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R&D EXPENDITURES AND FIRM PERFORMANCE: EMPIRICAL EVIDENCE ON FINNISH DATA

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ABSTRACT

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This study concentrates on the impacts that firm’s R&D investments have on firm performance. Also, the R&D activity as a part of the firm and its environment is discussed. In the empirical part of the study the impact of R&D expenditures on firm growth, profitability and value of stock prices (returns) is examined by using cross-sectional analyses.

Accounting and stock price data was gathered for 65 firms from year 1999 to year 2005. The effect of R&D expenditures on firm growth, profitability and stock returns was examined by using different time intervals in order to observe the possible causalities as reliably as possible.

The results indicate that firm’s R&D investments have positive effect on firm growth and profitability and, thereby were supportive of two main hypotheses of this study. However, no evidence was found that R&D expenses would affect stock returns by the examined data. Accordingly, the third main hypothesis was rejected.

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Tutkielman tavoitteena on tutkia yrityksen tutkimus- ja tuotekehitystoiminnan (T&K) vaikutuksia yrityksen suorituskykyyn. Tutkielmassa tarkastellaan myös lyhyesti T&K- toimintaa osana yrityksen toimintoja ja ympäristöä. Tutkielman empiirisessä osassa tutkitaan poikkileikkausmenetelmää käyttäen T&K-menojen vaikutusta yrityksen kasvuun, kannattavuuteen ja osakkeen hintaan (tuottoon).

Tutkielman empiirinen osa toteutettiin keräämällä tilinpäätös- ja osaketiedot 65 yritykselle vuosilta 1999-2005. T&K- menojen vaikutusta yrityksen kasvuun, kannattavuuteen ja osakkeen tuottoon tutkittiin eri aikavälejä käyttäen, jotta mahdolliset syy-seuraussuhteet voitaisiin luotettavasti osoittaa.

Tutkimustulokset osoittavat, että yrityksen T&K- menoilla on positiivinen vaikutus yrityksen kasvuun ja kannattavuuteen ja, siten tulokset tukevat kahta tutkimuksen päähypoteesia. Yrityksen T&K- menoilla ja osakkeen tuoton välillä ei kuitenkaan käytetyllä aineistolla empiiristä yhteyttä löytynyt, joten kolmas päähypoteesi hylättiin.

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1. INTRODUCTION

1.1 Background of the Study

Research and development (R&D) is one of the most important activities of a firm. R&D activities are essential for companies in order to maintain the current competitive position and to reach for new competitive advantages in the fast changing environment. But even though the business environment has changed considerably, the firms' innovation processes have changed very little through out the years (Tidd, 2001). In recent years, the importance of R&D activity has even grown, because of the significant technological changes. Especially, the increased growth in the intensive R&D industries, such as science-and knowledge-based industries, has increased the interest towards R&D. (Chan et al., 2001) There are also other reasons for firm's R&D investments. Beath et al. (1989) have identified two different forces motivating firm's R&D spending. These are profit incentive and competitive threat.[1] Also Clark and Fujimoto (1991) have specified factors that affect many industries. These are tough international competition, fragmented markets with demanding customers and fast changing technology.

Development process of a new product is considered to be most important business process of a firm, and whole firm should be involved in this process (Buckler & Zien, 1996). Innovation is crucial for creating value for the business and to economic growth (Buckler & Zien, 1996; Bottazzi & Peri, 2003). Today, together with internationalization, they form two of the most significant factors influencing business success of a firm (Golder, 2000). The

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[1] Profit incentive generates from the desire to increase profits by investing in R&D. Competitive threat on the other hand generates from the fact that firm has rivals, and therefore firm wishes to be the first firm to introduce new innovations in the markets. (Beath et al., 1989)

process, in which a firm invests resources in R&D activity in order to create new ideas, and the process of their exploitation, are significant components of the growth mechanism of modern market economies (Bottazzi & Peri, 2003).

In the literature of industrial economics the focus of technological innovation studies has been on the relation between R&D expenditures and the degree of market concentration. Researchers have also been interested in the incentives of firms to invest in R&D. (Del Monte & Papagni, 2003) A lot of attention has been also focused on the effects that corporate investment decisions have on market value (Chauvin & Hirschey, 1993).

Several different studies have found a positive relation between R&D activity and firm value. Especially in the US, a lot of studies have approached this issue. For example, Chauvin and Hirschey (1993) have found evidence that R&D and advertising expenditures have comprehensive and positive effects on firm's market value. Also Jaffe (1986), Cockburn and Griliches (1988) and Hall (1993) examined the effects of R&D expenditures on market value. They used market value to measure the expected economic results of companies. Also studies made in UK (see, e.g., Blundell et al., 1999; Toivanen et al., 2002; Hall & Oriani, 2003) support the positive relation between R&D expenses and the market value of a company.

Researchers have also found that stock market reacts usually positively to firms announcements to increase R&D expenditures (see, e.g., Woolridge & Snow, 1990; Chan et al. 1990). There are also several studies which examine the impact of reported R&D expenditures on stock returns. Especially, there are a lot of studies made in US and Japanese data (see, e.g., Chan et al., 2001; Xu & Zhang, 2004; Ho et al., 2005). However, a little interest has been focused on the influences of R&D expenditures on firm growth (Del Monte & Papagni, 2003). There are also only few international studies examining the impact of R&D expenses on firm profitability (see, e.g., Geroski et al., 1993 and Ayadi et al., 1996)

As was mentioned earlier, especially in the US number of studies has examined the relationship between R&D expenditures and firm market value. Also few studies made in the UK and in Central Europe have approached this same field of research. Most of these studies have also found evidence of a positive relation between R&D investments and market value of firm. However, according to our knowledge there are only few studies made in Finland relating to this issue. In addition, no studies examining the impact of R&D investments on firm growth, profitability or stock prices in Finland were found. This is an interesting matter to study while a great number of Finnish companies invest high amounts on R&D activity. And even though it is generally accepted that investments in R&D will bring future benefits for the firm, it would be interesting to empirically examine whether there exists a relation between R&D expenditures and firm growth, profitability or stock prices.

1.2 Objectives and Restrictions of the Study

The main objective of this study is to examine and discuss the influence of firm's R&D investments on firm performance. This is carried out by analyzing and discussing previous research study settings and the results of these studies. Also the role of firm's R&D activity as part of the firm and its environment are shortly discussed. The empirical part of this study examines with Finnish data, whether there exists a relation between firm's R&D expenditures and different firm performance measures. Accordingly, the impact of reported R&D expenditures on firm growth, profitability and stock prices is examined. The relationships will be empirically tested by using cross-sectional analyses.

Even though, it has been widely accepted that R&D activity creates future benefits for the firm, it is not definite that the positive relationship can be empirically found. The research questions to be discussed in this study are introduced as follows:

- What kind of role the R&D activity has in the firm itself and its environment?
- How the R&D investments are related to firm performance?
- How have the R&D investments been developed among companies listed in Helsinki Stock Exchange and, which industries are most intensive in their R&D?
- How do the R&D investments of a firm influence the growth and profitability of the firm and, is there a time period after which the influences are observable?
- How do the R&D investments affect the stock prices of firms and, is there also a certain time period after which these effects are observable?

The first question is actually a broad question relating to this study. This study examines the effects of R&D activity on a firm, but the emphasis is on the relationship between R&D expenses and firm performance. The last three questions are examined in the empirical part with Finnish data in order to examine whether the results are consistent and similar with the international studies.

In order to keep the study from growing too large, some restrictions have been made. This study neither discusses the financing aspect of R&D projects, i.e., where do firms get the finance for R&D investments nor the valuation of R&D projects. In the second chapter the problem of R&D expenditures accounting treatment is discussed in order to shed a light on the aspects that relate to the accounting treatment of R&D expenditures. But this study does not cover the problem of which one would be the accurate approach, capitalizing or expensing of R&D expenditures.

1.3 Structure of the Study

This study consists of theoretical and empirical analysis. The theoretical part of the study is carried out by analyzing previous articles and research papers. The theoretical part is a literature review, in which the theoretical background and framework is built, and the main research results from previous studies are presented and discussed.

Section 2 begins with a discussion of the significant concepts of the study. In the first part the basic concepts of this study are introduced. First the concepts of R&D, R&D expenditures and product innovation are briefly defined as well as that of intangible assets (in which R&D are included). Furthermore, their influence on firm market value is examined. This section also concentrates on the accounting treatment of R&D expenditures, i.e., R&D expenditures have to be expensed as incurred regardless of the possible future benefits.

Section 2 also reveals R&D activity in Finland. The annual progress of R&D investments in the whole country and industry classification of the most intensive R&D industries between years 1993 and 2003 are briefly presented and discussed. This chapter also identifies the core aspects of firms' innovation and R&D activity.

Section 3 concentrates on the effects of R&D expenditures on firm performance. The section begins with a discussion of R&D based growth theories. Next, the relation between R&D activity and different firm performance measures is covered. The end of this section introduces the research hypothesis to be examined in the empirical analyses.

From Section 4 begins the empirical part of this study. The beginning of this section introduces the methodology and research design. After this, the data and its collection are discussed. Also the different variables to be used in the analyses are identified and discussed. This section also introduces the empirical models to be tested in the analyses.

Section 5 discusses the empirical result and findings. First the descriptive statistics for each variable used in the analyses are presented. Also results from the test of normal distribution are presented. This section also discusses the results and findings of cross-correlations and regression analyses.

Section 6 contains conclusion from the study. The major empirical findings are summarized and contrasted to the international framework. Also suggestions for future research are covered.

2. THEORETICAL BACKGROUND

2.1 Definition of Key Concepts

It is necessary to define some key concepts relating to research and development in the beginning of this study. This section shortly discusses the definition of research and development and its expenditures. Also, the concepts of product development and product innovation are covered.

Also R&D expenditures as a part of intangible assets are discussed in this section. First the intangible assets are defined and R&D expenditures as a part of these assets. Also the effect of intangible assets on firm market value is determined. Finally, the accounting treatment of R&D expenditures is covered.

2.1.1 R&D and R&D Expenditures

International Accounting Standards Board (IASB, 2004) has defined the concepts of research and development (R&D). The research is defined as original and systematic clarification work, which purpose is to reach new scientific or technical information or understanding. Development on the other hand takes advantage of different research results or other knowledge in the planning process of new or substantially better than previous raw materials, equipments, products, processes, systems or services, before their commercial production or usage is implemented.

Among others Pappas and Remer (1985) have analyzed R&D activity. They studied R&D activity in large perspective and categorized it into five main categories. The following list introduces the five types and short definition of each of them:

- **Basic research:** The objective is to find primary knowledge.
- **Exploratory research:** Search of useful applications for scientific concepts.
- **Applied research:** The objective is to enhance the practicality of a particular application.
- **Development:** To improve the technology of a certain process or product.
- **Product improvement:** The aim is to modify a process or a product in the way that its marketability is increased or costs reduced or both.

The concepts of product development and product innovation differ from each other. Innovation can be seen as a process which emerges from the possibility of a new market or service for technology based innovation. The goal is to develop, produce, and market the invention in the way that it can reach commercial success. The innovation process includes the development of the invention and its introduction to the consumers through adoption and diffusion. The innovation process also includes the introduction of a brake through product and the reintroduction of the products of next development phases. It is important to notice that invention becomes innovation only after it has been processed through production and launched to markets. Innovation process includes aspects such as basic and applied research, product development, manufacturing, marketing, distribution, servicing, and later product upgrading and adaptation. It is also possible that innovation occurs in the diffusion process, for example, not only in product development. (Garcia & Calantone, 2002)

R&D expenditures are identified as the amount invested in the R&D activity of a company (Booth et al., 2003). Thereby, R&D expenditures reflect the amount firm has spent on innovation (Ho et al., 2005). All the direct and indirect costs that are employed to create and develop new processes, products and techniques are included in R&D expenses (Booth et al., 2003). These expenses are expected to create positive value for the firm e.g. as a yield in share price (Ho et al., 2005).

2.1.2 R&D Expenditures as Intangible Assets

Intangible assets can be identified as individualized non monetary property items without physical form. Individualized property item is separable, in other words it can be distinguished or released from the corporation and be sold, transferred, licensed, rented or changed. The criterion of individualization is also fulfilled, when the property item is based on contract or on other legal right regardless of the transferability or separability of the right from the corporate or other rights and responsibilities. (IASB, 2004)

Research and development is one of the intangible assets. R&D spending can be seen as investments on intangible assets, which will have positive influences on future cash flows. (Chauvin & Hirschey 1993) In some big technology industries the R&D investments can be even larger than earnings (Chan et al., 2001). R&D differs considerably from the firm's other capital and financial inputs (e.g., plant and equipment, property or project financing). R&D activity involves a high amount of information asymmetry. (Aboody & Lev, 2000) Aboody and Lev (2000) have identified three issues of R&D that relate to information asymmetry. Firstly, R&D projects are unique for the developing company. Thereby, investors can not attain information from the value or productivity of R&D by observing other firm's R&D performance. Largely, due to this uniqueness R&D involves high information asymmetry.

Secondly, there are no markets for R&D like there is for physical and financial assets. Most of the physical and financial assets are traded in organized market, where the prices indicate information about the value and productivity of the assets. And finally, the R&D expenditures are treated differently from other investments by accounting and reporting rules. R&D expenditures are expensed as incurred whereas other assets are valued periodically, and therefore provide important information for investors.

Firm’s all net assets affect the market value of its shares. The association between tangible assets value (e.g., equipment and plant) and stock price is quite clear. But firm’s shares reflect also the value of its intangible assets. (Chan et al., 2001) Important intangibles assets can vary from industry to another. Examples of significant intangible assets (besides the R&D expenditures) are the value of brand name, product differentiation and goodwill resulting from product differentiation. (Hall, 1993)

According to Brealey and Myers (2000) the market value of a firm consists of discounted future cash flows from the existing assets and net present value of the expected cash flows from investment possibilities in the future. The firm value changes, when stock market receives new information about changes in cash returns of present and future assets (Woolridge & Snow, 1990). In corporate finance, several studies have examined the pricing efficiency of stock markets. Most of the empirical studies consider the market as informationally efficient in relation to publicly available information (Brealey and Myers, 2000). Therefore the stock prices reflect all information that is publicly available and react quickly to new information that may influence the risk and return of securities (Woolridge & Snow, 1990).

2.1.3 Accounting for R&D Expenditures

Lately, the accounting research has been increasingly interested in valuation and analysis of intangible assets. Firm invests in intangible assets, because it wishes to have stronger position in the markets. By investing in intangibles firm tries to create, maintain and improve durable advantages, which would lead to profitability in the future. (Ballester et al., 2003) This section concentrates on the established accounting principles of R&D expenditures. Also the debate concerning expensing versus capitalizing is briefly discussed.

The International Accounting Standards Board (IASB, 2004) defines the accounting treatment of intangible assets in International Accounting Standard (IAS) 38. According to this standard research expenditures must be expensed as incurred. Development expenses on the other hand have to be wrote down to balance sheet if all of the following six requirements are fulfilled:

1. intangible asset can be technically carried out for use or sale,
2. corporate intends to complete the asset for use or sale,
3. corporate is able to use or sell the asset,
4. firm is able to verify that the intangible asset will generate economic future benefits,
5. firm must have enough technical, economical and other resources to complete the intangible asset and its use or sale, and
6. firm must reliably determine the costs that are caused in the development phase of the intangible asset.

According to several researchers, R&D expenditures create benefits in the future (see, e.g., Cockburn & Griliches, 1988; Bublitz & Ettredge, 1989; Lev &

Sougiannis, 1996). But they also involve a great uncertainty whether R&D investments will bring any future benefits at all (Kothari et al., 2002). If a link between R&D expenditures and future benefits and cash flow is found, should the expenditures be considered as assets by investors, when setting market stock prices (Ballester et al., 2003). The debate relating to the accounting treatment of R&D expenditures seems to revolve around the following two issues: the expected future benefits of the expenditures (might qualify them as an asset) and the uncertainty of these benefits (makes it impossible to qualify them as assets).

Opponents of the expensing rule of R&D investments argue that R&D outlays create some of the most valued economic assets in the economy and, if these expenses are not considered as assets, the relevance and credibility of financial statements would be reduced (Healy et al., 2002). On the other hand, proponents of the expensing of R&D expenditures point out that there may be significant measurement errors in expected R&D benefits because of the uncertainty of R&D outcomes. Thereby, investors and creditors may be misled by financial statements that include unreliable estimates. (Shi, 2003) Proponents also argue, that the corporate managers' ability to capitalize costs of projects, that probably will have low success, or to postpone writing down impaired R&D assets is eliminated, when R&D investments are expensed. Therefore, the objectivity of financial statements is improved by expensing R&D investments. (Healy et al., 2002)

According to Shi (2003) the question of how R&D expenditures should be treated in accounting, relates closely to the trade-offs between the riskiness and future benefits of R&D. In general, if future benefits are unpredictable and risky, it would be justified to expense R&D expenditures. On the other hand, the capitalization may be in order, if the uncertainty of future outcomes is not so high that it's still possible to measure asset. However, generally the uncertainty of the future benefits from R&D investments speak for expensing, even if on average the future benefits are positive (Kothari et al., 2002).

Researchers have examined the relation of R&D investments and equity valuation in order to find out the benefits of R&D activity (Shi, 2003). Researchers have found positive link between R&D expenses and stock prices/returns. This suggests that R&D investments generate net future benefits (see, e.g., Cockburn & Griliches, 1988; Bublitz & Ettredge, 1989; Lev & Sougiannis, 1996). However, Merton (1973, 1974) has questioned this kind of interpretation. According to Merton, in levered companies the riskiness and the benefits of R&D may have similar influences on the equity valuation. This means, that even if the expected future cash flows of a firm are constant, it’s possible that an increase in the uncertainty of future cash flows that are due to R&D investments, will increase the stock price (Shi, 2003).

2.2 R&D Activity of Firms

Companies have focused a lot of interest on innovation and product development throughout the years. Firm’s successful R&D activity leads to new products and more efficient production processes, which enables the firm to enter new market or decrease production costs. In consequence, the firms may attain larger market share and gain higher profits. But it should be remembered that the results from R&D activity are not observable until after a long time from the investment, and the investment may also turn out to be a failure (Xu & Zhang, 2004). This section reveals the main issues involved in firms’ R&D activity.

Since the 1990s, development of new products has become vital for firms operating in the global markets. Firms have speeded up new product development and commercialization in order to be more successful in the international markets. (Calantone et al., 1997) According to Buckler & Zien (1996) and Wind & Mahajan (1997), two of today's most significant business success factors are innovation and internationalization. Globalization of a firm should bring more innovation possibilities for the firm. This is possible, if the globalization increases the amount and diversity of the firm's knowledge. In order to be able to internationalize innovation process, firms should also be able to change their view of their markets. (Devinney, 1995)

Even though the importance to produce new successful products has increased, the developing process has not been improved simultaneously (Calantone et al., 1997). There are several important factors, which affect the development process of successful products. According to Golder (2000), knowledge management and the direction of information in a company are at the heart of product development and commercialization of new products. Open communication between the people participating in the product development process and in the analysis of market opportunities is also essential. Devinney (1995) also emphasizes the role of information in innovation process and points out that innovation is basically transformation of information into product. In order to be successful innovator, firm must manage the innovation process properly and realize that all aspects of its business process affect firm's information gathering and interpretation.

Devinney (1995) argue, that the firms that recognize the importance of transformation of information in order to fulfill customer needs, will be successful in the future. Therefore, it is important to take customer needs into consideration when developing new products. General reason for the failure of new products is that the customer orientation has been overlooked in the design process. Even if the product is technologically superior or has manufacturing advantages, it will fail in the markets if there is no need for it. Actually, the future users of the product are best sources of new ideas if the products face lots of changes in short time. (Calantone et al., 1995)

The important role of organizational characteristics and organizational limitations should be also noticed in product development (Golder, 2000). Factors that can be controlled by management have strong relation with new product outcomes. Therefore, managers may enhance the success of its new products. (Calantone et al., 1997) Many firms have been successful in developing new technology, but managers have failed to commercialize it (Nobelius, 2004). The decisions concerning product development are remarkably challenging for managers since the result can not be seen until long time after the decisions (Patterson, 1998). The possible high reward and uncertainty from the future cash flows are typical features of R&D investments (Xu & Zhang, 2004).

Commercialization of new products is especially challenging for firms competing in hostile environment. That is, firms operate in industries, where technology changes quickly and competition is though (Bourgeois & Eisenhardt, 1988) It is crucial for firms to keep up with the major technological changes in order to sustain their competitive position over time (Calantone et al., 1995). Because of different competitive and technological factors, companies may have much stronger urge to bring products to market more quickly (Calantone et al., 1997). If the company is the first to launch new product, it may give the company competitive advantage over its competitors such as higher market share. However, a product that has been rushed into markets may contain several flaws or competitors may launch new products with better position. Furthermore, competitors' products may perform better in the long run, if there are uncertainties about the best technology in the industry. In addition, if the later entrants have advantages such as lower costs, superior manufacturing techniques or improved product design, they may succeed better in the long run than earlier entrants. (Calantone et al., 1995)

In general, environmental issues should be taken into account in developing new products, because e.g. environmental hostility may influence the possible success of a firm (Calantone et al., 1997). Major changes in business environments bring also demanding challenges for firms' product development and marketing research (Wind & Mahajan, 1997). Firms must be aware of the major changes in the marketplace to be able to maintain the current competitive position (Calantone et al., 1995).

According to Tidd (2001), innovation can have substantial benefits on firm competitiveness, but it's not easy to find empirical connection between innovation and performance. R&D activity includes high uncertainty, it does not have clear rate of return and it's also difficult to manage. But, if a new technology is successfully and rapidly brought to markets, it can possibly lead to larger market share, higher prices and dominant designs. Ultimately success in R&D activity can lead to competitive advantage in the markets. (Nobelius, 2004) Therefore, it is profitable for companies to develop better products, technology, or organizational skills than its competitors. In addition, the company can grow more than the firms that have little or no research activity at all. (Del Monte & Papagni, 2003)

Tidd (2001) has developed a framework, which combines environmental contingencies, organizational configurations, innovation management and performance. This framework illustrates that the degree, type, organization and management of innovation is affected by the uncertainty and complexity of environment. In consequence, the better these factors relate together, or the more cohesive the configuration, the greater is the performance. Figure 1 illustrates the linkages between environmental contingencies, degree and type of innovation, organizational configurations and performance.

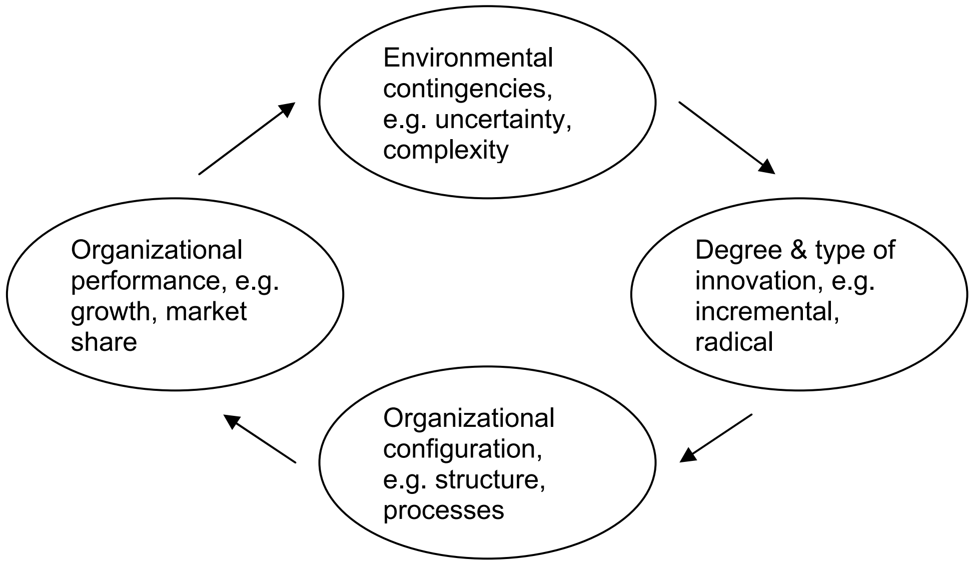

Figure 1. The association of environmental contingencies, degree and type of innovation, organizational configuration and organizational performance (Tidd, 2001).

2.3 R&D Investments and Competition

There are lot of industrialized countries (e.g., US and Japan) that try to gain and maintain their comparative advantage by developing and producing technologically better and more advanced products than their competitors. There are several different factors influencing the competitive position of a firm. Firm strategies such as advertising, financial structure, labor force and R&D expenditures affect the competitive position and also the profitability of the firm. (Lee & Shim, 1995) It is widely recognized that competition in the economy will generate more efficient employment of resources. It has also been suggested that competition will reduce costs, decrease slack, offer incentives to improve production systems and motivate for further innovation, even though there is no strong theoretical grounds and empirical evidence to support this kind of interpretation. (Nickell, 1996)

R&D expenditures have found to be in a relation with productivity growth, and various studies have concentrated on analyzing the association of competition and R&D expenses (Nickell, 1996). However, the research results of studies that try to associate innovation and competition have been inconsistent. In some cases, competition seems to enhance innovation, while in others reduce it. (Mukoyama, 2003) The typical flaw of these studies has been that they control incompletely technological opportunities, which differ considerably between different industries, and tend to be correlated with market concentration (Nickell, 1996).

According to Beath et al. (1989), one of the main reasons for firm's R&D investments is the threat of competitors. Also according to Tidd (2001), it is not difficult to realize what kind of influence innovation can have on the competitiveness of a company. Technological innovation is crucial factor in improving the competitive advantage of a firm (Zantout & Tsetsekos, 1994). Firms can gain comparative advantage by using R&D investments as a differentiation strategy. This is, because R&D activity results in new products or processes that are not easily imitated by competitors. According to evidence, this creates value for firms. (Erickson & Jacobson, 1992) The result of financial policy and investment decisions can be affected by strategic interaction, especially in situations of imperfect product markets, incomplete contracting or imperfect information. According to theory, competitive advantage has effect on companies' share value and wealth. But this depends on the nature of competition, whether it is tough or accommodating. Therefore, individual firms' share-price reactions to the announcement of new strategic changes should be influenced by the competition within an industry. (Sundaram et al., 1996)

R&D investments are viewed as one of the most important activity of a firm, particularly, in the high technology industries, such as electric and electronics, chemicals, drugs and machinery. (Lee & Shim, 1995) According to Del Monte and Papagni (2003), there are usually less technological opportunities in traditional industry sectors. Generally R&D expenditures do not seem to form a great barrier to entry in these sectors. In consequence, the larger profits gained from innovation are decreased when imitative firms enter these sectors. This leads to lower profits and competitive advantage if the firm is not able to launch new innovations continuously. But the case is quite the opposite in the sectors where there are high technological opportunities. Actually R&D investments and the intensity of R&D generate high barriers to entry. In the case where there is lot of substitutes for the products, and there is Bertrand competition in prices and in R&D, prices will close on marginal costs and the firm's profits will be zero.[2] (Del Monte & Papagni, 2003)

Even if the firm would have enough resources to produce new products and launch new technologies and organizational innovations, it is not definite that the firm will also attain competitive advantage and therefore, growth of profits. Also the time over which a firm may have competitive advantage has shortened, especially in sectors where there is lot of opportunities for innovation. It is also essential that the firm continue to innovate, if it wants to retain its leader position in the markets. These issues also explain in part why it is sometimes difficult to find relation between R&D expenditures and profitability. (Del Monte & Papagni, 2003)

Firm's announcement of R&D spending can be considered as a will to be the first to innovate, although firm might be over-investing due to threat of competitors. Therefore, it might be possible for firms to change the structure of competition to their own advantage within an industry. (Zantout & Tsetsekos, 1994) R&D investments may be used as an instrument of

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[2] Bertrand competition is basically a model of price competition between duopoly firms. Both firms charge their products by the price that would be charged under perfect competition. (Wikipedia; The Free Encyclopedia, 2006)

competition because of two reasons. Firstly, the interest towards R&D expenditures has been significant. Attention has been focused on R&D expenditures' relation to corporate governance mechanisms and managerial incentives. Secondly, the spillover effects of R&D expenditures and technological advancement have been widely studied in theoretical literature. (Sundaram et al., 1996)

When one firm announces a growth in R&D expenditures, it can transfer information within an industry. Rival firms' shareholders can conclude that the announcing firm is going to be the first to innovate and have the advantage of the first-mover. But, they can also conclude that the rival firms can benefit from the technology spillovers. Thereby rival firms can either fail to be the first to innovate or benefit from the R&D spillovers. (Zantout & Tsetsekos, 1994)

2.3.1 R&D Spillovers and Imitation

Variety of studies has examined the spillover effect of R&D expenditures (see, e.g., Jaffe, 1986; Zantout & Tsetsekos, 1994; Botazzi & Peri, 2003). The spillover effect can be defined as the influence that other firms' R&D has on the success of a firm's own R&D or vice versa. Spillover effect on a firm depends also on what kind of technological research the firm has. (Jaffe, 1986) R&D externalities can be divided into knowledge and market spillovers (Hanel & St-Pierre, 2002). Knowledge spillovers signify that other firms can freely use the knowledge of another firm without compensating the original firm or compensating less than its true value (Rouvinen, 1999; Hanel & St-Pierre, 2002). However, Campisi et al. (2000) argue that R&D activity generates firm specific silent and special knowledge, which can not be easily used at little or no cost by others firms. The market spillovers on the other hand occur when the company is forced (due to competition) to sell the new product at a price which does not match with the superiority of the new product in terms of what was available before (Hanel & St-Pierre, 2002). Thereby, some of the innovation's benefits are passed to the buyers by the innovating company (Jaffe, 1998).

The examination of R&D externalities has been challenging for researchers, because the actual spillovers are difficult to observe except anecdotally (Jaffe, 1986; Botazzi & Peri, 2003). Jaffe (1986) claims, that R&D spillovers have positive external effects from technological point of view, but only economical aspects of the firm's R&D success can be observed. The positive technological externality is also often negatively influenced by other firm's research because of competition.

However, it should be also considered that the effect of R&D externalities does not extend very far. Botazzi & Peri (2003) found evidence that R&D spillovers are quite localized and they diminish within 300 km from the source region. They found no spillovers outside this range. Localized R&D spillovers can develop, when the productivity of R&D in a region is influenced by the R&D resources used in another nearby region. Existing ideas are publicly available, or at least locally publicly available, information into innovation process, but the firm's R&D resources are private and unattainable for public use. The knowledge is increased in the region as new innovations are generated by local innovators. The new innovations are then diffused through personal and face-to-face interactions. The information benefits scientists in the region and close to it, but it diminishes as contacts decrease. (Botazzi & Peri, 2003)

According to free-rider hypothesis, it is possible for rival firms to enjoy from potential spillovers and therefore, have also positive wealth effects (Zantout & Tsetsekos, 1994). Firm's ability to use spillovers to its own advantage is partly dependent on firm's operating environment (Rouvinen, 1999). Firms that make R&D investments may not prevent also rival firms from benefiting from the results (Zantout & Tsetsekos, 1994). Many research models assume that knowledge is available to all in the economy, although every product is produced only in a one firm (Mukoyama, 2003). And, because knowledge is available to all, rival firms may enjoy from other firms research results with a lot less research effort (Jaffe, 1986). However, rival firms have to react quickly to new innovations or imitations to avoid high entry and mobility barriers while first movers benefits from the competitive advantage (Zantout & Tsetsekos, 1994).

Imitations can be seen as activities, where the firm learns from others. Many firms have started up by imitating. Several firms also develop new technology based on the knowledge they have learned from others. Example of a firm that started up by imitating is Toyota. Toyota imitated the Ford production system, and developed it into more efficient system called “lean production system”. (Mukoyama, 2003)

Mukoyama (2003) argue that outsiders have to imitate current industry leaders in order to engage in innovative activity and possibly become an industry leader in the future. The possible monopoly profit from the next-round innovation motivates outsiders to imitate others. Also Hoernig (2003) points out, that innovations appear “step-by-step”. This means that if a firm has fallen behind in technological development, it must first catch up the industry leaders before it’s able to overtake them.

2.3.2 Patents in Innovation Protection

It is possible for firms to use different kinds of mechanism, such as patents, to prevent rival firms from benefiting their innovations and new ideas (Cockburn & Griliches, 1988). It has been suggested that patent protection is an essential incentive for innovation. Furthermore, several research studies have considered R&D competition as patent races. (Campisi et al., 2000) Several different studies have also used patents as sources of innovative activity in a region. Patents have been used to track the intensity and direction of knowledge flows. (Botazzi & Peri, 2003) Patenting gives firms an incentive to engage in R&D activity. However, number of studies indicates that patents are unnecessary for R&D activities in almost every industry (apart from pharmaceutical and chemical inventions). Accordingly, imitation is costly regardless of the absence of a patent protection. (Campisi et al., 2000)

Even though firms can use patents to protect their innovations, it is not possible to totally prevent involuntary transfer of information. It has been suggested, that legal protection can not make information entirely unattainable. (Rouvinen, 1999) For example, Bottazi & Peri (2003) argue that the codified part of new innovation is fully publicly available information, because it can be read from the patent. But nonetheless, a part of the knowledge created with the innovation can not be used by others while it's attached to the experience of the scientists and other people of the firm. The accessibility and efficiency of legal remedies depends much on the firm and industry (Cockburn & Griliches, 1988).

It should be also considered that the efficiency of patents appropriating the returns of R&D varies. And, the firms' present value of returns from investing in patent protection should be different, because of the industry conditions and firm related factors. (Cockburn & Griliches, 1988) Jaffe (1986) argue that the companies, which are in regions where is a lot of research activity, have on average more patents per dollar of R&D and a higher return to R&D measured in accounting profits and market value. However, a firm with low R&D activity has to settle for lower profits and market value, if other companies in the area are intensive in their R&D activity. In addition, firms seem to adapt their technological position in relation to possible profits. These adjustments may cause ejection of excess returns.

2.4 R&D Investments in Finland

Finland has developed its competitiveness by investing in knowledge, innovations and new technology. The investments in R&D have been profitable generating superior knowledge and new significant innovations. (Tekes, 2005) These investments have ensured that Finland is one of the leading industrialized countries in the world. The World Economic Forum (2005) assessed Finland to be the most competitive economy in the world in year 2005, followed by United States, Sweden and Denmark. Finland has attained its first position in three consecutive years. Finland was also assessed number one in growth competitiveness rankings for the fourth time in the last five years. (The World Economic Forum, 2005)

According to the Statistics Finland (2005) the R&D expenditures of Finland resulted in 5.3 billion euros in year 2004. Companies' portion of the expenditures was approximately 3.7 billion euros. The total expenses accounted for 3.5 percents of the gross domestic product (GDP). The GDP share of R&D expenditures is the indicator of R&D input. The percent of R&D expenses of GDP indicates the relative efforts of a country to engage in new knowledge generation and existing knowledge utilization both in public and private sectors. (Ojanen, 2003) Figure 2 describes the changes in R&D spending as a percentage of GDP in some OECD-countries during the years 1992-2003.

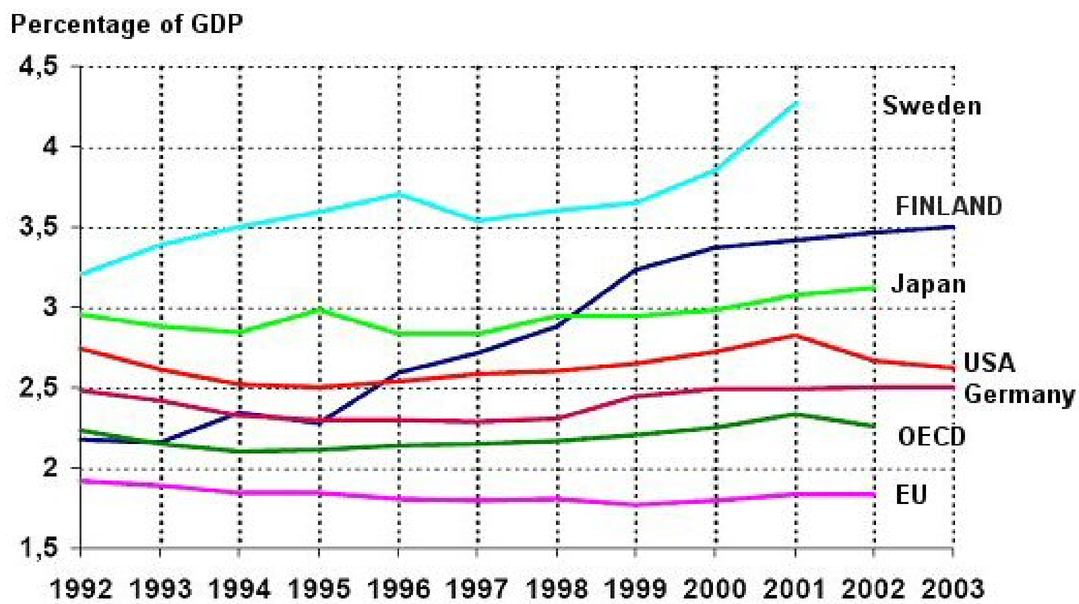

Figure 2. R&D input in some OECD-countries (Confederation of Finnish Industries/b).

Finland belongs to the leading edge, when the R&D expenses relative to the gross domestic product are compared among OECD-countries. This is also the way it should be since the present economic structure of Finland requires high level R&D investments. (Confederation of Finnish Industries/a)

Finland's high position in the international R&D statistics results from the long continued high growth in the R&D investments of firms. The financing of public sector has decreased into 25 percent which has lead to more short-term R&D work than earlier. In the long run low funding will harm the knowledge. (Confederation of Finnish Industries/a)

In Finland, the most intensive R&D industries are electronics and electrics industry, mechanical and metal product industry and technological industry. Also chemical, forest, food and construction industries invest in R&D. (Confederation of Finnish Industries/a) Figure 3 represents the changes of

R&D expenditures in Finland during the years 1993-2003. The R&D expenditures are also classified by industries.

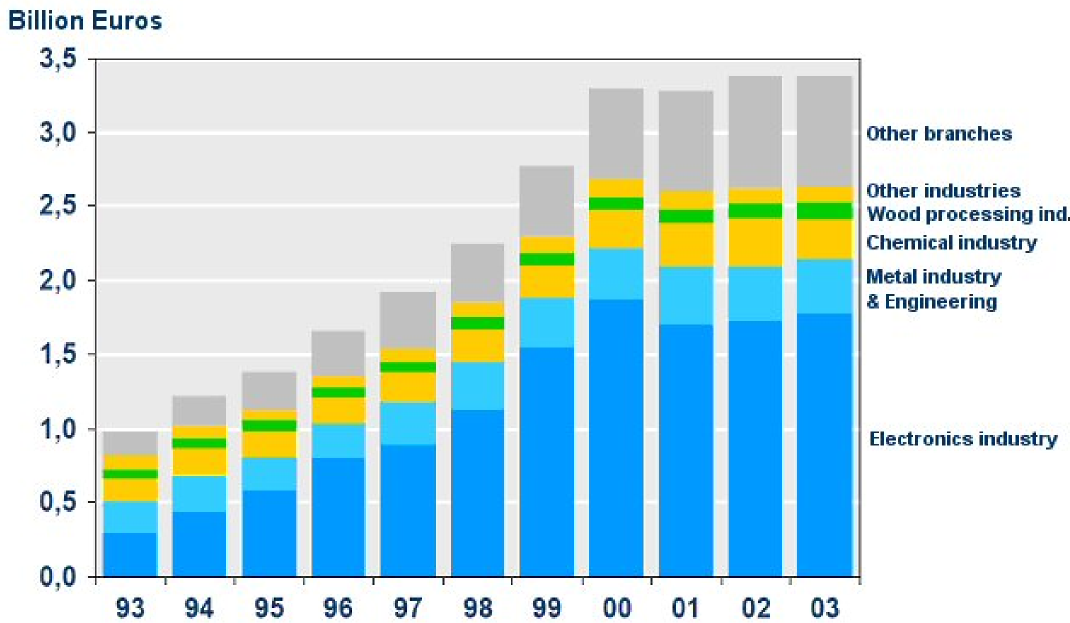

Figure 3. Industry classification of companies' R&D expenditures (Tekes, 2005).

3. R&D AND FIRM PERFORMANCE

3.1 R&D-Based Growth Theories

The theory of economic growth was based on Solow's neoclassical general equilibrium as long as few decades. The new growth theories take advantage of the deductions made by Solow (1956) and Swan (1956) (see, e.g., Romer, 1990). Solow and Swan concluded that technological change may lead to steady-state per-capita growth rate in specific conditions. (Firth & Mellor, 2000) The new growth theory is based on the idea that investment creates knowledge, which can be used for the generation of further innovations. For example, the production process or product quality may be improved by investing in R&D. The firm can also increase its knowledge capital by investing in R&D, this will lead to improved future productivity of R&D. (Smulders & Van de Klundert, 1995) In conclusion, the models of new growth theories reflect continuous endogenous growth which is based on learning (Firth & Mellor, 2000).

According to Garner et al. (2002) the growth opportunities of a firm can be seen as endogenous since companies' R&D investments are different. Firms try to obtain growth opportunities by making competitive investments. It is crucial for the firm to be the first to innovate in order to attain growth options. But the real option must be exercised, if firm wishes to benefit from the growth options. After the successful R&D investment the growth opportunities are executed when the option to manufacture the product for commercialization is exercised. Garner et al. (2002) also emphasize the speed of innovation while it is critical and affects positively the market value of the firm. Fast innovation makes it also possible to exercise early the real option.

The early study of Schumpeter (1934) pointed out the significance of innovation in economic development. Since the R&D activity of firms leads to innovation, many economists, economist policy makers and others are interested in the R&D process. They wish to understand the characteristics and nature of R&D and also the environment in which the R&D process would be successful. However, new ideas do not guarantee success, if they are not implemented and financed properly. (Booth et al., 2003)

Klette and Griliches (2000) argue, that much of today's economic studies on R&D investments and firm performance consist of economic models which contain very little of theoretical insight while theorist base their innovation and R&D models on macro issues and few specific facts. The macro growth theories have concentrated on the discovery that poor countries do not keep up with the rich countries. This is similar to the micro observation that the growth of the firm does not depend on the firm size.

The endogenous growth literature has been increasingly interested in developing models where growth generates from technological change. The technological change results from the resources devoted in R&D activity by profit-maximizing agents. It is assumed that R&D subsidies and other government policies may affect the long-term rate of economic growth. (Jones, 1995) The next two sections approach economic growth from the viewpoint of technological change. First, the model with expanding variety of products is discussed and then the model of quality ladders.

3.1.1 Expanding Variety of Products

There are models in which the technological advancement can bee observed as an increase in the amount of different products. In these models change in the number of products is considered as basic innovation trying to open up a new industry. The possible monopoly rents motivate researchers to invest more resources in the developing process of new products. By determining the state of technology with the number of selection of products and choosing one technical advance, it is possible to track and examine the long-term growth. However, the rate of growth is dependent on many different preferences and technology, for instance the cost of R&D, level of production, and the scale of economy measured by e.g. labor or human capital. (Barro & Sala-i-Martin, 2004)

The basic model of variety of products involves three influential factors. Firstly, producers hire labor and intermediate inputs to manufacture final output, which is sold in the markets at unit price. Secondly, firms invest resources into R&D activity in order to develop new products. After the product has been invented and it has received patent protection, the firm can sell the product at any price. This price will naturally maximize the profits. The final influential factor is that households maximize utility. (Barro & Sala-i-Martin, 2004)

Romer (1990) was the first to introduce a model of varieties structure which reflected endogenous growth. His framework was the first to model sustainable endogenous growth without disregarding the competition aspect of the neoclassical model (Firth & Mellor, 2000). His model generated endogenous growth by assuming that the costs of inventing process of new products decline as more ideas arise in the society. Furthermore, Romer (1990) assumed that the change in number of products is depended on the amount of labor engaged in R&D. (Barro & Sala-i-Martin, 2004) But, Jones (1995) has questioned this kind of estimation, because it would signify that there exists a positive relationship between the rate of technological change and the amount of R&D labor. He explains his point of view by demonstrating that the data for the United States and other advanced countries is in a conflict with this framework. The number of engineers, scientists and other employees involved in R&D activity has grown over the years, but the rate of productivity growth has not risen simultaneously.

3.1.2 Quality Ladders

Industrial organization economists have examined quality competition in patent races. Several different researches have tried to comprehend the incentive of firms to launch new and better products. In these studies R&D competition is seen as continuous race for technological dominance. The quality competition is ongoing and cyclical process, where new products are successful only for a limited time until they are replaced by new and improved products. Thereby, almost every product can be placed on a quality ladder, where the outdated version is below and the new, yet to be discovered, above. (Grossman & Helpman, 1991)

The ideas of quality ladder models are based on Schumpeter's (1934) estimates about endogenous growth. Schumpeterian model allows improvements to occur in each product's quality and productivity. An important feature of this approach is that the improved product or technology usually replaces the old one. In consequence, success in improving quality of products or productivity of production methods will destroy the monopoly rents of previous products and production methods. (Barro & Sala-i-Martin, 2004) This process was studied besides Schumpeter (1934) by Aghion and Howitt (1992). They called this process as "creative destruction".

Segerstrom et al. (1990) and Aghion and Howitt (1992) studied the quality competition and developed a theory of repeated quality innovations. They placed the patent race into a dynamic, general equilibrium model. Their results show a model in which the long-run growth results from endogenous technical change. Their models make it possible to examine the institutional and structural determinants of continual technological progress. (Grossman & Helpman, 1991)

Segerstrom et al. (1990) constructed a model which connects the hypothesis of product life cycle with the Schumpeter's idea of product innovation. The product life cycle hypothesis states that the rate at which a company develops and successfully markets new products is either treated as exogenously given or as defined function of the company's expenses used on new product development. Therefore, firm can assure successful product innovation by investing large amounts on product development. In other words, their model describes that the firm's probability of winning the R&D race is comparable to the resources allocated to R&D. If a firm succeeds in winning the race, it receives superior profits for the certain patent period, after which perfect competition dominates.

Similar to the work of Segerstrom et al. (1990) Aghion and Howitt (1992) developed an endogenous growth model where the research volume of any period is dependent on the expected research volume in the next period. Their model also supposes that single innovations are important enough to influence the whole economy. A period consists of the time between two different innovations. But since the innovation process is stochastic by nature it is impossible to estimate the length of each period. However, the relation between the research volumes in two successful periods can be viewed as deterministic. The amount of research in current period is negatively related to the expected amount of research in the next period. There are two effects involved. The first one is creative destruction, meaning that the return for the research in this period is the possible monopoly rents gained in the next period. These rents will last until the following innovation is discovered while the previous knowledge is obsolete. The second effect is general equilibrium effect which deals with the wage of skilled labor used in research or manufacturing. The expectation of more research in next period should also result in higher demand for skilled labor in next period. This on the other hand suggests higher wages for skilled labor.

Grossman and Helpman (1991) have pointed out that these studies include at least one unpleasant element. The difference between these two studies is that in Segerstrom et al. (1990) the patent races occur in a number of different industries in sequence where as in Aghion and Howitt (1992) the races take place at the entire economy level. In the model of Segerstrom et al. (1990) the whole research work in the economy has been allocated to improve a single product one after another until all products have been improved once, after this the cycle repeats. On the other hand, in the model of Aghion and Howitt (1992) all products are improved at the same time, if the research process is successful. Therefore, if there is only a one innovator, it receives monopoly position in all industries. (Grossman & Helpman, 1991)

Grossman and Helpman (1991) provided a solution to solve these difficulties. They based their approach on the works of Segerstrom et al. (1990) and Aghion and Howitt (1992). They anticipated a continuous flow of products situated each in their own quality ladder. Each product will follow stochastic progress up this ladder. Firms concentrate in single product and race to launch the next generation in the markets. These races occur simultaneously, and some of them succeed and others fail in any time period. In every industry, the success takes place with a probability per unit time that is relative to the amount of R&D resources allocated in improving that product. The model constructed by Grossman and Helpman (1991) describes many realistic components of the innovation process. For example, after a certain time period products become outdated, the progress is not regular in all sectors, research is linked to profit incentives and it is also possible to benefit from rivals by observing and analyzing their research success.

Klette and Griliches (2000) developed also a partial equilibrium model of endogenous firm growth. In their model R&D investments and stochastic innovations are the sources of firm growth. They also apply the quality ladder models in the macro growth literature, patent race literature and models of product differentiation in their model. The model by Klette and Griliches (2000) combines the model of firm performance and stochastic process of R&D investments. Their model enables to value, how the company behavior develops over time and how this behavior responds to the decisions and performance of its rivals. Their model is alternative to the models of Segerstrom et al. (1990), Aghion and Howitt (1992) and Grossman and Helpman (1991) which pays attention to the present firms' continuous innovation and growth or decline over several years.

The model of Klette and Griliches (2000) is, in certain parameters, consistent with the general empirical regularities of R&D investments, firm sales and firm growth. The first regularity is that, R&D intensities are independent on sales. The second is that, the firm growth is independent on size. This relation is often also known as the Gibrat's law. And the third regularity is that, the firm's size distribution is significantly skewed with constant differences in firm size. This holds for both sales and other variables, for example R&D investments. It should be noted that the second and third regularity are closely related to each other.

3.2 Methods of Measurement of R&D

Numerous studies have discussed the interaction of R&D expenditures and firm performance. Some of these studies have been also based on the assumption that firms investing in R&D will be able to execute the innovations and gain benefits from the investments. (Del Monte & Papagni 2003) But it is difficult to actually measure the inputs and outputs of innovation. And it is even more troublesome to generate relation between firm performance and measures of innovation. (Tidd, 2001)

There are two separate groups of innovation measures that are used. The first deals with financial and accounting performance, such as profitability and share price. The second concentrates on market performance, generally share or growth. (Tidd, 2001) Some empirical studies have used R&D expenditures as an input and patent applications as an output. But this kind of approach has raised a lot of discussion. The validity of patens as a measurement of productivity of R&D has been questioned in numerous studies. (Johnson & Pazderka, 1993)

Another approach of measuring R&D utilizes growth, profits, total factor productivity or unit costs as an output besides other normal factors. But these involve several different problems, for example the measurement of dependent variable and determination of the unit to be observed (whether it is firm, an industry or economy as a whole). The market value of a firm has been also used as a measure of success of the firms' R&D investments. This is because R&D expenses generate intangible capital for the firm. Thereby, the present value of expected returns from R&D should be taken into considerations by the markets while making valuations of the firm. (Johnson & Pazderka, 1993)

The R&D has been usually measured as R&D expenditures proportional to sales in research studies. This is a normalized measure of R&D intensity (Morbey & Reithner, 1990). But it might also be useful to use another index of R&D measure, when studying for instance the effect of R&D on market growth and the moderating role of R&D. It has been suggested that R&D expenditures per employee could be a better proxy for innovation. This is, because usually the number of employees has less variability in the short term than sales. The R&D expenditures per employee ratio may be steadier measurement in determining the long term commitment to innovation. (Lee & Shim, 1995; Morbey & Reithner, 1990)

Pakes (1984) argue that the R&D output has characteristics of mutual good. For example, the firm's R&D results can not be completely protected by patents and, therefore used solely by the innovating firm. The returns from R&D spending are received when the products or services are sold. Pakes (1984) also stresses that measures such as productivity or firm profits will not reflect R&D expenditures immediately. There is a time lag after which R&D expenditure improves productivity and profitability. The study by Hirschey and Weygandt (1984) indicate that R&D has economic life of five to ten years. On the other hand the firm's stock market value should reflect the changes of firm's R&D expenditures (Pakes, 1984).

3.3 Relation between R&D Activity and Firm Performance

In last few decades, researchers have become increasingly interested in measuring the influence of R&D expenditures on the firm's financial performance. Some authors have created models where market value depends (among other things) on the technological capital stock of the company (see, e.g., Jaffe, 1986). Whereas others have examined how different R&D based dimensions explain firm's long-run stock returns and operating performance (see, e.g., Lev & Sougiannis, 1996; Chan et al., 2001; Eberhart et al., 2004). In addition, some authors have studied the short-term reactions of stock returns when a firm announces changes in R&D expenditures (see, e.g., Chan et al., 1990; Woolridge & Snow, 1990; Doukas & Switzer, 1992). (Booth et al., 2003)

Accordingly, the relationship between R&D expenditures and market value has been studied empirically with two different kind of research frame. The first approach has investigated the announcement effects of increases in firm's R&D expenditures, and the second the relation between R&D expenses and market value. (Johnson & Pazderka, 1993) Common to all of these studies is that they confirm the assumptions that R&D expenses increase future cash flows of firm and current market value, but the strength of the effect is influenced by the country and sample (Booth et al., 2003).

Hanel and St-Pierre (2002) have established the connection between technological innovation and profitability in three different ways:

- **Signaling Effect.** Firm's announcements to increase R&D expenditures or launch new R&D projects affect the share value of the firm. E.g., Zantout and Tsetsekos (1994) discovered that in addition to the positive influence on its own share value, the announcement of new R&D projects will also create downward pressure on the competitors' share value. Also Sundaram et al. (1996) found that the announcement will have effect on both the firm's own and competitor's stock prices.
- **Effect of R&D Projects and Patents on Market Value of the Firm.** This impact has been discovered and documented by several researchers (see, e.g., Johnson & Pazderka, 1993; Hall, 1993).

- **Impact of Innovation on Profitability.** This studies the impact of new technology investments on actual profits whereas the previous approaches concentrated on the investor's anticipation of the company profitability. For instance, Jaffe (1986) documented a positive relationship between firm's accounting profit and R&D spending.

The remainder of this section discusses the first two connections, the announcement effect of R&D increases on share value of firm and the impact of reported R&D expenditures on the firm market value. After this, the third connection is more largely discussed in the Section 3.4, where technological innovation is also associated to firm growth.

3.3.1 Signaling Effect of R&D Expenditures

According to several studies the market is slow to associate public information (contrary to the hypothesis of efficient markets). Some studies also show that it takes years for the market to correct the revealed mispricing of firm's characteristics. (Eberhart et al., 2004) In efficient markets, there is no relationship between R&D intensity and future stock returns since the stock price impounds the value of the company's R&D capital. But many firms, that have intensive R&D activity, have few tangible assets. Their resources are tied to new, untested technologies involving high uncertainty. The firm's activity requires large expenditures in the beginning, but the results are not definite. The possible benefits are realized much later, and the life-cycles of the developed products can be also quite short. Also the accounting information regarding firm's R&D spending is usually only partly advantageous. (Chan et al., 2001)

Several different authors have examined the impact of announcements of increases in the R&D spending (see, e.g., Chan et al., 1990; Doukas & Switzer, 1992; Zantout & Tsetsekos, 1994; Sundaram et al., 1996; Eberhart et al., 2004). Some of these authors have found out that the announcement of R&D expenditures affects positively firm's market value. However, the research results considering the effect of announcement of R&D investments on stock price have been slightly inconsistent.

Eberhart et al. (2004) identify three factors that can be incorporated into R&D increases. Firstly, R&D increases are managerial decisions which distinguish them from other firm characteristics. Secondly, because managers rarely formally announce R&D increases, they differ from other events, for example stock repurchases. And finally, there is no time motivator for managers since R&D increases are investment decisions, not financing decisions. Zantout and Tsetsekos (1994) also argue, that firm's announcement of changes in R&D investments may have two different hidden messages. First, the announcement may indicate that the firm is likely to be the first to innovate and thereby, benefits from the first mover advantages. Or secondly, it signals the possibility that rival firms may benefit without cost through intra-industry spillovers. (Zantout & Tsetsekos, 1994)

The research results show that, on average, stock prices react positively to the announced plans to increase R&D expenses. The simultaneous events, such as announced growth in capital spending, do not have considerable effect on this relation. Moreover, the relation is found to be positive even in situations where the firm's earnings are declining. (Johnson & Pazderka, 1993) But Chan et al. (1990) have discussed a possibility of a different outcome. According to Chan et al. (1990) market values usually positively R&D activity, but when the short-term earnings of a company are decreasing, there is a possibility that the market will respond negatively to announcements of R&D investments.

Sundaram et al. (1996) studied the announcement effects of R&D spending on announcing firms' stock prices and also competitors' within the same industry. Especially, they examined the influence of competition in this relation and introduced new measure, competitive strategy, in their study. They divided the competitive strategy into ”strategic substitutes” and ”strategic complements” in order to describe the nature of competition, and also to point out the meaning of competition when firm announces new strategic decisions.[3] Also Zantout and Tsetsekos (1994) examined the effect of announcements of firms' intentions to increase R&D outlays, but only on rival firms' stock prices. They investigated the signals of first mover advantage and technology spillovers. Woolridge and Snow (1990) studied how stock market reacts to different kinds of publicly announced strategic corporate decisions. R&D projects were one of the strategic decisions examined in their study.

Sundaram et al. (1996) results indicate that the announcement effect of R&D investments is significantly and negatively related to the measure of competitive strategy. They also found significant positive effect on firms' stock responses, when firms announced changes in R&D outlays. The competitors' stock prices were also found to be positively affected when market reacts to the announcing firm's decisions. Also the study of Woolridge and Snow (1990) show evidence that stock market reacts positively and quickly to the investment decisions of companies. For the next 10 days from the announcement, they did not find any evidence of stock price declines. Zantout & Tsetsekos (1994) studied the announcement effect on competitor's stock prices and found out that the market value of firms can be affected by the signals sent by competitors. They found evidence that the announcement to increase firm's R&D expenses result in a positive abnormal return for the

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[3] When competition is in “strategic substitutes”, the competition is accommodating, and when the competition is in “strategic complements”, the competition is aggressive and tough (Sundaram et. al., 1996).

announcing firm and a negative for the rival firms. And even, when the announcement includes bad information for the announcing firm's shareholders, it is strategically advantageous, because rival firms lose significantly more.

Similar to the findings of Sundaram et al. (1996) Chan et al. (1990) and Doukas and Switzer (1992) found statistically significant abnormal daily returns on R&D announcements, especially in the high technology industries, where R&D spending is extremely significant. The positive influence of the announcement of growth in R&D on share-price provides positive evidence of strong relation between firm market value and R&D spending. This link is remarkably strong in large firms. (Chauvin & Hirschey, 1993)

Accordingly, stock market usually values positively firm's plans to increase R&D spending. The positive reaction in stock prices can be explained by the fact that shareholders see the possibility to additional growth opportunities in the announced increases (Zantout, 1997). But Zantout (1997) argue that there has been significant cross-sectional variation in the stock responses of previous studies (in the studies of Chan et. al. (1990) and Zantout and Tsetsekos (1994)). According to Zantout (1997), this leads to two things. Firstly, investor's may think that some of these R&D spending increases are bad investments and secondly, it suggests that R&D announcements are not the only factor influencing returns. There has to be also other indicators used to value the investment by investors.

The market response to announced increases in R&D expenditures has also found to be dependent on the industry in which the firm operates. (Johnson & Pazderka, 1993; Szewzcyk et al., 1996) Chan et al. (1990) report that R&D spending is more profitable for high technology firms than low technology firms. Whereas Szewzcyk et al. (1996) argue that firms that have better investment opportunities (such as high technology firms with market-to-book ratio greater than unity) will probably make better R&D investments. However, Eberhart et al. (2004) examined wider range of firms (high and low technology firms and high-growth and low-growth firms) and found evidence that all the firm categories benefit from R&D increases.

Management’s View of R&D Expenditures

According to American executives, they should make investments that would enhance the long term competitiveness of their companies, but it is considered difficult to carry out such investments in today’s business environment. Also the stock market has been seen as a barrier to long-run or strategic decision-making. (Woolridge & Snow 1990) But according to Goodacre and McGrath (1997), corporate management is interested in the effects that their decisions may have on the announced short-term earnings, and how investors respond to these earnings. But it has been considered, if corporate managers implement the long-run investments just to please the shareholder’s of the firm or do they reach for short-run profitability to satisfy securities analysts? Some authors have argued that stock market will force managers to do decision in the short-run while others have claimed that managers can create long-term strategies that are compensated by the stock market. (Woolridge & Snow, 1990)

Investors’ Reactions to R&D Expenditures

In informationally efficient markets the stock price reactions to corporate announcements reflects the market’s evaluation of the decisions made in the company (Woolridge & Snow, 1990). According to the efficient markets hypothesis, the stock prices should not be affected by the changes in accounting procedures, if the changes do not influence the future cash flows of the company (Goodacre & McGrath, 1997). Chauvin and Hirschey (1993) argue, that investors can use current cash flows, advertising data and R&D

investments as a help, when forming expectations about the size and variety of future cash flows. But Hall (1993) has found evidence that investors have short time horizons and they do not take long term rewards, such as R&D investments, into account while forming expectations. Also according to Chan et al. (2001), investors usually tend to accept the face values presented in firm's financial statements without considering the long-term benefits of R&D activity. These issues can lead to underpricing of stocks prices.

Researchers have identified two distinctive approaches to earnings numbers which investors can adopt. Goodacre and McGrath (1997) among others argue that investors may have mechanistic or myopic approach towards reported earnings. The mechanistic hypothesis states that the accounting procedures may mislead the stock market. This is possible even if the changes in accounting do not influence future cash flows. Therefore, this hypothesis predicts that the changes in accounting, which affect reported earnings, will have an impact on share price.

The myopic hypothesis on the other hand generates from a situation, where the reporting of positive earnings is regarded significant and, there is a high pressure for more cautious accounting procedures. Then corporate management may reduce optional expenditures, such as R&D, that have effect on short-term earnings, that is act myopically. The management can adopt myopic behavior towards R&D expenditures for example in situations, where managers act genuinely short-term (e.g., to gain personal goals, such as higher profit-related bonuses), investors have mechanistic approach to profits or managers believe that investors have mechanistic approach to profit or, investors genuinely view profits short-term or managers believe so. (Goodacre and McGrath,1997)

Jensen (1986) claims, that corporate managers will rather invest free cash flow in poor destinations than share it out to shareholders. Therefore, the firms having higher free cash flow will also evidently have higher agency costs of R&D investments. But low free cash flow firm's R&D investments may enhance the possibility of raising external financing. Szewzcyk et al. (1996) examined the free cash flow in order to find an explanation to the cross-sectional differences in the reactions of markets in R&D increases. They argued that the investment opportunities of the firm may cause the free cash flow agency costs. Firms probably will not have free cash flow, if they have good growth opportunities. Thereby, for the firms of low free cash flow or high Tobin's q the possible agency costs of R&D expenses are lowest. [4] The contrary holds for the opposite. However, Szewzcyk et al. (1996) did not found any evidence of free cash flow explaining abnormal cross-sectional returns in announcement period.

It has also been argued that the shares of the companies that invest in R&D would be coherently undervalued by stock exchange, because expensed R&D decreases earnings per share (EPS) in the year of expenditures. This is one of the most important performance criteria of the analysts. This view is believed to lead into systematic undervaluation of capital expenses and long-term R&D. Nonetheless, the weak relation between R&D expenditures and company evaluation (in relation to price to earnings (P/E)) proposes the possibility that undervaluation is industry related problem, if it even exists. (Tidd, 2001)

It is also possible to overestimate the benefits from R&D. Thereby, the stocks that are R&D intensive may be excessively valued. The innovating firms devote lot of resources on marketing efforts of their stocks. In consequence,

[4] Tobin's q is the measure of firm's market value named after the economist James Tobin. Tobin's q is the measure of company's debt and equity divided by the current replacement costs of its assets. (Brealey & Myers, 2000)

the market can value too optimistically the technological advancements of the R&D intensive firms. Overvaluation may also occur, if investors ignore the possibility that R&D investments are unprofitable. (Chan et al., 2001)

3.3.2 R&D Expenditures and Firm Market Value

Variety of studies has examined the influences of corporate investment decisions on the market value of the company. Previous studies have examined the association of R&D expenditures with future earnings and firm market value (see, e.g., Hirschey & Weygandt, 1985; Bublitz & Ettredge, 1989; Lev & Sougiannis, 1996; Aboody & Lev, 1998; Chan et al., 2001; Han & Manry, 2004; Xu & Zhang, 2004; Ho et. al., 2005). The association between R&D and stock returns is very interesting since the expected return on stock is very important investment and decision factor not only for investors, but also for the financial decision makers of the firm (Xu and Zhang, 2004).

Lev and Sougiannis (1996) studied the influence of R&D expenditures on the generation of future earnings. Whereas e.g., Hirschey and Weygandt (1985), Bublitz and Ettredge (1989), Aboody and Lev (1998), and Han and Manry (2004) have examined the value-relevance of R&D outlays by examining their association with market value measures, such as stock returns and Tobin’s q. Some of these studies have also addressed the question whether R&D expenditures should be capitalized because of the future benefits related to the expenses.

Hirschey and Weygandt (1985) examined R&D outlays from viewpoint of market value. They tried to find evidence of positive relation between R&D expenses and market value. Bublitz and Ettredge (1989) studied the relation between R&D expenditures and abnormal stock returns. They controlled unexpected revenues and other normal expenses in their model.

Hirschey and Weygandt (1985) found evidence suggesting that R&D expenditures affect systematically firm's market value and therefore R&D investments can be considered as intangible capital. Further, this suggests that R&D expenditures create positive future benefits and should be therefore capitalized and amortized. In addition, they found that R&D outlays have economic life for five to ten years. Bublitz and Ettredge (1989) neither found negative association between R&D expenses and stock returns. They also interpreted their result in the way that R&D expenditures should be recognized as assets.

Lev and Sougiannis (1996) tried to establish the reliability, objectivity and value-relevance of R&D capitalization in their study. This was carried out by examining the relationship between R&D expenditures and following earnings in a large number of R&D intensive companies. After this estimation they reported earnings and book values of the sample companies and adjusted them for the R&D capitalization in order to demonstrate that they are significantly related to stock prices and returns. This would signify that investors value R&D capitalization.

Lev and Sougiannis (1996) found strong relation between reported earnings and book values and stock prices and returns. This suggests that investors receive value-relevant information from R&D capitalization process. Furthermore, they found that stock prices do not fully reflect the R&D capital indicating that the shares of R&D intensive firms may be systematically mispriced or there is an additional risk factor related to R&D, which is compensated by excess returns.

Also Han and Manry (2004) tried to relate R&D outlays to firm market value. They examined R&D investment's value-relevance in Korean firms. Because Korean GAAP allows also capitalizing R&D expenses, they studied both capitalized and expensed R&D expenditures.

Han and Manry (2004) found that R&D expenditures affect positively to stock price. Markets also usually regard that capitalized R&D expenditures are investment with positive net present-value. Also fully expensed R&D expenditures were regarded as positive net present-value investments by markets. This may suggest that even if R&D expenditures are fully expensed, a portion of R&D expenses speaks for capitalization. Han and Manry (2004) also found that partially capitalized R&D expenditures had no considerable price impact, but the regression coefficient on R&D expenses was significantly less negative than on other expenses. This may suggest that these expenses have future economic benefits and that market may rather expense R&D expenditures than capitalize.

3.4 Corporate Growth and Profitability

Geroski et al. (1997) argue that the corporate growth rates at the present period reflect the changes of present expectations about the long-term profitability of a company. This indicates that growth rates of companies change randomly between firms and over time. However, academics have rarely examined how to exclusively price growth opportunities and possible assets of the company. Various studies have found that growth options do exist while studying measures of market values of equity in excess of book value, such as price-to-earnings, market-to-book value or price-to-sales ratios. Some researchers have documented also evidence that comparatively high levels of systematic risk may indicate growth opportunities for the company. (Garner et al., 2002)

It has been widely accepted that technological change has a great impact on economic growth (Davidson & Segerstrom, 1998). Firms also usually grow at the expense of other, not as successful, firms. Therefore, the nature of the firm and the characteristics of growth and also changes in the company structure and industry are important parts of technological transformation and industrial growth. (Lehtoranta, 1999) In addition, government can affect the speed of technological change. Researchers have developed a number of different kinds of models where firm's R&D decisions define the rate of technological change in the economy. (Davidson & Segerstrom, 1998) However, the growth process of firms differs between firms. Changes in firms' growth processes are large and separate rather than continuous. Plant-specific factors affect the financial performance of firms. (Lehtoranta, 1999)

According to Boer (1999) firm's R&D activity has only a little influence on corporate growth, but its effect on competitive advantage and shareholder value is tremendous. Also the other sources of corporate value growth should be recognized and managed properly. Examples of such sources of growth are price, market growth, market penetration, market share, manufacturing costs and overhead reduction.

Technology plays a significant role in changing and regulating the progress of business systems, especially in technology-intensive companies. But studies have shown that most of the new technology-based companies are not growth oriented. Their focus is more on firm profitability. (Lehtoranta, 1999) According to McGahan (2000) firm must fully understand the structural changes shaping the industry in which the firm operates in order to increase profitability. Plant-specific factors influence most strongly to profitability. Differences in their performance are due to unobserved business unit characteristics, such as production processes and management practices. (Lehtoranta, 1999)

R&D is usually associated with high profitability and performance in an increasing number of different industries. The resources devoted to R&D in order to produce superior products and services ultimately lead to market growth and profits. (Lee & Shim, 1995) Management can have a great impact on firm's future growth by deciding how much it invests in R&D. If the company allocates more resources into R&D than its competitors, it will usually end up with better rate of sales growth. If also the R&D expenditures per employee are greater than competition, it will lead to higher employee productivity than competitors. (Morbey & Reithner, 1990)

Morbey and Reithner (1990) suggest that there is a complex relation between profitability and R&D intensity. The productivity of the firm will have a great impact on the expected profit generated by increasing the R&D intensity. But even though the role of R&D expenses is significant, it alone does not secure firm success. The relation between profitability and company's competitive position is problematic because of the interacting influence of R&D on this relation. Also other strategic variables can moderate the influence of R&D on firm profitability. This means that the general model of R&D and market value may not be evident, when also other strategic variables such as advertising, firm size, financial structure etc. are brought to the relation. (Lee & Shim, 1995)

3.4.1 Measuring Firm Growth and Profitability

The difficulty with many traditional financial and accounting measures are that they focus is on short-term, and thereby, may cause undervaluation of innovation (Tidd, 2001). Company performance can be measured for instance by sales growth, profit margin or return on assets (Morbey & Reithner, 1990). However, the stock market value is considered to be more favorable performance indicator than for example ROI or profits, because it will probably reflect influence of innovation quicker (Tidd, 2001).

Different studies have examined the relation of R&D investments and productivity growth. Several previous studies have used sales growth as an indicator of firm growth (see, e.g., Lee & Shim, 1995; Del Monte & Papagni, 2003). Various US and Japanese companies employ sales as an indicator, when deciding firm targets, and therefore, emphasizes also sales growth (Kim & Song, 1990). This is probably one of the reasons, why also researchers have also used sales growth as an indicator of firm growth. But according to few studies the growth rate of a company can't be explained by other variables since it is contingent and unpredictable. Researchers of these studies have based their view on economic estimations which confirm Gibrat's law. According to Gibrat's law the growth of a company can be a result of several different factors, which have no average effect on growth. In consequence, the growth rate of a company can be seen as normal random variable. (Del Monte & Papagni, 2003)

Also profitability is widely used as a measure of firm performance. Return on Assets (ROA), Return on Equity (ROE), and Expenses to Revenue (also known as Operating Margin) are three significant ratios used to measure relative profitability of a firm. (Blaine, 1993) For example Ayadi et al. (1996) studied the impact of R&D expenses on ROE and ROI. Return on assets describes how efficiently the company assets are employed whereas return on equity measures the return created on the shareholder equity of the company. The operating margin, on the other hand, concentrates on the profitability of the basic operations of the company. (Blaine, 1993)

Each one of these measures is useful in valuating the profitability performance of a certain firm or industry, but it should be noted that each of these ratios involve some limitations. There are several false factors that may influence the firm's ROA, ROE, and operating margin. The most significant factors are: the tax rate and investment credits. Also the accounting methods accepted for income statements and balance sheet items may affect firm's ROA, ROE, and operating margin, especially, depreciation, R&D expenditure, minority investments, leases, goodwill, and currency translations; and the effect of debt versus equity while financing firm's activities. (Blaine, 1993)

Ratios (ROA, ROE) using net income to value profitability face the most obvious problems since the tax system has a great impact on the net income. But also other regulations have significant impact for example providing special deductions, allowances, or incentives. Also generally accepted accounting principles for instance for depreciation, R&D expenditures, foreign currency gains and losses may influence the net income by determining the range of deductible expenses. Finally, the net income is affected by the firm's capital structure (firm's choice between debt and equity) because interest payments are deducted before, but dividends after taxes. (Blaine, 1993)

3.4.2 Impact of R&D Expenditures on Growth and Profitability

The economic growth processes of industrialized countries, where technological innovation is the leading growth factor, are one of the reasons for the significance of R&D investments. Also, if technological innovation is the leading determinant of growth in economy, it should be also that in individual companies. (Ayadi et al., 1996) Several different research studies show that R&D investments affect positively to productivity, economic growth and profitability of the company. These studies have also helped to evaluate corporate performance and public policy at the industry level. But they have succeeded, mostly at the company level, to find positive effects of R&D activity, and for large companies only. (Garner et al., 2002)

A great number of the early studies of corporate performance concentrated on the relationship between R&D and sales growth. The findings of these studies suggest a high correlation between R&D and growth in sales. (Ayadi et al., 1996) The previous studies also show that there are differences of opinion and mixed research results on the relation of R&D and firm growth (Del Monte & Papagni, 2003). However, evidence has been found that in general R&D investments and new technology affect positively to the economic growth of the firm (Lehtoranta, 1999). As mentioned, a lot of studies have tried to find a link between R&D and firm performance. Most of these studies have concentrated on examining the relation of research intensity and firm growth and also the relation between innovation and firm growth. But researchers have not always been able to find evidence of such relation. (Del Monte & Papagni 2003)

Chauvin and Hirschey (1993) argue that R&D spending is usually more significant in large than small firms. Also the valuation effects of R&D are greater in larger firms, and this applies to both manufacturing and non-manufacturing firms. This proposes that, because of size advantage, R&D is more profitable for larger than smaller firms. Nonetheless it’s possible also for the smaller firms to make profitable R&D investments. Some studies have found evidence that well focused R&D investments, made by the smallest firms, can be profitable. (Chauvin & Hirschey, 1993) The companies that have low research intensity or no research at all grow less in the industry areas where there is lot of possibilities for innovation. Therefore on average, the firms that do no or little research will grow slower than those firms which are intensive in research. But it should be remembered that if research intensive firm has higher growth rate, the profits of the firm will not necessarily be larger. (Del Monte & Papagni, 2003)

Del Monte & Papagni (2003) studied the growth and innovation activity of firms in Italian firms. They found that R&D does not generate large barriers to entry and innovation does not seem to lead larger profits either since the new innovation is imitated quickly by other firms. Also the growth in the market share does not lead to higher profitability. Their study also shows that the influence of R&D on the growth of firm is smaller in the high research intensive sectors than in the traditional sectors.

According to Mukoyama (2003), imitation and competition may cause disadvantages, which will slow down the economic growth performance of a firm. The growth literature suggests, that expected competition decreases the reward from innovation and thereby, firm's innovation activity. He called this as the negative-incentive prediction in his study. But even though, it has been argued that competition decreases the growth of a company, Mukoyama (2003) found evidence that competition can also be associated with higher growth. Also Hoernig (2003) claims, that intense product market competition and imitation may enhance growth.

Lee and Shim (1995) examined the influence of R&D on the long-run performance of the firm and competitiveness in US and Japanese high technology industries. They found significant and positive relation between R&D activity and market growth in both these countries. The firm's continuous deployment of assets on R&D activity increases the market growth which will lead to competitive advantage in the long-run, especially, in the high technology industries. However, in order that the management of R&D would be successful and efficient, it should be closely related to other business functions for strategic and operational partnership. The significance of the R&D function in the firm can vary a lot depending on what kind of role R&D has in the competitive strategy of the company.

Ayadi et al. (1996) examined the relation between company's R&D investments and various profitability (ROE, ROI) and market value (Tobin's q, firm excess value) measures. They found evidence that on total capitalization and net worth based profitability measures were negatively related on the changes in R&D investments. On the contrary, evidence of a positive relation between market value measures, such as Tobin's q and excess value, and the R&D investments were found. On the other hand, Tidd (2001) found that high R&D expenditures and high rates of product launch are linked to lower profitability and ROI in the short term. But in the long run both these factors affect positively on the value of the business.

3.5 Research Hypotheses

The research hypotheses to be introduced and tested in this study are based on the previous studies and empirical evidence. Three main hypotheses were developed to test the impact of firm's R&D investments on firm growth, profitability and stock price. The first hypothesis tests whether there is a positive association between R&D expenditures and firm's long-run performance measured by growth in sales. Accordingly, the Hypothesis 1 (H_1) is introduced as:

> **H_1:** Firm's R&D activity is positively and significantly related to firm growth measured by sales growth.

The second hypothesis is similar to hypothesis one, but it tests the relationship between R&D expenditures and firm profitability, namely profit margin. Therefore, the Hypothesis 2 (H_2) is presented as:

> **H_2:** Firm's R&D activity is positively and significantly related to firm profitability measured by profit margin.

The third hypothesis tests the existence of positive relationship between R&D expenditures and stock price. In numerous research studies, this kind of study is conducted by examining the impact of R&D expenses on stock returns. Thereby, the impact of R&D expenses is examined also on stock returns in this study. Thereby, the Hypothesis 3 (H_3) is introduced as:

> **H_3:** Firm's R&D activity is positively and significantly related to the value of stock returns.

Since firm's R&D investments are hardly the only factor influencing firm growth, profitability or stock returns, also the effect of other explanatory and control variables alone and together with R&D expenditures are examined. The explanatory variables may also have effect on the relation between R&D investments and firm performance.

4. METHODOLOGY AND DATA

4.1 Methodology and Research Strategy

The cross-sectional analysis has been a usual methodology in previous studies that investigated the relation of R&D investments and firm performance. Some studies have also used panel data that is combined the cross-sectional analysis with time series analysis, in order to ensure broader and possibly more reliable research results. Previous articles investigating the impact of R&D spending on growth and profitability are usually conducted with either cross-sectional or panel data. For example, Lee and Shim (1995) used cross-sectional analysis to examine the effect of R&D expenses on sales growth in Japanese and US data whereas Ayadi et al. (1996) used panel data to study the effects of R&D on profitability and market value measures. In the articles, examining the relation of R&D investments and stock prices, the use of panel data has been more common than the use of cross-sectional data. (see, e.g., Han & Manry, 2004; Xu & Zhang, 2004).

Quantitative research methods are employed in the implementation of the empirical analysis of this study. The empirical analysis is begun by a short examination of the development of R&D investments in firms listed in the Helsinki Stock Exchange (OMXH) from year 1996 to 2004. A cross-sectional data is employed to examine the relations of chosen dependent and independent variables. The empirical analysis is divided into three separate analyses. Each of these analyses examines the effect of R&D expenses on different performance measure. The first empirical analysis examines the effect of two indicators' of R&D intensity on firm growth measured by growth rate of sales.[5] The second empirical analysis examines the relationship between the two R&D intensities and firm profitability. The firm profitability is measured by profit margin. The third analysis concentrates on the relation between one R&D intensity and stock returns.

The empirical analyses are carried out by using a linear regression analysis. The linear regression analyses are conducted by using the ordinary least squares (OLS) method. The SPSS 12.0 for Windows is utilized in the implementation of the empirical analyses.

4.2 Data and Sample Collection

All the three empirical analyses to be examined in this paper are conducted with Finnish data. Research sample consists of firms listed in the Helsinki Stock Exchange (OMXH). The data for the companies is collected mainly by using Thomson One Banker. Some of the missing values (mainly R&D expenditures) have been supplemented by values found from companies' financial statements.

The data for the first two empirical analyses that examine the impact of R&D expenditures on firm growth and firm profitability is collected from year 1999 to 2004. The sales growth and profit margin is collected from year 2004. The firms' R&D expenditures are gathered between years 1999 and 2003 and the other variables from year 2003. The data for the third empirical analysis examining the relationship of firm's R&D expenditures and stock return is gathered between years 1999 and 2005. The stock returns are gathered from year 2005 and the R&D expenditures between years 1999 and 2004. The other explanatory variables are from year 2004.

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[5] The two indicators' of R&D intensity to be used in the analyses are the ratio of R&D expenditures to sales and ratio of R&D expenditures to total assets.

A company has been included in the initial sample if it has all the necessary accounting and share price data available to compute the used variables. However, there are some missing values for some variables in some years. Especially, the lack of reported R&D expenditures has reduced the number of observations in the variables. Therefore, the number of observations of variables varies between different R&D measures.

The initial sample consists of all firms listed on the Helsinki Stock Exchange (OMXH). For closer analysis 65 firms, which had the necessary accounting and share price data available for the entire time period, were chosen. The sample is believed to be extensive enough in order that the empirical testing of the relationships between R&D expenses and different performance measures is possible. The industry classification of the sample can be seen from Table 1. Table 1 presents the number of firms included in the sample and the industry classification of the companies. In addition, Appendix 1 presents the lists of companies included in the sample and also their industry classification.

Table 1. Industry Classification of the Sample

Table presents the number of firms included in the initial sample and the industry classification of the companies.

Industry Classification	Number of Firms
Mechanical and Metal Products	15
Forest (Diversified Paper)	5
Electronics and Electrics (parts, components)	7
Food	4
Information Technology and Telecommunication	15
Chemicals and allied products	3
Drugs and Pharmaceuticals	3
Consumer Products and Services	10
Other Industries	3
Total	**65**

4.3 Specification of Variables and Research Designs

This section discusses the selection of appropriate variables and development of suitable research designs for each one of the three empirical analyses. First, the dependent and independent variables to be used in the empirical analyses are introduced and defined. Second, the research designs are represented and discussed.

The selection and introduction of variables to be used in the analyses of R&D intensity and firm growth and R&D intensity and firm profitability are discussed concurrently since they involve same independent variables and the equation formation is also similar. These two analyses differ only by the dependent variables.

4.3.1 R&D, Firm Growth and Profitability

Sales growth (SG_i) is chosen as an indicator of firm growth. The sales growth has been popular measurement of firm growth in several previous research studies (see, e.g., Lee & Shim, 1995 and Del Monte & Papagni, 2003) and is thereby, also used here. The annual growth in sales is calculated as follows;

$$SG_{i,t} = \frac{(S_{i,t} - S_{i,t-1})}{S_{i,t-1}}, \tag{1}$$

where $SG_{i,t}$ represents the sales growth of firm *i* at year *t*; $S_{i,t}$ is the sales of firm *i* at year *t* and, $S_{i,t-1}$ is the sales of firm *i* at year *t*-1.

Profitability of the firm is measured by profit margin. The profit margin is calculated by dividing earnings before interest and taxes (*EBIT*) by the sales of the firm *i* at the end of year *t*. The use of EBIT in the calculation of profit margin is considered to make the profit margin reflect the basic operations of a firm better. This way calculated profit margin might also be more appropriate measure of a firm's performance than e.g. ROA or ROE since it is measured before interest and tax payments (see, e.g., Blaine, 1993).

In the analyses the R&D expenditures are brought to the research model by using R&D intensity. This is a commonly used measurement of R&D expenses in several previous research studies. In the first two analyses two different measures of R&D intensity are used: the ratio of R&D expenditures to total sales (RD/S_i) and the ratio of R&D expenditures to the total assets (RD/A_i). The ratio of R&D expenditures to total sales is chosen because it has been widely used as a measure of R&D intensity in previous studies (see, e.g., Morbey & Reithner, 1990; Lee & Shim, 1995 and Del Monte & Papagni, 2003; Ho et al. 2005). However, it has received some criticism and, therefore another measure of R&D intensity is also used.[6] The ratio of R&D expenditures to total assets is chosen as another measure of R&D intensity since it has been argued that it might be more suitable and reflect innovation better. Xu and Zhang (2004) have argued that total assets might be more appropriate when calculating R&D intensity because the decision how much is invested in R&D activity should not be connected to the way the funds are obtained. Also the R&D intensity measured by the ratio of R&D expenditures to total assets is more independent on capital structure than it would be if the denominator were e.g. book value of equity.

It has been suggested that R&D expenses do not have immediate effect on growth or profitability. There is a time lag after which the effects of R&D investments can be observed. In previous studies, the impact of R&D on growth and profitability has been examined with quite short time lags, even though it has been argued, that it can take five to ten years until the effects of R&D are visible (see, e.g., Hirschey & Weygandt, 1990). For example, Morbey and Reithner (1990) calculated average R&D intensity from four years and, examined its impact on the following year’s firm performance, accordingly using only a one-year time lag. Also Del Monte and Papagni (2003) used one and two years as a time lag. Whereas, Lee and Shim (1995) measured all the variables they used in their study from the same five-year period and, thereby no time lag between R&D intensity and firm performance measure (sales growth) was used. Therefore, in this study the effects of R&D expenses on firm growth and profitability are also examined with longer time lags than one or two years, in order to better observe the causalities.

[6] The R&D expenditures are considered to be quite stable whereas the sales are considered to fluctuate more over time. Thereby, the use of sales as a denominator, when calculating the R&D intensity, can make the R&D intensity more volatile than it actually is. (Xu and Zhang, 2004)

The impact of R&D expenditures on growth and profitability of a firm is examined with one-, three- and five-year time lags. The examination of longer time lags is not possible since there is not enough R&D data available. But besides to use only an exact value of R&D intensity for a firm *i* at year *t* in the analyses, also two cumulative R&D intensity measures are calculated. Cumulative R&D intensities are used because single years may have unusual or exceptional values which might distort the analyses. Therefore cumulative R&D intensities might be better indicators of commitment to innovation than one-year R&D intensities. In this study the impact of one-year R&D intensity is examined with one-, three- and five-year lags. The effect of three-year cumulative R&D intensities is examined with one- and three-year time lags and the effect of five-year cumulative R&D intensities with one-year time lag. The one-year R&D intensity is the exact value of R&D intensity of firm *i* at year *t*, where as the three-and five-year cumulative R&D intensities are values of cumulative R&D intensity. Natural logarithm is taken from the different R&D intensities to normalize their distributions.

The cumulative R&D intensities are calculated as follows:

$$3CRD_{i,t} = 0.4RD_{i,t} + 0.3RD_{i,t-1} + 0.3RD_{i,t-2}\,, \tag{2}$$

where $3CRD_{i,t}$ is the three-year cumulative R&D intensity (Xu & Zhang, 2004). Similarly, the five-year cumulative R&D intensity has been defined as follows:

$$5CRD_{i,t} = 0.2RD_{i,t} + 0.2RD_{i,t-1} + 0.2RD_{i,t-2} + 0.2RD_{i,t-3} + 0.2RD_{i,t-4}\,, \tag{3}$$

where $RD_{i,t}$ is the R&D intensity, measured either by the ratio of R&D expenditures to sales or R&D expenditures to the total assets, of the firm *i* at year *t*, *t*-1, etc.

Besides R&D expenditures, there are also other factors that may affect firm's growth or profitability. Therefore other explanatory and moderating variables are also added to the equation. Some significant factors that might have effect on firm growth are considered and taken into account in the determination of the research model. These independent variables are labor productivity, debt ratio and, the effect of the industry in which the firm belongs. The labor productivity and debt ratio are measured one year before the calculation of dependent variables.

Firm's labor productivity ($LABP_i$) is calculated by dividing the earnings before interest and taxes (*EBIT*) by the number of the firm's employees. The labor productivity can be considered as an indicator of firm's production efficiency. It has also been recognized as one of the most important factors affecting firm performance and growth (Lee & Shim, 1995).

In addition, another independent variable to be taken into consideration in the regression is debt ratio ($DEBR_i$). The debt ratio of the firm is the firm's long-term debt divided by the sum of long-term debt and firm's equity (Brealey and Myers, 2000). Leverage of a firm is essential at least for one important reason. If the firm has high debts it may make it difficult for the firm to raise additional funds for possible R&D projects. This might harm the competitiveness of the firm in the long-term. (Lee & Shim, 1995)

Also the industry of the firm may have a role in the relation. Different industries may have various kinds of R&D intensities. For instance in the high technology industries the spending on R&D is more likely greater than in the low technology industries. A firm might be assumed to invest more in R&D

activity due to the industry it belongs. (Xu & Zhang, 2004) Therefore the industry effect of the firm is taken into consideration by using industry dummy (ID_i) variable. Associations of four industries that include the highest amount of firms are examined. The industries to be taken into consideration are electronics and electrics (ID_1), mechanical and metal products (ID_2), technological industry (ID_3) and consumer products and services (ID_4). The examination is restricted to these industries since these include highest amount of firms. Others include only few firms and might therefore confuse the analysis of relative small sample. All the variables to be used in the analyses are shown as summary in Appendix 2. It presents the names of the dependent and independent variables and their notation, formula and estimation.

The empirical model examining the effect of R&D intensity on sales growth and profit margin can be presented as follows:

$$Y_{i,t} = b_0 + b_1 RD_{i,t} + b_2 LABP_{i,t-1} + b_3 DEBR_{i,t-1} + b_4 ID_{i,t} + \varepsilon_{i,t}\,, \tag{4}$$

where $Y_{i,t}$ is the $SG_{i,t}$; the sales growth of firm *i* at year *t* or $PM_{i,t}$; the profit margin of firm *i* at year *t*; $RD_{i,t}$ is the R&D intensity ($RD_{i,t}$, $3CRD_{i,t}$ or $5CRD_{i,t}$) either the ratio of R&D expenses to sales or the ratio of R&D expenses to total assets measured with one-, three- or five-year time lag; $LABP_{i,t}$ is the labor productivity of firm *i* at year *t*-1; $DEBR_{i,t}$ is the debt ratio of firm *i* at year *t*-1; $ID_{i,t}$ is the industry dummy variable of firm *i* and $\varepsilon_{i,t}$ is the random variable.

The examined model is tested using cross-sectional linear regression model in both analyses. Both of the analyses include same independent variables and thereby, the same research model can be employed in both cases. The effect of independent variables on dependent variables is examined separately and jointly.

4.3.2 R&D and Stock Prices

In the third analysis, the impact of R&D expenditures on stock price is examined by studying the relation of different R&D intensities and stock returns. Continuously compounded returns are employed. The stock returns are measured for each stock annually and, also dividends are taken into account in the calculation. Therefore, the annual stock return is calculated as follows:

$$R_{i,t} = \ln\left(\frac{P_{i,t} + D_{i,t}}{P_{i,t-1}}\right), \tag{5}$$

where $P_{i,t}$ and $P_{i,t\text{-}1}$ are stock prices of firm *i* at year end *t* and *t*-1; $D_{i,t}$ are the dividends of firm *i* in year *t* and; ln is the natural logarithm.

In this third analysis the R&D intensity is only measured by one R&D intensity measure. A same ratio is employed as was in the previous analyses. Accordingly, R&D intensity is the natural logarithm ratio of R&D expenditures to total assets. This R&D intensity measure was chosen since the measure has been used in previous studies and it has found to influence stock returns (see, e.g., Xu and Zhang, 2004). The use of total assets as a denominator is also favorable since e.g. the book and market value of equity and earnings have found to be able to predict stock returns, and might therefore distort the analysis (Xu & Zhang, 2004).

Also here, it is necessary to consider the time lag after which the effects of R&D could be observable in stock returns. In the study of Xu and Zhang (2004) the adequate mean lag was considered to be between years 1.2 and 2.5. But it may also take longer time for the R&D effects to materialize. However, Ho et al. (2005) argue that longer time lags than three years may have significant disadvantages. The stock returns may not reflect longer time period R&D expenditures because also other factors such as economic, industry and firm related factors may affect firm's stock price. In addition, the longer the time lag the smaller is usually the sample size. Therefore, their used one- and three-year lags in their study. In this study, the effect of R&D expenses on stock returns is also examined with one- and three-year time lags. Also, the influence of three-year cumulative R&D intensity is investigated as was in the two previous analyses.[7]

Also other variables are included into this analysis. There are several studies which have examined the impact of different variables on stock returns (see, e.g., Fama & French, 1992 and Bulkley et al., 2004). For example studies examining the stock returns in Japanese market have found out that book-to-market value of equity explains the cross-sectional variation of stock returns (Xu & Zhang, 2004). Also according to Bulkley et al. (2004) the book-to-market ratio has the power to predict cross-section stock returns.

Fama and French (1992) investigated US stocks and found out that firm equity size and book-to-market value of equity are able to explain stock returns, but they did not find relation between Capital Asset Pricing Model based market beta and stock returns. However, the CAPM assumes that the higher the systematic risk (measured by the market beta of the stock) is, the higher are the expected returns (Xu & Zhang, 2004). Therefore we will also include the market beta of the stock into the analysis. The market beta is estimated by using 36 monthly logarithmic stock returns up to the calculation

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[7] The three-year cumulative R&D intensity is calculated by using the equation (2);

$$3CRD_{i,t} = 0.4RD_{i,t} + 0.3RD_{i,t-1} + 0.3RD_{i,t-2}$$

where $RD_{i,t}$ is the R&D intensity measured by dividing R&D expenditures by total assets of firm *i* at year *t*, *t*-1 and *t*-2.

of stock returns.[8] The return index of Hex-portfolio index is used in the estimation of beta.

Besides the market beta of the stock, we will also include the book-to-market value of equity and firm equity size into the analysis. Thereby, we will follow the methodology of Xu and Zhang (2004), who examined the effect of R&D expenses on stock prices in Japanese markets. The firm equity size is measured by the natural logarithm of market value of equity at the end of the year. The book-to-market value of equity is measured by natural logarithmic ratio of the book value of equity to its market value. Both values are measured at the same year-end, year before the measurement of stock returns.

Also, the industries of the firms are taken into consideration by including the industry dummy variables into the model. The associations of the same four industries that were examined in first two analyses are examined and for the same reason as previously argued.[9] The industries to be taken into consideration are electronics and electrics (ID_1), mechanical and metal products (ID_2), technological industry (ID_3) and consumer products and services (ID_4). All the variables that are included into this analysis can be also seen as a summary from the Appendix 2.

The following equation presents the regression model to be used to examine the relation of variables:

$$R_{i,t} = b_0 + b_1 RD_{i,t} + b_2 ME_{i,t-1} + b_3 (BMV)_{i.t-1} + b_4 \beta_{i,t-1} + b_5 ID_{i,t} + \varepsilon_{i,t} \,, \quad (6)$$

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[8] For one firm the beta was estimated by using 24 monthly returns since there was not stock price information available from longer time period.
[9] The chosen industries include the highest number of industries. Other industries include only few firms.

where $R_{i,t}$ is the annual stock return of stock i at year t; $RD_{i,t}$ is the measure of the R&D intensity ($RD_{i,t}$ or $3CRD_{i,t}$) with one- or three-year lag of firm i at year t; $ME_{i,t}$ is the natural logarithm of market value of equity of firm i at year t-1; $BMV_{i,t}$ is the natural logarithm of book-to-market value of equity of firm i at year t-1; $\beta_{i,t}$ is the market beta of stock i at year t-1; $ID_{i,t}$ is the industry dummy; $\varepsilon_{i,t}$ is the random component.

The cross-sectional regression analysis to be used partly follows the framework presented by Fama and MacBeth (1973), which was also employed by Xu and Zhang (2004). The effect of independent variables on stock returns is examined both separately and jointly.

5. EMPIRICAL RESULTS AND FINDINGS

5.1 Progress of R&D Spending in Finnish Listed Companies

We start the section 5 by looking at the progress of R&D intensities of the R&D active firms in Finland. Four different measures of R&D intensities are calculated from year 1996 to year 2004 for the firms listed in Helsinki Stock Exchange (OMXH). The R&D expenditures are examined within all firms doing R&D activity and within classified industries. Accordingly, the company's investment on R&D activity is usually measured by R&D intensity, where the R&D expenditures of the firm are represented as a proportion of some measure of firm size. Here the R&D expenses are expressed relative to sales, number of employees, total assets and book value of equity.

Table 2 presents statistics on the progress of R&D expenditures of the firms doing R&D activity and listed in the OMX Helsinki from year 1996 to year 2004. The table presents only those firm's R&D intensities that have the necessary data available to calculate all the R&D intensities in question. Also such firms have been extracted which have exceptionally high or low R&D intensity values.

Table 2 illustrates that all the measured R&D intensities have grown steadily from year 1996 to year 2003, but in year 2004 all the R&D intensities have declined. Also a little drop can be observed in all of the intensities in some years. The R&D expenditures were almost three (2.98) percent of sales in year 1996, but it has more than doubled by year 2003 to 6.37 percent. Same kind of development can be observed in all of the calculated R&D intensities. Also the number of firms reporting R&D expenditures has grown considerably. Overall, the table shows that firms have recognized the growing importance of R&D activity and increased their investments on R&D activity.

Table 2. R&D Intensities for Firms Investing in R&D Activity

This table presents the R&D intensities calculated for firms doing R&D activity and listed in the Helsinki Stock Exchange. The R&D intensities are expressed from year 1996 to 2004. R&D intensities are the ratios of R&D expenditures to total sales, number of employees, total assets and book value of equity. Table presents only those firm's R&D intensities that have the necessary data available to calculate all the R&D intensities in question.

Companies doing R&D Activity					
		R&D Expenditures as Percent of			
Year	**Number of Firms**	**Total Sales**	**Number of Employees**	**Total Assets**	**Book Value of Equity**
1996	38	2.98	0.47	3.41	7.97
1997	47	3.27	0.63	4.13	7.39
1998	52	4.30	0.69	5.48	14.92
1999	56	5.41	0.78	6.39	15.01
2000	62	6.13	0.91	5.87	13.80
2001	61	6.11	0.96	6.13	14.81
2002	64	6.62	0.94	6.25	14.79
2003	64	6.37	0.99	6.78	11.35
2004	64	5.18	0.94	5.51	10.99
Average	56	5.17	0.81	5.55	12.34

Also the R&D intensities of classified industries were examined in order to discover which industries are most active in their R&D spending. Table 3 provides statistics on the R&D intensities of industries. The same R&D intensities were used as in the examination of progress of R&D expenditures. All the calculated R&D intensities are the average of each industry from year 1996 to 2004. The firms included in the industries are listed in the OMX Helsinki and have the necessary data available to calculate all the R&D intensities. Also from this analysis the firms, that have uncommonly high or low values for intensities, are eliminated.

Table 3. Research and Development Intensities for Industries

This table presents the average R&D intensities from year 1996 to year 2004 for selected industries. All the firms included in the industries are listed in the OMXH and have the necessary data available to calculate all the intensities examined. The R&D intensities are the ratios of R&D expenditures to total sales, number of employees, total assets and book value of equity. The industries are ranked by R&D expenditures relative to sales.

Research and Development intensities for Industries

	R&D Expenditure as Percent of			
Industry	**Total Sales**	**Employees**	**Total Assets**	**Book Value of Equity**
Information Technology and Telecommunications	14.45	2.27	14.40	29.57
Drugs and Pharmaceuticals	6.41	1.01	6.71	5.99
Electronics and Electrics	5.22	1.00	7.35	18.49
Mechanical and Metal Products	3.24	0.57	4.02	10.68
Consumer Products/Services	1.96	0.26	2.26	4.92
Chemicals	1.41	0.33	1.60	3.65
Other Industries	1.29	0.27	1.52	4.29
Food	1.05	0.27	1.45	3.75
Forest	0.59	0.13	0.51	1.71

The table 3 shows that the R&D spending is concentrated on technology and science-based industries. The industry of information technology and telecommunications is found to have the highest ratios of R&D spending. In this industry the R&D investments are approximately 14.5 percent of sales and also of total assets. The drugs and pharmaceuticals industry is next in the ranking. The R&D costs are 6.4 percent of sales and 6.7 percent of total assets in this industry. It is not surprising that the more traditional industries are found at the bottom. Food and forest industries have on average invested least in R&D activity.

5.2 Descriptive Statistics

This part discusses the descriptive statistics of different variables used in the three empirical analyses. First the descriptive statistics for the variables used to study the relationships between R&D expenditures and firm growth and R&D expenditures and profitability are covered. These analyses are discussed concurrently since they involve a lot of same variables. Next the descriptive statistics for variables used to model the relation of R&D expenditures and stock returns are discussed.

For each variable the minimum, maximum, mean, standard deviation, skewness and kurtosis are reported. Also the results of the test of normal distribution are reported. Minimum, maximum and standard deviation are used to describe the dispersion and mean the focus of the variables. The skewness and kurtosis are helpful in examining the normal distribution of the variables.

5.2.1 Statistics of the Variables in First Two Analyses

Tables 4a and 4b presents the descriptive statistics for the variables used to examine the relations of R&D expenditures and firm growth and R&D expenditures and firm profitability. Minimum, maximum, mean and standard deviation is reported for each variable in Table 4a. Table 4b presents the values of skewness and kurtosis and, the results of the normality test. The descriptive statistics are reported for the sales growth (SG_i) and profit margin (PM_i) of year 2004, for the different measures of R&D intensity with various time lags and, for labor productivity ($LABP_i$) and debt ratio ($DEBR_i$) of year 2003.

Table 4a. Descriptive Statistics of the Variables

This table presents the descriptive statistics for variables used to analyze the impact of R&D expenditures on firm growth and profitability. $SG_{i,t}$ is the sales growth and $PM_{i,t}$ is the profit margin of year 2004. RD/S_i, RD/A_i, $3CRD/S_i$, $3CRD/A_i$, $5CRD/S_i$ and $5CRD/A_i$ are measures of R&D intensity in different years. $LABP_{i,t\text{-}1}$ is the labor productivity and $DEBR_{i,t\text{-}1}$ is the debt ratio of year 2003.

Variable	N	Minimum	Maximum	Mean	Standard Deviation
$SG_{i,t}$	65	-0.406	0.987	0.069	0.206
$PM_{i,t}$	65	-1.527	1.252	0.047	0.293
$RD/S_{i,t\text{-}1}$	65	-6.420	1.670	-3.508	1.433
$RD/S_{i,t\text{-}3}$	62	-5.550	-0.900	-3.464	1.151
$RD/S_{i,t\text{-}5}$	57	-5.520	-1.050	-3.614	1.170
$3CRD/S_{i,t\text{-}1}$	65	-6.630	3.790	-3.451	1.574
$3CRD/S_{i,t\text{-}3}$	59	-5.690	-1.120	-3.610	1.167
$5CRD/S_{i,t\text{-}1}$	58	-5.730	-1.010	-3.583	1.199
$RD/A_{i,t\text{-}1}$	65	-6.170	-0.170	-3.395	1.346
$RD/A_{i,t\text{-}3}$	61	-5.900	-0.660	-3.316	1.224
$RD/A_{i,t\text{-}5}$	55	-6.130	-0.660	-3.506	1.283
$3CRD/A_{i,t\text{-}1}$	65	-6.390	-0.030	-3.403	1.353
$3CRD/A_{i,t\text{-}3}$	58	-5.740	-1.190	-3.498	1.212
$5CRD/A_{i,t\text{-}1}$	58	-5.740	-0.950	-3.475	1.229
$LABP_{i,t\text{-}1}$	65	-0.575	0.100	-0.006	0.082
$DEBR_{i,t\text{-}1}$	65	-0.144	1.368	0.272	0.228

The three-year cumulative R&D intensity ($3CRD/S_{i,t\text{-}1}$) has the greatest range and standard deviation. The observation values of $3CRD/S_{i,t\text{-}1}$ have the largest distance from the mean value. It is notable that both of the three-year cumulative R&D intensities of year 2003 ($3CRD/S_{i,t\text{-}1}$, $3CRD/A_{i,t\text{-}1}$) have wider ranges and bigger standard deviations than none of the one-year R&D intensities although the former should be steadier measures of R&D intensity than the later. Especially $3CRD/S_{i,t\text{-}1}$ has notably bigger range than the one-year R&D intensities. The difference between the other one-year R&D intensities ($RD/A_{i,t\text{-}1}$, $RD/A_{i,t\text{-}3}$, $RD/A_{i,t\text{-}5}$) and $3CRD/A_{i,t\text{-}1}$ is not as large. This indicates that there might be one or more outliers included in the $3CRD/S_{i,t\text{-}1}$ variable. When the two R&D intensity measures (R&D expenditures relative to total sales and R&D expenditures relative to total asset) are compared in each time-lag level, it is evident that $RD/A_{i,t\text{-}1}$ and $3CRD/A_{i,t\text{-}1}$ are steadier variables than their counterparts. But as the time lag grows the difference between the two R&D intensity measures is no longer as significant.

Accordingly, the skewness, kurtosis and the results of the Kolmogorov-Smirnov one-sample test are reported in Table 4b. The skewness and kurtosis can also be used to examine the normal distribution of the variables. If the variables are normally distributed the values of skewness and kurtosis should be close to zero.

Table 4b. Descriptive Statistics of the Variables

Table presents the values of skewness, kurtosis and also result of normality test for each variable. The normal distribution of the variables was examined by using one-sample Kolmogorov-Smirnov test.

Variable	N	Skewness	Kurtosis	Kolmogorov-Smirnov
$SG_{i,t}$	65	1.641	6.555	0.002
$PM_{i,t}$	65	-1.838	17.279	0.000
$RD/S_{i,t\text{-}1}$	65	0.771	1.619	0.200*
$RD/S_{i,t\text{-}3}$	62	0.252	-0.628	0.200*
$RD/S_{i,t\text{-}5}$	57	0.330	-0.768	0.200*
$3CRD/S_{i,t\text{-}1}$	65	1.455	5.881	0.200*
$3CRD/S_{i,t\text{-}3}$	59	0.260	-0.776	0.200*
$5CRD/S_{i,t\text{-}1}$	58	0.245	-0.671	0.200*
$RD/A_{i,t\text{-}1}$	65	-0.005	-0.218	0.200*
$RD/A_{i,t\text{-}3}$	61	-0.170	-0.636	0.200*
$RD/A_{i,t\text{-}5}$	55	0.084	-0.634	0.200*
$3CRD/A_{i,t\text{-}1}$	65	-0.101	-0.269	0.200*
$3CRD/A_{i,t\text{-}3}$	58	-0.028	-0.901	0.200*
$5CRD/A_{i,t\text{-}1}$	58	-0.054	-0.817	0.200*
$LABP_{i,t\text{-}1}$	65	-5.749	38.510	0.000
$DEBR_{i,t\text{-}1}$	65	1.707	7.160	0.097

* This is a lower bound of true significance.

The table shows that the kurtosis of sales growth ($SG_{i,t}$), profit margin ($PM_{i,t}$), labor productivity ($LABP_{i,t\text{-}1}$), debt ratio ($DEBR_{i,t\text{-}1}$) and $3CRD/S_{i,t\text{-}1}$ are not close to zero. Especially profit margin and labor productivity have particularly high values of kurtosis. Also the values of skewness of these variables differ from zero, but not as much as the values of kurtosis. This indicates that none of these variables are normally distributed, but most evidently profit margin and labor productivity are not normally distributed. On the contrary, the skewness and kurtosis values of all the other R&D intensity variables (except $3CRD/S_{i,t\text{-}1}$) indicate normal distribution for these variables. This probably results from the fact that the natural logarithm was taken from the R&D intensity variables.

Profit margin and labor productivity have also the highest negative values of skewness. The negative value of skewness of these variables signifies that a great majority of the observation values is concentrated on the right whereas the data of other variables with positive skewness is concentrated on the left. All the variables that have high positive value of kurtosis suggest that the distributions of these variables are centered. Especially, the distributions of profit margin and labor productivity are strongly centered.

The skewness and kurtosis values of the variables indicated that sales growth, profit margin, labor productivity, debt ratio and $3CRD/S_{i,t\text{-}1}$ are not normally distributed. The normality of the variables was further examined by using one-sample Kolmogorov-Smirnov test. The null hypothesis is normal distribution and the results of the normality test indicate that all the R&D intensities are significantly normally distributed, also $3CRD/S_{i,t\text{-}1}$ ($p>0.05$). Also debt ratio is normally distributed, but not as significantly as the R&D intensities. This indicates that some modifications should be done to the other variables ($SG_{i,t}$, $PM_{i,t}$ and $LABP_{i,t\text{-}1}$) in order to carry on the analysis and fulfill the assumptions of correlation and regression analyses.

5.2.2 Statistics of the Variables in the Third Analysis

Tables 4c and 4d present the descriptive statistics for the variables used to examine the relations of stock returns and different R&D intensities. Minimum, maximum, mean and standard deviation is reported for each variable in Table 4c. Table 4d reports skewness, kurtosis and results of the Kolmogorov-Smirnov normality test. The descriptive statistics are presented for stock returns ($R_{i,t}$) of year 2005, various R&D intensities, market value of equity ($ME_{i,t\text{-}1}$), book-to-market value of equity ($BMV_{i,t\text{-}1}$) and market beta ($\beta_{i,t\text{-}1}$).

Table 4c. Descriptive Statistics of the Variables

Table presents the descriptive statistics for the variables used to analyze the influence of R&D expenses on stock returns. $R_{i,t}$ is the annual stock return of year 2005. $RD/A_{i,t\text{-}1}$ and $RD/A_{i,t\text{-}3}$ are logarithmic one-year R&D intensities in years 2004 and 2002 whereas $3CRD/A_{i,t\text{-}1}$ and $3CRD/A_{i,t\text{-}3}$ are logarithmic three-year cumulative R&D intensities at year 2004 and 2002. $ME_{i,t\text{-}1}$ is the logarithmic value of market capitalization, $BMV_{i,t\text{-}1}$ is the logarithmic book-to-market value of equity and, $\beta_{i,t\text{-}1}$ is the Capital Asset Pricing Model beta at year 2004.

Variables	N	Minimum	Maximum	Mean	Standard Deviation
$R_{i,t}$	63	-0.767	0.551	-0.153	0.304
$RD/A_{i,t\text{-}1}$	63	-7.910	-0.050	-3.505	1.399
$3CRD/A_{i,t\text{-}1}$	63	-6.420	0.110	-3.377	1.342
$RD/A_{i,t\text{-}3}$	63	-6.850	0.470	-3.408	1.436
$3CRD/A_{i,t\text{-}3}$	63	-5.870	-0.110	-3.373	1.298
$ME_{i,t\text{-}1}$	63	1.442	12.134	5.259	2.194
$BMV_{i,t\text{-}1}$	63	-0.340	0.990	0.411	0.223
$\beta_{i,t\text{-}1}$	63	0.215	2.962	1.268	0.671

The firm equity size ($ME_{i,t\text{-}1}$) has widest range. Also, all the R&D intensities have quite large ranges. There are not considerable differences between the ranges of R&D intensities. Also, there is not a lot of variation in the mean values or standard deviations of R&D intensities. The three-year cumulative R&D intensities have lower ranges and standard deviation than one-year

R&D intensities which indicates, that they are steadier measures of R&D than one-year R&D intensities. The market value of equity has also highest standard deviation, when measured with absolute values. But while measured with relative values the stock return has the highest standard deviation.

The findings in Table 4d indicate that the distribution of most variables follow approximately normal distribution. According to the skewness and kurtosis values of the variables, each one of them is normally distributed.[10] These findings are also supported by the results of Kolmogorov-Smirnov normality test. With one exception, the market value of equity is not significantly normally distributed according to this test.

Table 4d. Descriptive Statistics of the Variables

Table presents the values of skewness, kurtosis and also the result of the normality test for each variable. The normal distribution of the variables was examined by using one-sample Kolmogorov-Smirnov test.

Variable	N	Skewness	Kurtosis	Kolmogorov-Smirnov
$R_{i,t}$	63	0.099	-0.088	0.200*
$RD/A_{i,t-1}$	63	-0.422	0.662	0.200*
$3CRD/A_{i,t-1}$	63	-0.137	-0.144	0.200*
$RD/A_{i,t-3}$	63	-0.147	-0.002	0.200*
$3CRD/A_{i,t-3}$	63	-0.076	-0.479	0.200*
$ME_{i,t-1}$	63	0.796	0.655	0.045
$BMV_{i,t-1}$	63	-0.154	1.321	0.200*
$\beta_{i,t-1}$	63	0.561	-0.341	0.074

* This is a lower bound of true significance.

[10] The values of skewness and kurtosis are close to zero for the variables, which indicates normal distributions.

5.3 Cross-Correlations and Regression Analyses

First, the cross-correlations of independent variables are analyzed before moving on to the regression analyses. The cross-correlations are tested in order to examine the possible multicollinearity between the independent variables. Pearson's correlation coefficient is used to test the correlations. Before the correlation analyses, the variables, that did not fulfill the assumptions of correlation and regression analyses, were transformed. Variables were changed into normally distributed variables by taking natural logarithm value of the variables. The variables which included negative observation values were first changed to positive to be able to take the natural logarithm. Also outstandingly high or low observation values that might distort the analysis and suggest correlation even though there would not be any were eliminated from the variables.

The linear regression analyses are conducted by using the ordinary least squares (OLS) method. The regression analyses consist of two parts. The first includes the simple regression analyses, where the regressions are run between dependent variable and one independent variable at time. After this the regression analyses are extended step by step into a multiple regression analyses. Accordingly, the independent variables are added one by one into the regressions in order to observe whether the new independent variables bring additional explanation to the relations.

5.3.1 Relations between R&D, Growth and Profitability

Cross-Correlations

Table 5 provides statistics on the cross-correlations of the independent variables used to examine the relations of R&D intensity and firm growth and R&D intensity and firm profitability. The correlation between R&D intensities is not necessary to examine while the R&D intensities are run separately in the regressions.

Table 5. Cross-Correlations of the Independent Variables

Table presents the correlations between the independent variables that were used in the examination of the effect of R&D expenses on firm growth and profitability. The correlations were tested by using Pearson's correlation coefficient.

	$LABP_{i,t\text{-}1}$	$DEBR_{i,t\text{-}1}$
$RD/S_{i,t\text{-}1}$	0.053	-0.549**
$RD/A_{i,t\text{-}1}$	-0.053	-0.532**
$3CRD/S_{i,t\text{-}1}$	0.047	-0.579**
$3CRD/A_{i,t\text{-}1}$	-0.048	-0.547**
$5CRD/S_{i,t\text{-}1}$	-0.056	-0.624***
$5CRD/A_{i,t\text{-}1}$	-0.127	-0.585***
$RD/S_{i,t\text{-}3}$	0.013	-0.567**
$RD/A_{i,t\text{-}3}$	-0.087	-0.519**
$3CRD/S_{i,t\text{-}3}$	-0.063	-0.655***
$3CRD/A_{i,t\text{-}3}$	-0.103	-0.620***
$RD/S_{i,t\text{-}5}$	-0.045	-0.625***
$RD/A_{i,t\text{-}5}$	-0.069	-0.589***
$LABP_{i,t\text{-}1}$		-0.092

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$.

The findings in Table 5 indicate that a great majority of the R&D intensities are negatively and insignificantly correlated with labor productivity ($LABP_{i,t\text{-}1}$). Exceptions are the one- and three-year-lagged one-year R&D intensities

($RD/S_{i,t\text{-}1}$, $RD/S_{i,t\text{-}3}$) of year 2003 and 2001 and the three-year cumulative R&D intensity of year 2003 ($3CRD/S_{i,t\text{-}1}$) that are positively, but not significantly correlated with labor productivity. However, all the R&D intensities are negatively and significantly ($p<0.01$ or $p<0.001$) correlated with debt ratio ($DEBR_{i,t\text{-}1}$). The correlation of debt ratio with the R&D intensities should be closely taken into consideration when testing the regression analyses since the coefficients suggest of multicollinearity between these independent variables. However, the correlation coefficients do not exceed 0.90, which would suggest serious problems in the model, if both variables were entered in the regression at the same time. Labor productivity ($LABP_{i,t\text{-}1}$) and debt ratio ($DEBR_{i,t\text{-}1}$) are negatively but not significantly correlated with each other.

Regression Analyses

Tables 6, 7a, 7b, 8a and 8b present the results of linear regressions between R&D intensities and firm growth and profitability. Table 6 presents the results of simple regressions, whereas Tables 7a, 7b, 8a and 8b present the results of multiple regressions. In Table 6, the results of both simple regressions, when the dependent variable is either sales growth ($SG_{i,t}$) or profit margin ($PM_{i,t}$), are combined. The results of multiple regressions, where the dependent variable is sales growth ($SG_{i,t}$) of year 2004, are presented in Tables 7a and 7b, while the results, where the dependent variable is profit margin ($PM_{i,t}$) of year 2004, are presented in Tables 8a and 8b.

The residuals were found to be normally distributed in each regression run and, no evidence of heteroscedasticity was found. Also due to the transformation of the variables the distributions of all the variables were close to normal distribution. However, multicollinearity rose in to a problem, when the industry dummy (ID_i) variable was entered into the multiple regressions. Thereby, the regression results with and without the industry dummy were reported. After controlling for the basic defaults of the regression analysis no evidence of violations of the assumptions of regression analysis was found.

Simple Regressions

Accordingly, the Table 6 presents the results of simple regressions. The table presents the regression results for each independent variable separately. For each one of the variables the coefficient and t-statistics are presented. In addition, the R^2 and F-statistics are reported. The t-statistics and F-statistics are shown in parentheses.

The findings in Table 6 indicate that R&D investments have positive impact on firm growth, all the R&D intensities have positive coefficient. All R&D intensities also explain significantly the cross-sectional sales growth of year 2004, except the one-year R&D intensity of year 2003 ($RD/S_{i,t\text{-}1}$), the three-year cumulative R&D intensity of year 2001 ($3CRD/S_{i,t\text{-}3}$) and the one-year R&D intensity of year 1999 ($RD/S_{i,t\text{-}5}$). Thereby, the presented results are supportive of Hypotheses 1; R&D expenditures are positively and significantly related to firm growth. These results are also consistent with the results of previous studies (see, e.g., Morbey & Reithner, 1990; Boer, 1994; Lee & Shim, 1995; Del Monte & Papagni, 2003).

Table 6. Results of the Simple Regressions:
Dependent Variables Sales Growth and Profit Margin

This table presents the results of simple regressions between dependent variable, either sales growth ($SG_{i,t}$) or profit margin ($PM_{i,t}$) of year 2004, and one independent variable at time. Table presents the coefficients and t-statistics for each independent variable. Also R^2 and F-statistics are reported for each regression. The t-statistics and F-statistics are shown in parentheses.

Dependent Variable:		**Sales Growth ($SG_{i,t}$)**		**Profit Margin ($PM_{i,t}$)**	
Independent Variables	**N**	**Coefficient (t-statistics)**	**R^2 (F-statistics)**	**Coefficient (t-statistics)**	**R^2 (F-statistics)**
$RD/S_{i,t-1}$	60	0.405 (1.892)	0.058 (3.579)	0.564** (3.363)	0.163** (11.309)
$RD/A_{i,t-1}$	60	0.429* (2.019)	0.066* (4.078)	0.394* (2.250)	0.080* (5.061)
$3CRD/S_{i,t-1}$	60	0.436* (2.056)	0.068* (4.227)	0.574** (3.451)	0.170** (11.912)
$3CRD/A_{i,t-1}$	60	0.507* (2.413)	0.091* (5.823)	0.461* (2.315)	0.085* (5.358)
$5CRD/S_{i,t-1}$	52	0.572* (2.666)	0.124* (7.109)	0.542** (2.872)	0.142** (8.246)
$5CRD/A_{i,t-1}$	52	0.696** (3.429)	0.190** (11.757)	0.367 (1.896)	0.067 (3.594)
$RD/S_{i,t-3}$	62	0.555* (2.231)	0.077* (4.977)	0.638** (3.352)	0.160** (11.238)
$RD/A_{i,t-3}$	61	0.760** (3.268)	0.153** (10.678)	0.428* (2.133)	0.074* (4.549)
$3CRD/S_{i,t-3}$	59	0.431 (1.748)	0.051 (3.055)	0.490* (2.359)	0.112* (7.072)
$3CRD/A_{i,t-3}$	58	0.547* (2.358)	0.090* (5.561)	0.323 (1.733)	0.052 (3.002)
$RD/S_{i,t-5}$	57	0.433 (1.734)	0.052 (3.007)	0.477 (2.499)	0.104* (6.244)
$RD/A_{i,t-5}$	55	0.488* (2.137)	0.079* (4.565)	0.293 (1.576)	0.046 (2.485)
$LABP_{i,t-1}$	60	-0.199 (-1.319)	0.029 (1.740)	0.215 (1.736)	0.049 (3.013)
$DEBR_{i,t-1}$	60	1.157 (0.750)	0.010 (0.562)	-4.398*** (-3.821)	0.201*** (14.597)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

When the different one-year R&D intensities presented in Table 6 are compared between each other, the results show that the three-year-lagged R&D intensities explain most of the sales growth. The results also show that the three-year cumulative R&D intensities are not necessarily better explanatory variables that the same time lagged one-year R&D intensities. When the time lag is one year, the three-year cumulative R&D intensities explain more about sales growth, but when the time lag is three years the situation is quite the opposite; the one-year R&D intensities explain more. However, the results show that the five-year cumulative R&D expenditures relative to total assets ($5CRD/A_{i,t\text{-}1}$) explains most significantly (p<0.01) sales growth of all the R&D intensities. $5CRD/A_{i,t\text{-}1}$ explains about 19.0 percents of the sales growth. When the regression results of the two different R&D intensity measures are compared, the ratios of R&D expenses to total assets seem to explain sales growth better in every examined time lag level.

The simple regression results of the other explanatory variables indicate that neither labor productivity ($LABP_{i,t\text{-}1}$) nor debt ratio ($DEBR_{i,t\text{-}1}$) alone affects significantly sales growth. The labor productivity is negatively and debt ratio positively related to sales growth, but as mentioned the relations are not significant. The R^2 of both of these variables are very low.

The results presented in Table 6 also show that all the R&D intensities are positively related to the profit margin. All the R&D intensities, that are calculated by dividing R&D expenses by sales, are positively and significantly (p<0.01 or p<0.05) related to profit margin. The five-year cumulative R&D intensity of year 2003 ($5CRD/A_{i,t\text{-}1}$), the three-year cumulative R&D intensity of year 2001 ($3CRD/A_{i,t\text{-}3}$) and the one-year R&D intensity of year 1999 ($RD/A_{i,t\text{-}5}$) are the only R&D intensities that do not significantly relate to profit margin. Therefore, the findings provide support of Hypotheses 2; R&D spending has positive and significant impact on firm profitability measured by profit margin. In general, the results are in line with previous empirical findings, R&D spending and innovating have impact on profitability (see, e.g., Ayadi et al. 1996; Geroski et al. 1993). However, Ayadi et al. (1996) found evidence of a negative relationship between R&D and return on equity (ROE), but no significant relation between R&D and return on investment (ROI) was found.

While comparing the different time lagged one-year R&D intensities, the three-year-lagged R&D intensities ($RD/S_{i,t-3}$, $RD/A_{i,t-3}$) seem to explain most about the profit margin. However, the difference between the R^2 of one- and three-year-lagged one-year R&D intensities is not significant. When the R^2 all the different R&D intensities, are examined more closely, the three-year cumulative R&D intensities ($3CRD/S_{i,t-1}$, $3CRD/A_{i,t-1}$) have the highest R^2. However, the R^2s of the one- and three-year-lagged one-year R&D intensities do not differ considerably from the R^2 of $3CRD/S_{i,t-1}$ or $3CRD/A_{i,t-1}$. In general, the R&D expenditures relative to sales, explain better profit margin. In every examined time lag level, the R&D intensities that are calculated by dividing R&D expenditures by sales resulted with higher coefficients and R^2s.

The results of the other explanatory variables indicate that the effect of labor productivity is positive, but not significant. Debt ratio on the other hand is negatively and significantly ($p< 0.001$) related to profit margin. The debt ratio explains approximately one fifth of profit margin. Thereby, the impact of debt ratio on profit margin is higher than none of the R&D intensities. The use of EBIT in the calculation of profit margin has probably effect on this relation since the impact of taxes and interest are not yet visible in the profitability measure.

Multiple Regressions

Tables 7a and 8a presents the multiple regression results, where R&D expenditures are measured by one-year R&D intensities and three- and five-year cumulative R&D intensities with one year time lag. Tables 7b and 8b present the regression results, where the R&D expenses are measured by three- and five-year-lagged one-year R&D intensities and three-year-lagged three-year cumulative R&D intensities. The dependent variables sales growth ($SG_{i,t}$) and profit margin ($PM_{i,t}$) are measured at year 2004. In the tables the coefficient and t-statistics (in parentheses) are reported for each variable. In addition, the R^2, the adjusted R^2 and F-statistics are reported for each multiple regression. Also, the amount of observations is presented.

As was mentioned earlier the results of the multiple regressions are reported with and without the industry dummy (ID_i) variable. Tables 7a, 7b, 8a and 8b present the results of multiple regressions without the industry dummy. The regression results with the industry dummy variable are reported in Appendix 3. However, the results presented in Appendix 3 should be taken cautiously since the multicollinearity between the variables rose considerably high after including the industry dummy into the regressions. Besides, in general the industry dummy did not bring substantial additional explanation to the relations contrary to assumption made in the structuring of the research model.

R&D Expenditures and Sales Growth

The findings in Tables 7a and 7b indicate that the longer time has gone from the R&D investment the bigger is the impact of R&D on firm sales growth. The R&D intensities of year 1999 ($RD/S_{i,t\text{-}5}$, $RD/A_{i,t\text{-}5}$) have the highest R^2s of the one-year R&D intensities. Also from the three-year cumulative R&D intensities the three-year-lagged R&D intensities ($3CRD/S_{i,t\text{-}3}$, $3CRD/A_{i,t\text{-}3}$)

explained more than one-year-lagged cumulative R&D intensities. Therefore, the significance of R&D expenditures as an explanatory factor of sales growth increases in every examined time interval.

Table 7a. Results of the Multiple Regressions:
Dependent Variable Sales Growth

Table presents the results of the multiple regressions, where the dependent variable was sales growth ($SG_{i,t}$) of year 2004. The time lag between the independent variables and sales growth is one year. The coefficients and t-statistics are presented for each variable used in the regressions. The t-statistics are in parentheses. In addition, R^2, adjusted R^2 and F-statistics are reported for each multiple regression.

Independent Variable	One-Year R&D Intensities		Three-Year Cumulative R&D Intensities		Five-Year Cumulative R&D Intensities	
	R1	**R2**	**R3**	**R4**	**R5**	**R6**
(Constant)	-5.193 (-3.521)	-4.886 (-3.185)	-4.993 (-3.432)	-4.502 (-3.017)	-4.552 (-2.958)	-3.774 (-2.539)
$RD/S_{i,t-1}$	0.709** (2.878)					
$RD/A_{i,t-1}$		0.692** (2.825)				
$3CRD/S_{i,t-1}$			0.795** (3.211)			
$3CRD/A_{i,t-1}$				0.825** (3.418)		
$5CRD/S_{i,t-1}$					1.053*** (4.238)	
$5CRD/A_{i,t-1}$						1.152*** (5.097)
$LABP_{i,t-1}$	-0.189 (-1.315)	-0.138 (-0.954)	-0.184 (-1.302)	-0.131 (-0.926)	-0.215 (-1.516)	-0.146 (-1.076)
$DEBR_{i,t-1}$	3.702* (2.132)	3.612* (2.086)	4.219* (2.407)	4.196* (2.465)	5.515** (3.189)	5.782** (3.640)
R^2	0.160*	0.156*	0.186**	0.202**	0.331***	0.403***
Adjusted R^2	0.115	0.111	0.142	0.159	0.289	0.366
F-statistics	3.556	3.451	4.257	4.732	7.903	10.808
N	60	60	60	60	52	52

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 7b. Results of Multiple Regressions: Dependent Variable Sales Growth

Table presents the results of multiple regressions, where dependent variable was sales growth ($SG_{i,t}$) of year 2004. R&D intensities are measured three and five years before sales growth. Labor productivity ($LABP_{i,t}$) and debt ratio ($DEBR_{i,t}$) are measured one year before sales growth. The coefficients and t-statistics are presented for each variable used in the regressions. The t-statistics are in parentheses. In addition, R^2, adjusted R^2 and F-statistics are reported for each multiple regression.

Independent Variable	**One-Year R&D Intensities**		**Three-Year Cumulative R&D Intensities**		**One-Year R&D Intensities**	
	R7	**R8**	**R9**	**R10**	**R11**	**R12**
(Constant)	-4.028 (-2.630)	-3.561 (-2.275)	-4.255 (-2.705)	-3.959 (-2.660)	-4.601 (-2.898)	-4.739 (-3.150)
$RD/S_{i,t-3}$	0.996** (3.548)					
$RD/A_{i,t-3}$		0.998** (3.695)				
$3CRD/S_{i,t-3}$			1.147*** (4.054)			
$3CRD/A_{i,t-3}$				1.176*** (4.604)		
$RD/S_{i,t-5}$					1.040** (3.663)	
$RD/A_{i,t-5}$						0.979*** (3.948)
$LABP_{i,t-1}$	-0.128 (-0.904)	-0.076 (-0.534)	-0.146 (-1.062)	-0.114 (-0.867)	-0.162 (-1.152)	-0.152 (-1.105)
$DEBR_{i,t-1}$	4.663* (2.618)	4.514* (2.632)	7.192*** (3.797)	7.255*** (4.149)	6.341** (3.309)	6.220** (3.439)
R^2	0.208**	0.229**	0.299***	0.351***	0.264**	0.299**
Adjusted R^2	0.165	0.185	0.258	0.313	0.220	0.256
F-statistics	4.826	5.240	7.383	9.210	5.983	6.836
N	59	57	56	55	54	52

* p< 0.05, ** p< 0.01, *** p< 0.001.

However, according to the results the five-year cumulative R&D intensities (in Table 8a) have higher R^2 than the one-year R&D intensities or three-year cumulative R&D intensities. The five-year cumulative R&D intensities ($5CRD/S_{i,t-1}$, $5CRD/A_{i,t-1}$) explained most about the sales growth even though the time lag is only a one year. Further the regression, where the R&D

intensity is measured by $5CRD/A_{i,t\text{-}1}$, is found to have the highest R^2. The variables in the last regression explain a little over 40 percent of sales growth. This probably results from the fact that the R&D expenditures are gathered from five-year period and thereby, the effect of R&D expenses cumulates from longer time period than in the other R&D intensities. Also, the three-year-lagged three-year cumulative R&D intensities ($3CRD/S_{i,t\text{-}3}$, $3CRD/A_{i,t\text{-}3}$) have quite high R^2s and the coefficients are even higher than the coefficients of five-year cumulative R&D intensities. Both of these R&D intensities explain sales as significantly ($p<0.001$).

From the other explanatory variables the labor productivity ($LABP_{i,t\text{-}1}$) is negatively, but again not significantly related to sales growth in each one of the multiple regression (see both Table 8a and 8b). However, the R^2 of the regressions increased after including the labor productivity in the regression. The debt ratio ($DEBT_{i,t\text{-}1}$) is positively and significantly related to sales growth in every multiple regression. Its relation to sales growth is most significant ($p< 0.001$), when the R&D expenses are measured by three-year cumulative R&D intensities in year 2001 ($3CRD/S_{i,t\text{-}3}$, $3CRD/A_{i,t\text{-}3}$). It seems that the debt ratio has moderating effect on the relation between R&D intensities and sales growth since together the debt ratio and R&D intensities explain more about sales growth than individually. This is not surprising because the firm's debts were considered important while making the financing decision of R&D investments (see, e.g., Lee & Shim, 1995).

When the two different R&D intensity measures are compared between each other, the R&D intensities measured by R&D expenditures relative to total asset seem to explain more about sales growth. However, the difference between the two different R&D intensity measures is not substantial. Thereby, it can be concluded that both R&D intensity measures are as valid in explaining cross-sectional sales growth. In conclusion, it is evident that the longer is the time lag from the R&D investments the more significant is the impact of firm's R&D activity on sales growth. Even though the sample size in tables 8a and 8b is smaller in the last two regressions than in the first four, it is not considered to have considerable effect on the results. Firstly, the sample size is not substantially smaller in the last two regressions and secondly, the similar and the growing effect can also be observed between the first four regressions, where R&D expenses are measured by the one-year R&D intensities or the thee-year cumulative R&D intensities.

R&D Expenditures and Profit margin

The results of multiple regressions, where the dependent variable was the profit margin ($PM_{i,t}$) of year 2004, are shown in Tables 8a and 8b. The results of the multiple regressions in Tables 8a and 8b indicate that the significance of R&D intensities in explaining profit margin has declined in the multiple regressions. All the R&D intensities have positive coefficients, but they are not significant. Also, the coefficients of the ratios of R&D expenditures to sales are higher than the coefficient of R&D expenditures relative to total assets.

When the regressions with different time lag and differently calculated R&D intensities are compared, the regressions, where the R&D intensities are the one-year R&D intensities with three-year time lag, explain most of the cross-sectional profit margin. In addition, the three-year-lagged one-year R&D intensity calculated by dividing R&D expenses by sales ($RD/S_{i,t\text{-}3}$) explain most significantly ($p<0.001$) and has the highest R^2. However, the regressions of one-year and three-year cumulative R&D intensities with one-year time lag explain profit margin almost as well (see Table 8a). Also, when the R^2's of different regressions are examined in Table 8a, both first and third and second and fourth regressions have the same R^2. This probably results from the mutual correlation between debt ratio and different R&D intensities.

Table 8a. Results of Multiple Regressions: Dependent variable Profit Margin

Table presents the results of the multiple regressions, where the dependent variable was profit margin ($PM_{i,t}$) of year 2004. The independent variables are measured one year before profit margin. The coefficients and t-statistics are presented for each variable used in the regressions. The t-statistics are in parentheses. In addition, R^2, adjusted R^2 and F-statistics are reported for each multiple regression.

Independent Variable	**One-Year R&D Intensities**		**Three-Year Cumulative R&D Intensities**		**Five-Year Cumulative R&D Intensities**	
	R1	**R2**	**R3**	**R4**	**R5**	**R6**
(Constant)	-1.478 (-1.293)	-1.908 (-1.577)	-1.466 (-1.280)	-1.901 (-1.570)	-1.565 (-1.049)	-2.292 (-1.471)
$RD/S_{i,t\text{-}1}$	0.316 (1.655)					
$RD/A_{i,t\text{-}1}$		0.125 (0.649)				
$3CRD/S_{i,t\text{-}1}$			0.324 (1.664)			
$3CRD/A_{i,t\text{-}1}$				0.129 (0.660)		
$5CRD/S_{i,t\text{-}1}$					0.371 (1.538)	
$5CRD/A_{i,t\text{-}1}$						0.135 (0.569)
$LABP_{i,t\text{-}1}$	0.174 (1.568)	0.183 (1.603)	0.176 (1.586)	0.183 (1.603)	0.165 (1.203)	0.151 (1.057)
$DEBR_{i,t\text{-}1}$	-3.005* (-2.233)	-3.744** (-2.741)	-2.898* (-2.101)	-3.718** (-2.692)	-2.040 (-1.217)	-3.103 (-1.863)
R^2	0.269**	0.239**	0.269**	0.239**	0.201*	0.168*
Adjusted R^2	0.230	0.198	0.230	0.198	0.151	0.116
F-statistics	6.862	5.855	6.876	5.861	4.035	3.223
N	60	60	60	60	52	52

* p< 0.05, ** p< 0.01, *** p< 0.001.

When the R&D intensities are calculated from longer time period ($5CRD/S_{i,t-1}$, $5CRD/A_{i,t-1}$) or with longer time lag ($RD/S_{i,t\text{-}5}$, $RD/A_{i,t\text{-}5}$), clear drops in the R^2's of these regressions are observable. However, similar trend is observed from the multiple regressions as from simple regressions: the regressions, in which the R&D expenses are measured by the one-year and three-year cumulative R&D intensities, explain more about profit margin than five-year cumulative R&D intensities or five-year lagged one-year R&D intensities.

Table 8b. Results of the Multiple Regressions: Dependent Variable Profit Margin

Table presents the results of multiple regressions, where the dependent variable was profit margin ($PM_{i,t}$) of year 2004. R&D intensities are measured three and five years before the calculation of profit margin. Labor productivity and debt ratio are measured one year before profit margin. The coefficients and t-statistics are presented for each variable used in the regressions. The t-statistics are in parentheses. In addition, R^2, adjusted R^2 and F-statistics are reported for each multiple regression.

Independent Variable	**One-Year R&D Intensities**		**Three-Year Cumulative R&D intensities**		**One-Year R&D Intensities**	
	R7	**R8**	**R9**	**R10**	**R11**	**R12**
(Constant)	-1.158 (-0.965)	-1.590 (-1.225)	-1.796 (-1.336)	-2.438 (-1.776)	-1.929 (-1.425)	-2.557 (-1.878)
$RD/S_{i,t\text{-}3}$	0.394 (1.784)					
$RD/A_{i,t\text{-}3}$		0.201 (0.897)				
$3CRD/S_{i,t\text{-}3}$			0.296 (1.220)			
$3CRD/A_{i,t\text{-}3}$				0.088 (0.373)		
$RD/S_{i,t\text{-}5}$					0.244 (1.004)	
$RD/A_{i,t\text{-}5}$						0.040 (0.177)
$LABP_{i,t\text{-}1}$	0.186 (1.653)	0.195 (1.644)	0.165 (1.385)	0.153 (1.245)	0.161 (1.331)	0.151 (1.200)
$DEBR_{i,t\text{-}1}$	-3.051* (-2.189)	-3.763* (-2.651)	-2.240 (-1.384)	-3.157 (-1.961)	-2.657 (-1.627)	-3.947* (-2.143)
R^2	0.287***	0.255**	0.192*	0.171*	0.189*	0.171*
Adjusted R^2	0.248	0.212	0.144	0.121	0.140	0.117
F-statistics	7.256	5.931	4.038	3.428	3.812	3.221
N	58	56	55	54	53	51

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

The labor productivity is positively, but not significantly related to profit margin in each regression run (see both Table 8a and 8b). However, also here the R^2 of the regressions grew after including the labor productivity in the regressions. But the labor productivity did not bring substantial additional explanation to profit margin as it did not to the sales growth. The debt ratio on the other hand is negatively and significantly related to profit margin in first four regressions in Table 8a and in the first two and in the last regressions in Table 8b. The coefficients of debt ratio are higher, when R&D intensities are the ratios of R&D expenditures to total assets. The influence of debt ratio in explaining profit margin is higher than other independent variables.

In overall, the R&D intensities calculated by dividing R&D expenditures by sales seem to explain more about profit margin than R&D expenses relative to total assets. The results point out the importance of firm's R&D investments in creation of positive future benefits for the firm. The effects of R&D expenses on profit margin are most significant approximately three years after the investment. However, the impact of R&D investments on profit margin is almost as significantly observed only one year after the investment. This is surprising results since it would be probable for the effect to take longer time to be visible.

5.3.2 Relation between R&D and Stock Returns

Cross-Correlations

Table 9 presents the results of the cross-correlation analysis between the independent variables used in the examination of the impact of R&D expenditures on stock returns. The correlations between the R&D intensities are not essential to examine since the intensities are used one at the time in the regressions and therefore are not reported in the correlation matrix of Table 9.

Table 9. Cross-correlations of the Independent Variables

Table presents the results of cross-correlations between the independent variables that are used in the regressions to examine the impact of R&D expenses on stock returns. The correlations were tested by using Pearson's correlation coefficient.

	$RD/A_{i,t-1}$	$3CRD/A_{i,t-1}$	$RD/A_{i,t-3}$	$3CRD/A_{i,t-3}$	$ME_{i,t-1}$	$BMV_{i,t-1}$	$\beta_{i,t}$
$RD/A_{i,t-1}$	1.000						
$3CRD/A_{i,t-1}$		1.000					
$RD/A_{i,t-3}$			1.000				
$3CRD/A_{i,t-3}$				1.000			
$ME_{i,t-1}$	-0.371	-0.432**	-0.392**	-0.416**	1.000		
$BMV_{i,t-1}$	-0.341	-0.483***	-0.506***	-0.531***	0.053	1.000	
$\beta_{i,t-1}$	0.177	0.130	0.175	0.164	0.382**	-0.066	1.000

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$.

The correlation results indicate that there is multicollinearity between some independent variables, but the correlations are not so high that they would create major difficulties if placed concurrently in the regressions. The market value of equity ($ME_{i,t-1}$) is negatively and significantly ($p<0.01$) correlated with each of the R&D intensities, except with $RD/A_{i,t-1}$. The book-to-market value of equity ($BMV_{i,t-1}$) is also negatively correlated with the R&D intensity measures, except with ($RD/A_{i,t-1}$) and its correlation with the R&D variables is equally significant ($p<0.001$). The correlation of market beta with the market capitalization is positive and significant ($p<0.01$) and with the book-to-market value of equity negative and insignificant.

Regression Analysis

Table 10 presents the results of the simple regressions run between stock returns of year 2005 and one independent variable at time. The results of multiple regressions are shown in Table 11.

No evidence of violations of the assumptions of regression analysis was found. The residuals were found to be normally distributed and homoscedastic. All the variables were also close to normal distribution and multicollinearity between variables was not a problem, even though the correlation analysis showed correlation between some independent variables.

Simple Regressions

The results in Table 10 indicate that none of the R&D intensities relates significantly to stock returns. All the R&D intensities are negatively, but not significantly (p>0.05) related to stock returns. Thereby, the results are not supportive of Hypotheses 3. R&D expenditures do not have significant impact on stock returns based on the data and time interval being evaluated. R&D investments do not generate value for the firms in the time horizons examined. In general the results indicate that investors should not pay a lot of attention on reported R&D expenditures while making investment decisions since the R&D spending do not reflect into the stock prices.

The findings are not supportive of a great majority of previous research studies that have reported positive and significant relationship between R&D expenses and stock returns (see, e.g., Han & Manry, 2004; Ho et al., 2005). However, Xu and Zhang (2003) found evidence of a positive relation, but very weak in general. Their investigated also different sub periods, where the research results resulted mixed. For some sub periods they found negative association while for others positive. Also, Chan et al. (2001) did not find strong relation between R&D investments and stock returns.

Table 10. Results of the Simple Regressions: Dependent Variable Stock Returns

Table presents the results of seven simple regressions, where the dependent variable was stock return ($R_{i,t}$) of year 2005 and the independent variable was varied. The R&D intensities are measured one and three years before stock returns. Table presents the coefficient and t-statistics for each variable. The t-statistics are shown in parentheses. Also the R^2 and F-statistics are reported.

Independent Variable	N	Coefficient (t-statistics)	R^2 (F-statistics)
$RD/A_{i,t\text{-}1}$	62	-0.017 (-0.593)	0.006 (0.351)
$3CRD/A_{i,t\text{-}1}$	62	-0.031 (-1.043)	0.018 (1.088)
$RD/A_{i,t\text{-}3}$	62	-0.022 (-0.777)	0.010 (0.604)
$3CRD/A_{i,t\text{-}3}$	62	-0.026 (-0.843)	0.012 (0.711)
$ME_{i,t\text{-}1}$	62	0.002 (0.098)	0.000 (0.010)
$BMV_{i,t\text{-}1}$	62	0.130 (0.701)	0.008 (0.491)
β_i	62	0.071 (1.284)	0.027 (1.648)

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$

The findings in Table 10 also suggest that the market value of equity, book-to-market value of equity and market beta of the stock are all positively related to stock returns but not significantly. The coefficients and R^2's of these variables are generally very low. However, other studies have neither been able to find relation for these measures and stock returns. For example Xu and Zhang (2004) and Ho et al. (2005) found insignificant relation between market beta and returns. Xu and Zhang (2004) also discovered a weak relation between size and returns, whereas Ho et al. (2005) found quite strong relation. Xu and Zhang (2004) found also insignificant book-to-market effect for some sub period in their study.

Multiple Regressions

Similar findings and results are presented in Table 11 for the multiple regressions as was in the simple regressions. The results indicate, that the independent variables together, are not significantly related to stock returns. All R&D intensities remain insignificant in explaining stock returns. Each one of the R&D intensities is negatively related to stock returns, but the coefficients and t-statistics are higher than in the simple regressions.

Also market value of equity, book-to-market value of equity and market beta remains insignificant in explaining returns. The size is negatively related whereas book-to-market and market beta are positively related to returns. Also the industry dummies did not bring additional explanation to the relation of stock returns and R&D intensities. The mechanical and metal products industry (ID_2) has negative coefficients while the other industries (electronics and electrics (ID_1), technological industry (ID_3) and consumer products and services (ID_4)) have positive coefficients (except in R1 the technological industry (ID_3) has negative coefficient).

Table 11. Results of the Multiple Regressions: Dependent Variable Stock Returns

Table presents the results of multiple regressions, where the dependent variable was stock returns ($R_{i,t}$) of year 2005. The coefficient and t-statistics are presented for each variable used in the regressions. The t-statistics are in parentheses. Also R^2, adjusted R^2, and F-statistics are reported for each multiple regression.

Independent Variable	**One-Year R&D Intensity**		**Three-Year Cumulative R&D Intensities**	
	R1	**R2**	**R3**	**R4**
(Constant)	-0.346 (-1.566)	-0.356 (-1.673)	-0.419 (-1.968)	-0.373 (-1.688)
$RD/A_{i,t\text{-}1}$	-0.020 (-0.499)			
$RD/A_{i,t\text{-}3}$		-0.030 (-0.640)		
$3CRD/A_{i,t\text{-}1}$			-0.057 (-1.144)	
$3CRD/A_{i,t\text{-}3}$				-0.039 (-0.698)
$ME_{i,t\text{-}1}$	-0.013 (-0.611)	-0.016 (-0.702)	-0.022 (-0.956)	-0.017 (-0.751)
$BMV_{i,t\text{-}1}$	0.172 (0.810)	0.127 (0.551)	0.088 (0.390)	0.108 (0.452)
β_i	0.089 (1.242)	0.093 (1.287)	0.093 (1.315)	0.093 (1.290)
ID_1	0.095 (0.563)	0.097 (0.583)	0.123 (0.740)	0.102 (0.610)
ID_2	-0.145 (-1.227)	-0.137 (-1.146)	-0.122 (-1.044)	-0.134 (-1.117)
ID_3	-0.008 (-0.057)	0.008 (0.055)	0.054 (0.355)	0.019 (0.124)
ID_4	0.119 (0.948)	0.123 (0.979)	0.127 (1.024)	0.119 (0.955)
$\mathbf{R^2}$	0.147	0.150	0.164	0.151
Adjusted R^2	0.018	0.021	0.038	0.023
F-statistics	1.143	1.166	1.297	1.177
N	62	62	62	62

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Since the impact of R&D expenditures was not observable on stock returns with the used cross-sectional data and time lags examined, an additional analysis is carried out. Accordingly, the effect of R&D expenditures on stock returns is further analyzed by examining the impact of three-year-lagged one-year R&D intensity and one-year-lagged three-year cumulative R&D intensity on stock returns between years 1999 and 2005. These R&D intensities were chosen because it might take longer time than one year for the effect of R&D intensities to reflect on stock prices. The analysis is conducted only between stock returns and R&D intensities, other explanatory variables are not included. The results from this analysis are presented in Table 12. The descriptive statistics for the variables of this time period are reported in Appendix 4.

The findings of Table 12 indicate that in some years the effect of R&D expenses is observable in stock returns. The effect of R&D expenditures relative to total assets from year 1999, is negatively and significantly (p<0.001) related to the stock returns of year 2002. Also the three-year cumulative R&D intensity of year 2001 and 2002 are related to the stock returns of years 2002 and 2003. However, in 2002 the coefficient is negative while in year 2003 positive, but both relations are as significant (p<0.05).

Table 12. Results of the Additional Test

Table presents the results of regression analyses run between years 1999 and 2005. The time lag between R&D intensities and stock returns is three years. Table presents the coefficients and t-statistics for each R&D intensity. Also R^2 and F-statistics for each regression are presented. The t-statistics and F-statistics are shown in parentheses.

	$RD/A_{i,t-3}$			$3CRD/A_{i,t-1}$		
$R_{i,t}$	**N**	**Coefficient (t-statistics)**	**R^2 (F-statistics)**	**N**	**Coefficient (t-statistics)**	**R^2 (F-statistics)**
2002	47	-0.111*** (-2.860)	0.154*** (8.178)	50	-0.097* (-2.444)	0.111* (5.973)
2003	61	0.051 (1.627)	0.043 (2.648)	62	0.067* (2.607)	0.102* (6.798)
2004	58	-0.030 (1.224)	0.026 (1.498)	61	-0.016 (-0.755)	0.010 (0.570)
2005	62	-0.022 (-0.777)	0.010 (0.604)	63	-0.005 (-0.168)	0.000 (0.028)

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$.

Both used R&D intensities provide mixed research results. In year 2003, both R&D intensities are positively related to stock returns while in other years negatively. And even though in years 2002 and 2003 the $3CRD/A_{i,t-1}$ suggests of a significant (p<0.05) relation between R&D intensities and stock returns, the relation is not considerably high. Whereas the relation of $RD/A_{i,t-3}$ with the stock return of year 2002 is more significant (p<0.001). In conclusion, this additional test provides a little additional evidence of the relation between R&D expenditures and stock returns. But since the relation could not been observed in every year, there are probably other factors influencing the relation of R&D expenses and stock returns. These can be for example economical or industry related factors.

6. CONCLUSION

This study examines the role of firm's research and development (R&D) investments in explaining firm performance. This study also discusses the R&D activity as a part of the firm itself and its environment. Three main hypotheses were developed to test the impact of firm's R&D expenditures on firm growth, profitability and stock prices. In addition, the impact of R&D expenditures on growth, profitability and stock returns was examined together with few other explanatory variables. This was carried out to see if the R&D expenses with other independent variables explained more about firm growth, profitability and stock price than R&D expenses alone and whether the other explanatory variables have effect on the examined relations. The empirical analyses were carried out by using cross-sectional data.

The empirical findings of this study, regarding the relation of R&D expenses and growth, suggest a positive and significant relation between these measures. Thereby, the results are supportive of some of the previous empirical findings. It has been argued that the effects of R&D investments take several years to materialize and, the research results of this study are supportive of this insight since the five-year cumulative R&D intensities explained most of the sales growth of firms. Also the significance of R&D investments in explaining sales growth grew, when the time distance between the made investments and the point, when the sales growth was measured, increased. The both used R&D intensity measures were helpful in explaining the sales growth of firm, but on average R&D expenditures relative total assets explained more about sales growth.

R&D expenditures were found also to have a positive and significant effect on firm profitability, measured by profit margin. In general, the results are in line with previous studies showing the impact of R&D on profitability. However, the used profitability measures have been different in the studies, so direct comparison between the studies is not possible. Three-year-lagged one-year R&D intensities were found to have highest effect on profit margin according to both R&D intensity measures used. However, the difference to the other used intensities (especially one-year and three-year cumulative R&D intensities with one-year time lag) was not considerably large. Both used R&D intensities explained profit margin, but the impact of R&D expenses relative to sales was more significant.

The third analysis examined the influence of R&D on stock returns. The findings of the primary analysis indicated that R&D expenses are negatively, but not significantly related to stock returns. Thereby, the results are not supportive of a great majority of research results that suggested significant positive relation between these measures. However, some previous studies have only found a weak relation between R&D spending and stock returns. Market value of equity, book-to-market value of equity and market beta was also found to be insignificant in explaining stock returns. Because of these insignificant research results, an additional analysis was done. The impact of R&D expenses on stock returns was examined for the time period of 1999-2005. In this time period the effect of R&D intensities was observable in the stock returns of years 2002 and 2003. Therefore, the additional test provided a little evidence of a relation between R&D expenditures and stock returns.

Some suggestions and possibilities for further research rise while processing this study. Firstly, the research data could be extended to firms not listed in the Helsinki Stock Exchange. Thereby obtained research data could be more extensive and possibly more firms could be included to some industries. However, this way obtained research data enables only to examine the relations of R&D expenses and firm growth or profitability not R&D expenses and firm market value. Also other kind of firm classifications might be interesting to do, for example divide firms into nonmanufacturing and manufacturing firms. Secondly, it would be interesting to test the impact of R&D expenses on different growth and profitability measures than sales growth and profit margin. In addition, it could also be worthwhile to test the effect of other explanatory variables on the relation of R&D expenditures and firm performance. Also, when it is possible to obtain R&D expenditures for more firms from a longer time period, it would be interesting to see how extensive economic life the R&D expenditures have.

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APPENDICES

Appendix 1. List of the firms included in the initial sample and their industry classification.

Company	Industry
Cencorp Oyj	Electronics & Components
Vacon	Electronics
PKC Group Oyj	Electronics
Efore	Electronics
Incap	Electronics & Components
Okmetic	Electronics & Components
Teleste	Electronics & Components
Kekkilä	Chemicals
Uponor	Chemicals
Kemira	Chemicals
M-real	Diversified Paper
Stora Enso	Diversified Paper
Stromsdal	Diversified Paper
UPM-Kymmene	Diversified Paper
Huhtamäki	Packaging Products
Elektrobit Group	Industrial Machinery
Larox	Industrial Machinery
Kyro	Machinery & Equipment
KCI Konecranes	Industrial Machinery
KONE	Miscellaneous Construction
Rautaruukki	Metal Products
Outokumpu	Metal Products
Nordic Aluminium	Metal Products
Ponsse	Acricultural Machinery
Raute	Industrial Machinery
Rocla	Industrial Machinery
Metso	Machinery & Equipment
Wärtsilä	Engines
Kesla Oyj	Machinery & Equipment
Elecster Oyj	Machinery & Equipment
Lassila & Tikanoja	Miscellaneous Utilities
Panostaja Oyj	Miscellaneous Companies
Fortum	Miscellaneous Oil, Gas & Coal
Atria	Food
HK Ruokatalo	Food
Lännen Tehtaat	Food
Raisio	Food
Biohit Oyj	Medical, Surgical & Dental Supplier
Biotie Therapies	Medical Services
Orion	Drugs
Comptel Oyj	Systems & Subsystems
SSH Communic.	Systems & Subsystems
Stonesoft Oyj	Systems &

	Subsystems
Endero	Systems & Subsystems
Proha	Service Organizations
Sentera	Systems & Subsystems
Basware	Systems & Subsystems
Nokia	Diversified Electronics
Benefon	Miscellaneous Electronics
Vaisala	Instruments, Gauges, etc.
Tecnomen	Systems & Subsystems
Tekla	Systems & Subsystems
F-secure	Systems & Subsystems
Elisa	Telecommunications
TeliaSonera	Telecommunications
Tulikivi	Brick, Clay & Refractory Products
Honkarakenne	Log Houses
Nokian renkaat	Rubber & Tires
Tamfelt	Textiles
Amer Sports	Sporting Goods
Fiskars	Diversified Metal Products
Martela	Furnishings
Rapala VMC Oyj	Sporting Goods
SanomaWSOY	Printing & Publishing
Exel Oyj	Sporting Goods

Appendix 2. Summary of the variables included in the analyses.

This table presents all the variables that are used to examine the impact of R&D expenditures on firm growth and profitability. Table presents the variables, their notation, formula and, how the variables have been estimated.

Variables	Notation	Formula	Proxied by
Sales Growth	$SG_{i,t}$	$\frac{(S_{i,t} - S_{i,t-1})}{S_{i,t-1}}$	Sales growth is the sales of firm *i* at year *t* minus sales in the previous year *t*-1 divided by the sales of year *t*-1.
Profit Margin	$PM_{i,t}$	$\frac{EBIT_{i,t}}{SALES_{i,t}}$	Profit margin is the *EBIT* divided by the sales of firm *i* at year *t*.
R&D Intensity	$RD_{i,t}$, $3CRD_{i,t}$ or $5CRD_{i,t}$	$\frac{RDE_{i,t}}{SALES_{i,t}}$, or $\frac{RDE_{i,t}}{TASSETS_{i,t}}$, see also equations 2 and 3.	R&D intensity is the natural logarithm of the ratio of R&D expenditures relative to sales or total assets of firm *i* at year end *t*.
Labor Productivity	$LABP_{i,t}$	$\frac{EBIT_{i,t}}{EMPS_{i,t}}$	Labor productivity is the *EBIT* divided by the number of employees of firm *i* at year end *t*.
Debt Ratio	$DEBR_{i,t}$	$\frac{LTDEBT_{i,t}}{(LTDEBT_{i,t} + EQY_{i,t})}$	Debt ratio is the ratio of long-term debt divided by the sum of long-term debt and equity of firm *i* at year *t*.
Industry Dummy	$ID_{i,t}$		Industries to be considered: electronics/electrics (ID_1), mechanical/metal product (ID_2), technological (ID_3) and, consumer products/services (ID_4).

This table presents all the variables to be used to examine the impact of R&D expenditures on stock returns. Table presents the variables, their notation, formula and how the variables have been estimated.

Variables	Notation	Formula	Proxied by
Stock Returns	$R_{i,t}$	$\ln\left(\frac{P_{i,t}+D_{i,t}}{P_{i,t-1}}\right)$	The annual stock return is the natural logarithm of stock price added by dividends of firm *i* at year *t* and divided by price at previous year *t*-1.
Firm Size	$ME_{i,t}$	$\ln(ME)_{i,t}$	Natural logarithm of the market capitalization of firm *i* at end of year *t*.
R&D Intensity	$RD_{i,t}$, $3CRD_{i,t}$	$\frac{RDE_{i,t}}{TASSETS_{i,t}}$, see also equation 2.	R&D intensity is the natural logarithm of R&D expenditures divided by total assets of firm *i* at year end *t*.
Book-to-Market Value of Equity	$BMV_{i,t}$	$\ln\left(\frac{BE}{ME}+1\right)_{i,t}$	$BMV_{i,t}$ is the natural logarithm of book-to-market value of equity of firm *i* at year *t*. $BE_{i,t}$ is the book value of equity and $ME_{i,t}$ is the market capitalization of firm *i* at year *t*.
Risk	$\beta_{i,t}$	$\beta_{i,t}$	$\beta_{i,t}$ is CAPM beta of firm *i,* estimated by using 36 monthly stock returns up to the calculation of annual stock return of firm *i* at year *t*.
Industry Dummy	$ID_{i,t}$		Industries to be considered: electronics end electrics (ID_1), mechanical and metal product (ID_2), technological (ID_3), consumer products/services (ID_4).

Appendix 3. Tables present the results of the multiple regressions, where the industry dummy was also included.

Table presents the results of multiple regressions, where the used dependent variable was sales growth ($SG_{i,t}$)of year 2004. Industry dummies are included in the regressions.

Independent Variables	One-Year R&D Intensities		Three-Year Cumulative R&D Intensities		Five-Year Cumulative R&D Intensities	
	R1	**R2**	**R3**	**R4**	**R5**	**R6**
(Constant)	-5.289 (-2.535)	-5.406 (-2.538)	-4.515 (-2.116)	-4.091 (-1.872)	-4.741 (-2.211)	-3.743 (-1.846)
$RD/S_{i,t\text{-}1}$	0.407 (1.975)					
$RD/A_{i,t\text{-}1}$		0.356 (1.820)				
$3CRD/S_{i,t\text{-}1}$			0.513* (2.367)			
$3CRD/A_{i,t\text{-}1}$				0.516* (2.513)		
$5CRD/S_{i,t\text{-}1}$					0.621* (2.691)	
$5CRD/A_{i,t\text{-}1}$						0.718** (3.526)
$LABP_{i,t\text{-}1}$	-0.152 (-1.188)	-0.114 (-0.880)	-0.148 (-1.179)	-0.100 (-0.796)	-0.172 (-1.385)	-0.121 (-1.006)
$DEBR_{i,t\text{-}1}$	0.277 (1.746)	0.279 (1.731)	0.314 (1.976)	0.318* (2.017)	0.470** (2.961)	0.493** (3.319)
ID_1	0.086 (0.524)	0.095 (0.572)	0.031 (0.188)	0.007 (0.043)	0.170 (1.099)	0.116 (0.786)
ID_2	0.131 (0.787)	0.141 (0.844)	0.079 (0.468)	0.064 (0.380)	0.093 (0.572)	0.030 (0.194)
ID_3	-0.016 (-0.068)	0.049 (0.224)	-0.105 (-0.438)	-0.085 (-0.374)	-0.015 (-0.064)	-0.052 (-0.251)
ID_4	0.019 (0.123)	0.025 (0.167)	-0.015 (-0.099)	-0.015 (-0.101)	0.014 (0.093)	-0.002 (-0.012)
R^2	0.180	0.171	0.204	0.214	0.363**	0.422**
Adjusted R^2	0.070	0.060	0.097	0.108	0.262	0.330
F-statistics	1.630	1.535	1.906	2.021	3.584	4.584
N	60	60	60	60	52	52

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$

Table presents the results of multiple regressions, where the used dependent variable was sales growth ($SG_{i,t}$) of year 2004. Industry dummies are included in the regressions.

Independent Variables	One-Year R&D Intensities		Three-Year Cumulative R&D Intensities		One-Year R&D Intensities	
	R7	**R8**	**R9**	**R10**	**R11**	**R12**
(Constant)	-3.479 (-1.526)	-3.401 (-1.482)	-4.115 (-1.857)	-3.918 (-1.890)	-4.708 (-2.194)	-4.963 (-2.450)
$RD/S_{i,t\text{-}3}$	1.117** (2.719)					
$RD/A_{i,t\text{-}3}$		1.026* (2.664)				
$3CRD/S_{i,t\text{-}3}$			1.196** (3.012)			
$3CRD/A_{i,t\text{-}3}$				1.189** (3.338)		
$RD/S_{i,t\text{-}5}$					1.050** (2.752)	
$RD/A_{i,t\text{-}5}$						0.943** (2.779)
$LABP_{i,t\text{-}1}$	-0.113 (-0.771)	-0.055 (-0.376)	-0.114 (-1.024)	-0.113 (-0.839)	-0.160 (-1.118)	-0.147 (-1.048)
$DEBR_{i,t\text{-}1}$	4.164* (2.203)	3.962* (2.133)	6.887** (3.544)	6.806** (3.718)	5.915** (2.964)	5.607** (2.920)
ID_1	0.298 (0.265)	0.247 (0.216)	1.254 (1.138)	1.024 (0.958)	1.448 (1.298)	1.298 (1.148)
ID_2	0.716 (0.849)	0.936 (1.062)	0.334 (0.419)	0.379 (0.470)	0.472 (0.578)	0.635 (0.737)
ID_3	-0.583 (-0.442)	-0.232 (-0.201)	-0.426 (-0.382)	-0.399 (-0.387)	-0.294 (-0.262)	-0.238 (-0.216)
ID_4	0.293 (0.324)	0.374 (0.416)	0.325 (0.400)	0.322 (0.417)	-0.294 (-0.262)	0.531 (0.652)
R^2	0.240*	0.262*	0.341**	0.386**	0.316*	0.346**
Adjusted R^2	0.136	0.157	0.245	0.294	0.212	0.242
F-statistics	2.300	2.490	3.549	4.220	3.034	3.329
N	59	57	56	55	54	52

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$

Table presents the results of multiple regressions, where the dependent variable was profit margin ($PM_{i,t}$) of year 2004. Industry dummies are included in the regressions.

Independent Variables	**One-Year R&D Intensities**		**Three-Year Cumulative R&D Intensities**		**Five-Year Cumulative R&D Intensities**	
	R1	**R2**	**R3**	**R4**	**R5**	**R6**
(Constant)	-1.307 (-0.810)	-2.606 (-1.559)	-1.136 (-0.679)	-2.619 (-1.487)	-1.548 (-0.733)	-3.501 (-1.646)
$RD/S_{i,t-1}$	0.279 (1.455)					
$RD/A_{i,t-1}$		0.047 (0.256)				
$3CRD/S_{i,t-1}$			0.306 (1.492)			
$3CRD/A_{i,t-1}$				0.044 (0.221)		
$5CRD/S_{i,t-1}$					0.298 (1.164)	
$5CRD/A_{i,t-1}$						-0.017 (-0.070)
$LABP_{i,t-1}$	0.166 (1.394)	0.173 (1.411)	0.168 (1.416)	0.172 (1.406)	0.142 (1.034)	0.125 (0.880)
$DEBR_{i,t-1}$	-0.271 (-1.832)	-0.322* (-2.122)	-0.257 (-1.711)	-0.324* (-2.119)	-0.179 (-1.017)	-0.274 (-1.563)
ID_1	-0.069 (-0.455)	0.019 (0.122)	-0.088 (-0.555)	0.019 (0.115)	-0.030 (-0.172)	0.075 (0.428)
ID_2	-0.108 (-0.695)	-0.034 (-0.212)	-0.127 (-0.793)	-0.034 (-0.208)	-0.071 (-0.391)	0.037 (0.198)
ID_3	-0.021 (-0.096)	0.153 (0.734)	-0.047 (-0.206)	0.153 (0.690)	-0.009 (-0.034)	0.220 (0.892)
ID_4	0.068 (0.484)	0.095 (0.665)	0.052 (0.368)	0.093 (0.646)	0.084 (0.520)	0.130 (0.796)
R^2	0.289	0.261	0.290	0.260	0.216	0.192
Adjusted R^2	0.193	0.161	0.194	0.161	0.091	0.063
F-statistics	3.014*	2.618*	3.035**	2.615*	1.728	1.490
N	60	60	60	60	52	52

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table presents the results of multiple regressions, where the dependent variable was profit margin ($PM_{i,t}$) of year 2004. Industry dummies are included in the regressions.

Independent Variables	One-Year R&D Intensities		Three-Year Cumulative R&D Intensities		One-Year R&D Intensities	
	R7	R8	R9	R10	R11	R12
(Constant)	-0.715 (-0.383)	-2.272 (-1.151)	-2.106 (-1.046)	-3.757 (-1.893)	-2.451 (-1.273)	-3.902 (-2.065)
$RD/S_{i,t\text{-}3}$	0.533 (1.546)					
$RD/A_{i,t\text{-}3}$		0.147 (0.436)				
$3CRD/S_{i,t\text{-}3}$			0.285 (0.768)			
$3CRD/A_{i,t\text{-}3}$				-0.099 (-0.285)		
$RD/S_{i,t\text{-}5}$					0.207 (0.592)	
$RD/A_{i,t\text{-}5}$						-0.142 (-0.442)
$LABP_{i,t\text{-}1}$	0.175 (1.499)	0.180 (1.458)	0.153 (1.237)	0.140 (1.106)	0.151 (1.195)	0.147 (1.131)
$DEBR_{i,t\text{-}1}$	-2.685 (-1.803)	-3.224* (-2.079)	-1.998 (-1.174)	-2.761 (-1.617)	-2.288 (-1.309)	-2.945 (-1.667)
ID_1	-0.459 (-0.492)	0.117 (0.117)	0.027 (0.027)	0.584 (0.561)	0.179 (0.176)	0.724 (0.672)
ID_2	-0.418 (-0.593)	-0.099 (-0.127)	-0.120 (-0.162)	0.267 (0.336)	0.001 (0.001)	0.393 (0.474)
ID_3	-0.269 (-0.259)	0.604 (0.584)	0.226 (0.213)	1.010 (0.981)	0.429 (0.407)	1.155 (1.075)
ID_4	0.412 (0.564)	0.596 (0.774)	0.456 (0.624)	0.643 (0.873)	0.569 (0.773)	0.705 (0.920)
R^2	0.307**	0.276*	0.204	0.195	0.204	0.199
Adjusted R^2	0.210	0.171	0.085	0.073	0.080	0.069
F-statistics	3.171	2.615	1.721	1.597	1.650	1.528
N	58	56	55	54	53	51

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$

Appendix 4. The descriptive statistics of the variables of the additional test.

Table presents the descriptive statistics for the variables of the additional test, which were used to analyze the influence of R&D expenses on stock returns. $R_{i,t}$ is the annual stock return from year 2002 to 2005. $RD/A_{i,t\text{-}3}$ is the three-year-lagged one-year R&D intensity measured from year 1999 to 2002 and $3CRD/A_{i,t\text{-}1}$ are logarithmic three-year cumulative R&D intensities from year 1999 to 2004.

Variables	N	Minimum	Maximum	Mean	Standard Deviation
$R_{i,t}$	255	-2.140	2.553	0.014	0.467
$3CRD/A_{i,t\text{-}1}$	249	-6.423	0.107	-3.410	1.294
$RD/A_{i,t\text{-}3}$	241	-6.849	0.466	-3.397	1.282

Table presents the values of skewness, kurtosis and results of the Kolmogorov-Smirnov normality test for each variable of the additional test.

Variable	N	Skewness	Kurtosis	Kolmogorov-Smirnov
$R_{i,t}$	255	-0.430	5.260	0.200*
$3CRD/A_{i,t\text{-}1}$	249	-0.084	-0.414	0.200*
$RD/A_{i,t\text{-}3}$	241	-0.112	-0.415	0.200*