapes, structural steelwork, compressors, pumps, bearings, elevators and escalators.
2770 Industrial Transportation	2771 Delivery Services	Operators of mail and package delivery services for commercial and consumer use. Includes courier and logistic services primarily involving air transportation.
	2773 Marine Transportation	Providers of on-water transportation for commercial markets, such as container shipping. Excludes ports, which are classified under Transportation Services, and shipbuilders, which are classified under Commercial Vehicles & Trucks.
	2775 Railroads	Providers of industrial railway transportation and railway lines. Excludes passenger railway companies, which are classified under Travel & Tourism, and manufacturers of rail cars, which are classified under Commercial Vehicles & Trucks.
	2777 Transportation Services	Companies providing services to the Industrial Transportation sector, including companies that manage airports, train depots, roads, bridges, tunnels, ports, and providers of logistic services to shippers of goods. Includes companies that provide aircraft and vehicle maintenance services.
	2779 Trucking	Companies that provide commercial trucking services. Excludes road and tunnel operators, which are classified under Transportation Services, and vehicle rental and taxi companies, which are classified under Travel & Tourism.
2790 Support Services	2791 Business Support Services	Providers of nonfinancial services to a wide range of industrial enterprises and governments. Includes providers of printing services, management consultants, office cleaning services, and companies that install, service and monitor alarm and security systems.
	2793 Business Training & Employment Agencies	Providers of business or management training courses and employment services.
	2795 Financial Administration	Providers of computerized transaction processing, data communication and information services, including payroll, bill payment and employee benefit services.

	2797 Industrial Suppliers	Distributors and wholesalers of diversified products and equipment primarily used in the commercial and industrial sectors. Includes builders merchants.
	2799 Waste & Disposal Services	Providers of pollution control and environmental services for the management, recovery and disposal of solid and hazardous waste materials, such as landfills and recycling centres. Excludes manufacturers of industrial air and water filtration equipment, which are classified under Industrial Machinery.
3350 Automobiles & Parts	3353 Automobiles	Makers of motorcycles and passenger vehicles, including cars, sport utility vehicles (SUVs) and light trucks. Excludes makers of heavy trucks, which are classified under Commercial Vehicles & Trucks, and makers of recreational vehicles (RVs and ATVs), which are classified under Recreational Products.
	3355 Auto Parts	Manufacturers and distributors of new and replacement parts for motorcycles and automobiles, such as engines, carburetors and batteries. Excludes producers of tires, which are classified under Tires.
	3357 Tires	Manufacturers, distributors and retreaters of automobile, truck and motorcycle tires.
3530 Beverages	3533 Brewers	Manufacturers and shippers of cider or malt products such as beer, ale and stout.
	3535 Distillers & Vintners	Producers, distillers, vintners, blenders and shippers of wine and spirits such as whisky, brandy, rum, gin or liqueurs.
	3537 Soft Drinks	Manufacturers, bottlers and distributors of non-alcoholic beverages, such as soda, fruit juices, tea, coffee and bottled water.
3570 Food Producers	3573 Farming & Fishing	Companies that grow crops or raise livestock, operate fisheries or own nontobacco plantations. Includes manufacturers of livestock feeds and seeds and other agricultural products but excludes manufacturers of fertilizers or pesticides, which are classified under Specialty Chemicals.
	3577 Food Products	Food producers, including meatpacking, snacks, fruits, vegetables, dairy products and frozen seafood. Includes producers of pet food and manufacturers of dietary supplements, vitamins and related items. Excludes producers of fruit juices, tea, coffee, bottled water and other non-alcoholic beverages, which are classified under Soft Drinks.
3720 Household Goods & Home Construction	3722 Durable Household Products	Manufacturers and distributors of domestic appliances, lighting, hand tools and power tools, hardware, cutlery, tableware, garden equipment, luggage, towels and linens.
	3724 Nondurable Household Products	Producers and distributors of pens, paper goods, batteries, light bulbs, tissues, toilet paper and cleaning products such as soaps and polishes.
	3726 Furnishings	Manufacturers and distributors of furniture, including chairs, tables, desks, carpeting, wallpaper and office furniture.
	3728 Home Construction	Constructors of residential homes, including manufacturers of mobile and prefabricated homes intended for use in one place.
3740 Leisure Goods	3743 Consumer Electronics	Manufacturers and distributors of consumer electronics, such as TVs, VCRs, DVD players, audio equipment, cable boxes, calculators and camcorders.
	3745 Recreational Products	Manufacturers and distributors of recreational equipment. Includes musical instruments, photographic equipment and supplies, RVs, ATVs and marine recreational vehicles such as yachts, dinghies and speedboats.
	3747 Toys	Manufacturers and distributors of toys and video/computer games, including such toys and games as playing cards, board games, stuffed animals and dolls.
3760 Personal Goods	3763 Clothing & Accessories	Manufacturers and distributors of all types of clothing, jewelry, watches or textiles. Includes sportswear, sunglasses, eyeglass frames, leather clothing and goods, and processors of hides and skins.
	3765 Footwear	Manufacturers and distributors of shoes, boots, sandals, sneakers and other types of footwear.
	3767 Personal Products	Makers and distributors of cosmetics, toiletries and personal-care and hygiene products, including deodorants, soaps, toothpaste, perfumes, diapers, shampoos, razors and feminine-hygiene products. Includes makers of contraceptives other than oral contraceptives, which are classified under Pharmaceuticals.
3780 Tobacco	3785 Tobacco	Manufacturers and distributors of cigarettes, cigars and other tobacco products. Includes tobacco plantations.

4530 Health Care Equipment & Services	4533 Health Care Providers	Owners and operators of health maintenance organizations, hospitals, clinics, dentists, opticians, nursing homes, rehabilitation and retirement centers. Excludes veterinary services, which are classified under Specialized Consumer Services.
	4535 Medical Equipment	Manufacturers and distributors of medical devices such as MRI scanners, prosthetics, pacemakers, X-ray machines and other non-disposable medical devices.
	4537 Medical Supplies	Manufacturers and distributors of medical supplies used by health care providers and the general public. Includes makers of contact lenses, eyeglass lenses, bandages and other disposable medical supplies.
4570 Pharmaceuticals & Biotechnology	4573 Biotechnology	Companies engaged in research into and development of biological substances for the purposes of drug discovery and diagnostic development, and which derive the majority of their revenue from either the sale or licensing of these drugs and diagnostic tools.
	4577 Pharmaceuticals	Manufacturers of prescription or over-the-counter drugs, such as aspirin, cold remedies and birth control pills. Includes vaccine producers but excludes vitamin producers, which are classified under Food Products.
5330 Food & Drug Retailers	5333 Drug Retailers	Operators of pharmacies, including wholesalers and distributors catering to these businesses.
	5337 Food Retailers & Wholesalers	Supermarkets, food-oriented convenience stores and other food retailers and distributors. Includes retailers of dietary supplements and vitamins.
5370 General Retailers	5371 Apparel Retailers	Retailers and wholesalers specializing mainly in clothing, shoes, jewelry, sunglasses and other accessories.
	5373 Broadline Retailers	Retail outlets and wholesalers offering a wide variety of products including both hard goods and soft goods.
	5375 Home Improvement Retailers	Retailers and wholesalers concentrating on the sale of home improvement products, including garden equipment, carpets, wallpaper, paint, home furniture, blinds and curtains, and building materials.
	5377 Specialized Consumer Services	Providers of consumer services such as auction houses, day-care centres, dry cleaners, schools, consumer rental companies, veterinary clinics, hair salons and providers of funeral, lawn-maintenance, consumer-storage, heating and cooling installation and plumbing services.
	5379 Specialty Retailers	Retailers and wholesalers concentrating on a single class of goods, such as electronics, books, automotive parts or closeouts. Includes automobile dealerships, video rental stores, dollar stores, duty-free shops and automotive fuel stations not owned by oil companies.
5550 Media	5553 Broadcasting & Entertainment	Producers, operators and broadcasters of radio, television, music and filmed entertainment. Excludes movie theatres, which are classified under Recreational Services.
	5555 Media Agencies	Companies providing advertising, public relations and marketing services. Includes billboard providers and telemarketers.
	5557 Publishing	Publishers of information via printed or electronic media.
5750 Travel & Leisure	5751 Airlines	Companies providing primarily passenger air transport. Excludes airports, which are classified under Transportation Services.
	5752 Gambling	Providers of gambling and casino facilities. Includes online casinos, racetracks and the manufacturers of pachinko machines and casino and lottery equipment.
	5753 Hotels	Operators and managers of hotels, motels, lodges, resorts, spas and campgrounds.
	5755 Recreational Services	Providers of leisure facilities and services, including fitness centers, cruise lines, movie theatres and sports teams.
	5757 Restaurants & Bars	Operators of restaurants, fast-food facilities, coffee shops and bars. Includes integrated brewery companies and catering companies.
	5759 Travel & Tourism	Companies providing travel and tourism related services, including travel agents, online travel reservation services, automobile rental firms and companies that primarily provide passenger transportation, such as buses, taxis, passenger rail and ferry companies.

6530 Fixed Line Telecommunications	6535 Fixed Line Telecommunications	Providers of fixed-line telephone services, including regional and long-distance. Includes companies that primarily provide telephone services through the internet. Excludes companies whose primary business is Internet access, which are classified under Internet.
6570 Mobile Telecommunications	6575 Mobile Telecommunications	Providers of mobile telephone services, including cellular, satellite and paging services. Includes wireless tower companies that own, operate and lease mobile site towers to multiple wireless service providers.
7530 Electricity	7535 Conventional Electricity	Companies generating and distributing electricity through the burning of fossil fuels such as coal, petroleum and natural gas, and through nuclear energy.
	7537 Alternative Electricity	Companies generating and distributing electricity from a renewable source. Includes companies that produce solar, water, wind and geothermal electricity.
7570 Gas, Water & Multi-utilities	7573 Gas Distribution	Distributors of gas to end users. Excludes providers of natural gas as a commodity, which are classified under the Oil & Gas industry.
	7575 Multi-utilities	Utility companies with significant presence in more than one utility.
	7577 Water	Companies providing water to end users, including water treatment plants.
8350 Banks	8355 Banks	Banks providing a broad range of financial services, including retail banking, loans and money transmissions.
8530 Nonlife Insurance	8532 Full Line Insurance	Insurance companies with life, health, property & casualty and reinsurance interests, no one of which predominates.
	8534 Insurance Brokers	Insurance brokers and agencies.
	8536 Property & Casualty Insurance	Companies engaged principally in accident, fire, automotive, marine, malpractice and other classes of nonlife insurance.
	8538 Reinsurance	Companies engaged principally in reinsurance.
8570 Life Insurance	8575 Life Insurance	Companies engaged principally in life and health insurance.
8630 Real Estate Investment & Services	8633 Real Estate Holding & Development	Companies that invest directly or indirectly in real estate through development, investment or ownership. Excludes real estate investment trusts and similar entities, which are classified as Real Estate Investment Trusts.
	8637 Real Estate Services	Companies that provide services to real estate companies but do not own the properties themselves. Includes agencies, brokers, leasing companies, management companies and advisory services. Excludes real estate investment trusts and similar entities, which are classified as Real Estate Investment Trusts.
8670 Real Estate Investment Trusts	8671 Industrial & Office REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in office, industrial and flex properties.
	8672 Retail REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in retail properties. Includes malls, shopping centers, strip centers and factory outlets.
	8673 Residential REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in residential home properties. Includes apartment buildings and residential communities.
	8674 Diversified REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that invest in a variety of property types without a concentration on any single type.
	8675 Specialty REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that invest in self-storage properties, properties in the health care industry such as hospitals, assisted living facilities and health care laboratories, and other specialized properties such as auto dealership facilities, timber properties and net lease properties.
	8676 Mortgage REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that are directly involved in lending money to real estate owners and operators or indirectly through the purchase of mortgages or mortgage backed securities.
	8677 Hotel & Lodging REITs	Real estate investment trusts or corporations (REITs) or listed property trusts (LPTs) that primarily invest in hotels or lodging properties.
8770 Financial Services	8771 Asset Managers	Companies that provide custodial, trustee and other related fiduciary services. Includes mutual fund management companies.
	8773 Consumer Finance	Credit card companies and providers of personal finance services such as personal loans and check cashing companies.

	8775 Specialty Finance	Companies engaged in financial activities not specified elsewhere. Includes companies not classified under Equity Investment Instruments or Nonequity Investment Instruments engaged primarily in owning stakes in a diversified range of companies.
	8777 Investment Services	Companies providing a range of specialized financial services, including securities brokers and dealers, online brokers and security or commodity exchanges.
	8779 Mortgage Finance	Companies that provide mortgages, mortgage insurance and other related services.
8980 Equity Investment Instruments	8985 Equity Investment Instruments	Corporate closed-ended investment entities identified under distinguishing legislation, such as investment trusts and venture capital trusts.
8990 Non-equity Investment Instruments	8995 Non-equity Investment Instruments	Non-corporate, open-ended investment instruments such as open-ended investment companies and funds, unit trusts, ETFs and currency funds and split capital trusts.
9530 Software & Computer Services	9533 Computer Services	Companies that provide consulting services to other businesses relating to information technology. Includes providers of computer-system design, systems integration, network and systems operations, data management and storage, repair services and technical support.
	9535 Internet	Companies providing Internet-related services, such as Internet access providers and search engines and providers of Web site design, Web hosting, domain-name registration and e-mail services.
	9537 Software	Publishers and distributors of computer software for home or corporate use. Excludes computer game producers, which are classified under Toys.
9570 Technology Hardware & Equipment	9572 Computer Hardware	Manufacturers and distributors of computers, servers, mainframes, workstations and other computer hardware and subsystems, such as mass-storage drives, mice, keyboards and printers.
	9574 Electronic Office Equipment	Manufacturers and distributors of electronic office equipment, including photocopiers and fax machines.
	9576 Semiconductors	Producers and distributors of semiconductors and other integrated chips, including other products related to the semiconductor industry, such as semiconductor capital equipment and motherboards. Excludes makers of printed circuit boards, which are classified under Electrical Components & Equipment.
	9578 Telecommunications Equipment	Makers and distributors of high-technology communication products, including satellites, mobile telephones, fibres optics, switching devices, local and wide-area networks, teleconferencing equipment and connectivity devices for computers, including hubs and routers.

Notes: * indicate the sector classification that was used in this thesis

Table 4 – Equity market indexes used in this thesis

Country	Financial Market	Financial Index
Finland	Helsinki OMX Exchange	OMX Helsinki 25
France	Euronext Paris	CAC 40
Italy	Borsa Italiana – LSE Group	FTSE MIB 40
Germany	Frankfurt Stock Exchange	DAX 30
Sweden	Stockholm Stock Exchange	OMX Stockholm 30
United Kingdom	London Stock Exchange	FTSE 100

Source: Datastream

Table 5 – Risk free rates for testing Fama and French (1993) model

Country	Financial Market	Risk free rate
Finland	Helsinki OMX Exchange	Finland Treasury Bill 1 Month
France	Euronext Paris	France Treasury Bill 1 Month
Germany	Frankfurt Stock Exchange	Germany Government Bill 1 Month
Sweden	Stockholm Stock Exchange	Sweden Treasury Bill 30 Day
United Kingdom	London Stock Exchange	UK Treasury Bill 1 Month

Source: Datastream

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