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INNOVATION AND FIRM PERFORMANCE

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Abstract:

Innovation is considered the main contributor to economic development in advanced economies, as well as being a key factor in the social and cultural evolution. Besides, increasing levels of competition and decreasing product life cycles involve that innovations may be more important than ever in allowing firms to improve profitability and maintain competitive advantage. However, because of the difficulties in measuring both innovation and firm performance, previous literature highlights mixed trends. This work empirically analyses the effect of innovation efforts on firm performance, using panel data models from 498 Nordic firms over the period 2008-2016. Because firm performance is a multidimensional construct, the relationship is analysed by using the ROA, ROE, labour productivity, capital productivity, debt to equity ratio and working capital over total assets as dependent variables. Results suggest that profitability is the most influenced by innovation, while other measures present differences between firm sectors and size.

Key Words: Research & development, innovation, firm performance, panel data model, dummy variable.

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1 INTRODUCTION

Today, innovation is considered the main contributor to economic development in advanced economies, as well as being a key factor in the social and cultural evolution. As a result, the rise of firms operating under the conviction that innovation is the key competitive driver has been observed. The Oslo Manual (2005) states that measures of the impact of innovation on enterprise perfromance are among the most important innovation indicators, but they are also among the most difficult to obatian. However, as stated by Kendall *et al.* (2010), because of increasing levels of competition and decreasing product life cycles, a firm's ability to generate a continuous steam of innovations may be more important than ever in allowing a firm to improve profitability and maintain competitive advantage.

As mentioned by Geoffrey (2015), in principle, innovation may lead to the creation of products or services that might improve revenues, or it may turn to be a process that would diminish operating expenses. However, the author states that even though this relationship has been widely studied in the financial literature, results highlight mixed trends. This way, scholars' stress both positive and negative linkage between R&D intensity and profitability indicators (Geoffrey, 2015). On the other hand, the literature includes extensive studies that document a positive linkage between R&D spending and revenue growth (Geoffrey, 2015). Besides, Mohnen and Hall (2013) conclude that innovation leads to a better productivity performance. In any case, the evaluation of innovation on firm performance must bear in mind that performance is a multidimensional construct (Murphy *et al.*, 1996).

This work aims to contribute to the analysis of the way innovation practices affect firm performance. As a final degree project and having taken part in a six months internship in an innovation management consultancy firm, the application of econometrical tools learnt through the years of study have been applied to proving the conviction under which this firm operates: Is innovation the key competitive driver for firms in today's society?

For that purpose, this work describes first the innovation context at both the macro and the firm level. Then, previous results on the linkage between innovation and firm performance are reviewed. Finally, this work contributes to the evaluation of this relationship by considering several performance measures – return on assets, return on equity, labor productivity, capital productivity, debt to equity ratio and working capital over total assets – due to the complexity involved in the measurement of this dimension. Thus, a broader picture of this effect is obtained. Moreover, differences between both firm size and sector

are analyzed. This way, the obtained results are decomposed aiming to show if mitigations on the mean effect belong to positive and negative effects between different types of firms. Hence, panel data models for 498 Nordic firms over the period 2008-2016 are estimated.

The results show that increases in innovation efforts by Nordic firms over the period 2008-2016 help them raising their economic and financial profitability. However, only significant differences for small firms' financial profitability one year after innovation efforts are increased are observed. Regarding capital productivity differences between firms are observed, helping to explain why the overall effect is not significant in the first year. As for the ability to increase future investment capacity, medium size and the wholesale and trade sector firms present the highest positive results in both years, whereas large firms and the manufacture sector show the negative and significant differences.

This work is structured in eight different sections. This first part introduces the topic that is examined in depth in the following sections. Section II explains the motivation for the analysis of the effect of innovation on firm performance, as having taken part in a six-moth internship in an innovation management consultancy firm. Section III provides the context of innovation, starting from some general definitions and putting it into place in a macro and firm context later on. Section IV reviews the literature that has been developed previously in relation to innovation and firm performance. Then, since this work focuses on an empirical analysis, section V mentions the data sources used, while section VI explains the theoretical models evaluated for the analysis of innovation efforts on firm performance at the general level and differentiating the effects by firm size and sectors. Section VI comments the results obtained, and the last section offers the concluding remarks of the study.

2 ZABALA INNOVATION CONSULTING, S.A.

Zabala Innovation Consulting, S.A. is an international consultancy headquartered in Pamplona since in 1986. Jose Mari Zabala, a chemical engineer phD in Applied Natural Sciences, founded the firm to help its clients improve their competitiveness through the management of R+D+I related problems. In order to do so, the firm bases its activities on obtaining both financial (grants and loans) and fiscal (tax reliefs) aid from Regional, National and European institutions. It works with innovative projects related to all of the following areas (Zabala, 2018): Life Sciences (Health, Biotechnology, Chemistry and processes food), Digital Transformation (TIC, Open Data, Security, Internet, 4.0 Industry), Social Challenges

(Smart Cities, Transport, Environment, Materials and Energy) and Industrial Area (materials, processes, and products).

The company's mission is to become innovation the key competitive factor of organizations. This way, it aims to improve the quality of life, sustainability, progress, employment and wealth of societies helping companies, public administrations, technology centres and universities to develop both new products and innovative processes and services that allow organizations grow and be more competitive at the National and International level. Its vision is to become the leader in R+D+I project presentation, approval and management, as well as being a referent in innovation related issues in national and international environments (Zabala, 2015).

At present, the firm is composed by more than 200 professionals, 11 head offices and around 1,500 clients. Its head offices are located in Spain (Pamplona, Madrid, Barcelona, Seville, Valencia, Vigo, Bilbao and Zaragoza), France (Paris), Colombia (Bogotá), Belgium (Brussels) and Great Britain (London). However, it collaborates with partners all around the world: México, Turkey, Check Republic, Poland, Rumania, Portugal, India, Argentina, Bolivia, Brazil, Canada, Chile, China, United States, Israel, Austria, Germany, Peru, Bulgaria, Holland, Italy.

The firm operates under the conviction that innovation is the key competitive driver in today's society. Public Administrations offer opportunities to those firms that make investments to improve their competitiveness by adding competitive progress in their processes and products. In this framework, the consultancy firm deals as an intermediate agent between public administrations, technological centres and corporations helping them to carry out innovative projects. Due to that reason, the six months internship performed in Zabala Innovation Consulting, S.A. has motivated a deeper study of the importance of innovation.

3 R+D+I CONTEXT:

This section provides the framework to better understand innovation in the recent context. Statistics Institutes, such as the regional statistics institute of Navarre, claim that nowadays, the process of innovation is the main contributor to economic development in advanced economies, as well as being a key factor in the social and cultural evolution (Navarra, 2016). Hence, this work considers it a relevant reason to study the issue in depth. Prior to analyze

the effect that R+D+I practices involve, though, it is important to clearly state what these concepts refer to.

With that purpose, the Frascati Manual (2015) is mentioned. As explained its last version (OECD, 2015), in June 1963, the OECD met with national experts on research and experimental development (R&D) statistics at the Villa Falconeri in Frascati, Italy. The result was the first official version of the Proposed Standard Practice for Surveys of Research and Development, which has come to be better known as the Frascati Manual. Although the manual is basically a technical document, it is a cornerstone of OECD efforts to increase the understanding of the role played by science, technology and innovation when analyzing national systems of research and innovation. Furthermore, by providing internationally accepted definitions of R&D and classifications of its component activities, the manual contributes to intergovernmental discussions on good practices for science and technology policies (OECD, 2015).

Frascati's manual defines the three activities covered by the term R&D (OECD, 2015): basic research, applied research and experimental development. Basic research is referred to experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view. Applied research is original investigation undertaken in order to acquire new knowledge. It is, however, directed primarily towards a specific, practical aim or objective. Experimental development is systematic work, drawing on knowledge gained from research and practical experience and producing additional knowledge, which is directed to producing new products or processes or to improving existing products or processes. This manual follows the SNA convention in which "product" refers to a good or a service. Further, throughout the manual, "process" refers to the transformation of inputs to outputs and to their delivery or to organizational structures or practices.

Additionally to that, there are other series of methodological manuals, which include guidance document on the measurement of innovation (OECD, 2015). Among them, it is worth it mentioning the Oslo Manual 2005. As stated in its last version (OECD, 2005), a considerable body of work was undertaken during the 1980s and 1990s to develop models and analytical frameworks for the study of innovation. Experimentation with early surveys and their results, along with the need for a coherent set of concepts and tools led to the first edition of the Oslo Manual in 1992, which focused on technological product and process (TPP) innovation in manufacturing. This became the reference for various large-scale surveys

examining the nature and impacts of innovation in the business sector, such as the European Community Innovation Survey (CIS), currently in its fourth round. Results from such surveys have driven further refinements in the Oslo Manual framework in terms of concepts, definitions and methodology leading to a second edition published in 1997 which, among other things, expanded coverage to service sectors.

Since then, the analysis of results from surveys and changing policy needs led to the launching of another revision of the manual, which could be found in the third edition (2005). As there had been a growing sense that much of innovation in service sectors was not adequately captured by the TPP concept, it was decided to address the question of non-technological innovation in such revision. As a result, the scope of what is considered an innovation has been expanded to include two new types: marketing and organizational innovation (OECD, 2005).

Today, the Oslo manual (2005), developed jointly by Eurostat and the OECD, defines innovation as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations. This broad definition of an innovation encompasses a wide range of possible innovations. An innovation can be more narrowly categorized as the implementation of one or more types of innovations, for instance product and process innovations. This narrower definition of product and process innovations can be related to the definition of technological product and process innovation used in the second edition of the Oslo Manual.

In line with that, the Oslo Manual (2005) states that innovation activities are all scientific, technological, organizational, financial and commercial steps which actually, or are intended to, lead to the implementation of innovations. Some innovation activities are themselves innovative, others are not novel activities but are necessary for the implementation of innovations. Innovation activities also include R&D that is not directly related to the development of a specific innovation. With this consideration in mind, it is mentioned that innovation activities vary greatly in their nature from firm to firm. Some firms engage in well-defined innovation projects, such as the development and introduction of a new product, whereas others primarily make continuous improvements to their products, processes and operations. Both types of firms can be innovative: an innovation can consist of the implementation of a single significant change, or of a series of smaller incremental changes that together constitute a significant change.

Thus, an innovative firm is one that has implemented an innovation during the period under review. A narrower definition is provided as well. Here, a product/ process innovative firm is one that has implemented a new or significantly improved product or process during the period under review. This definition, which includes all firms that have implemented a product or process innovation, is similar to the definition of the TPP innovative firm in the previous edition of the Manual (OECD, 2005).

The Oslo Manual (2005) also provides definitions for the different types of innovations. A product innovation is the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics. A process innovation is the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software. A marketing innovation is the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing. An organizational innovation is the implementation of a new organizational method in the firm's business practices, workplace organization or external relations.

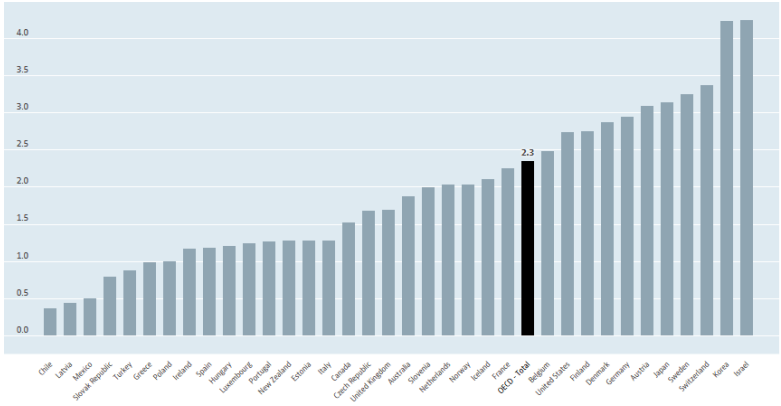
According to the Oslo Manual (2005), there are three key agents of innovation: Public Administrations, Firms, and technological centers and universities. Public Administrations are in charge of developing the appropriate incentives to support innovation, as well as regulating it. Technological centers offer technological support adjusted to firms' necessities. Firms create such innovation by new products, processes or management models. Firms need to bear in mind that all the commercial, technical, financial and human factor need to be properly developed for the success of any innovative project.

3.1 R+D+I at the Macro Level:

With the purpose of evaluating how innovative nations and regions are, the R+D expenditure as a % GDP serves as a measure of the innovation intensity. This data is provided by the (OECD, 2018), and it is represented in figure 1. As for OECD countries, it is observed that these are the countries with the highest share of R+D expenditure over the GDP in 2016 (latest available data): Israel (4.3% GDP), Korea (4.2% GDP), Switzerland (3.4% GDP), Sweden (3.3% GDP), Japan (3.1% GDP), Austria (3.1% GDP), Germany (2.9% GPD), Denmark (2.9% GDP), Finland (2.7% GDP), United States (2.7% GDP),

Belgium (2.5% GDP), France (2.2% GDP), Iceland (2.1% GDP), and Norway (2.1% GDP). The countries with the least expenditure in R+D are: Chile (0.4% GDP), Latvia (0.4% GDP), Mexico (0.5% GDP), Slovak Republic (0.8% GDP), Turkey (0.9% GDP), Greece (1% GDP), Poland (1% GDP), Ireland (1.2% GDP) and Spain (1.2% GDP).

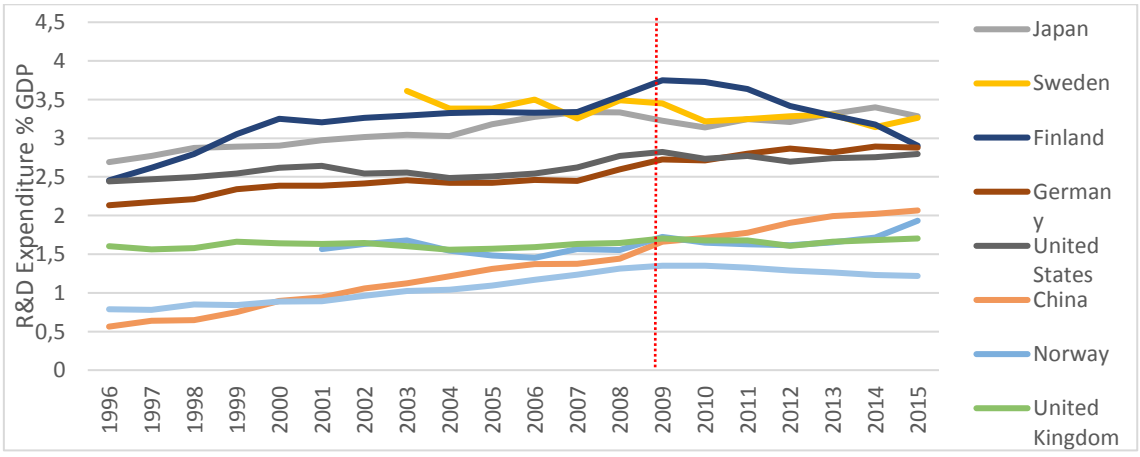
Figure 1: *Research and Development Expenditure (% GDP) in OECD Countries (2016).*



Source: OECD, 2018

Figure 2 presents the evolution of R&D in selected countries during 1996-2015 (OECD, 2018). It is observed that, in general, all countries have increased their R&D expenditure intensity (with an exception of Sweden, which has a negative variation in R&D expenditure as a percentage of GDP). China, on the other hand, is the country with the highest growth in R&D expenditure %GDP, being this 2.67 times higher in 2015 when compared to 1996 data. In any case, Japan, Sweden, Finland, Germany and the United States appear to be the countries with the highest R&D expenses, whereas Spain, United Kingdom, Norway and China lie behind.

Figure 2: *Evolution of Research and Development Expenditure (% GDP) in Selected Countries*



Source: Own Elaboration. Data from OECD, 2018

The interest of analyzing these data is to observe whether R+D expenditure affects economic performance in the global context. In this line, there exist several studies that have provided interesting findings. Dorronsoro (2015) showed how different measures of innovation affect economic outcomes in Europe. In particular, he analyses the correlation between innovation and unemployment. Innovation is calculated by the innovation union scoreboard (2015), and it is represented in the horizontal axes. Unemployment rate for the first quarter of 2015 is obtained from Eurostat (2015). It happens that more innovation, which is measured by the Innovation Union Scores, imply less unemployment. Figure 1 in the appendix. The analysis is also elaborated for the case of Spanish regions as it is presented in figure 2 in the appendix. The vertical axes shows the unemployment rate for the last quarter in 2017 for the different regions (INE, 2017), whereas in the horizontal axes the R&D expenditure over the GDP is represented (INE, 2016). It is also observed that higher R&D expenditure involves decreases in the rate of unemployment.

3.2 R+D+I at the Firm Level:

Regarding the firm context, the Global Innovation 1000 study (Strategy&, 2017) analyses spending at the world's 1000 largest publicly listed corporate R&D spenders. It provides data on R+D expenditures, Revenue, R+D intensity (R+D expenditure as a % Revenue) from 2011-2017. As presented in table 1 in the appendix, the firm with the largest Research and Development expenses in 2017 was "Amazon.com, Inc", which corresponded to the retailing industry group. It was followed by "Alphabet Inc." (software and services industry), "Inter Corporation" (semiconductors and semiconductor equipment industry), "Volkswagen Aktiengesellschaft" (automobiles and components), "Microsoft Corporation" (software and services), "Roche Holding AG" (pharmaceuticals, biotechnology and life sciences), "Merck & Co., Inc." (pharmaceutical, biotechnology and life sciences), "Apple Inc." (information technology), and "Novartis AG" (healthcare), among the top 10 innovative companies.

As explained in the above-mentioned study, this ranking helps to explain how innovative practices are changing. Some years ago, automobile and pharmaceutical sectors were the sectors with the highest R+D expenditure levels. In recent years, though, ICT sectors (Amazon, Google, Microsoft, Intel…) appear to be at the top of the list.

4 LITERATURE REVIEW:

This work aims to analyse how innovation related practices affect firm performance. As mentioned by Kendall *et al.* (2010), because of increasing levels of competition and decreasing product life cycles, a firm's ability to generate a continuous steam of innovations may be more important than ever in allowing a firm to improve profitability and maintain competitive advantage. Because of that reason, the investigation of the impact that R&D investments have on corporate performance has been a topic of great interest for both the academic arena and the business environment, especially over the past three decades (Geoffrey, 2015). As mentioned by Geoffrey (2015), in principle, innovation may lead to the creation of products or services that might improve revenues, or it may turn to be a process that would diminish operating expenses.

However, the author states that even though this relationship has been widely studied in the financial literature, results highlight mixed trends. In fact, the Oslo Manual (OECD, 2005) notes that measures of the impact of innovation on enterprise *perfromance* are among the most important innovation indicators, but they are also among the most difficult to obatian". Therefore, this section reviews previous evaluations on a growing body of literature on the analysis of the impact of innovation on firm performance.

Note, that performance is a multidimensional construct (Murphy *et al.*, 1996). As mentioned by Chakravarthy (1986), many authors indicate that company performance is a complex phenomenon requiring more than a single criterion to characterize it. In fact, the literature recognizes that performance is a construct that covers diverse intentions and levels inside the organization. Therefore, evaluating serveral measures is recognized as a more complete way to capture the effect of Research and Development expense on corporate performance.

To mention some of them, the afforementioned authors note that profitability is a common indicator of performance, and return on assets (ROA) and return on equity (ROE) are two common indicators measuring this dimension. In fact, the foremost approximates to the economic profitability of a company, whereas the second ratio explains the financial profitability. Chakravarthy (1986) also explain that productivity is another important way to weight up the capacity of the company and relates to company efficiency. For that purpose, labour and capital productivity are often evaluated. To follow with, the ability to raise long-term capital resources is measured by the debt to equity ratio (DOE) accoring the author,

and the firm's investment in its future can be evaluated by the working capital to total assets ratio.

The way to obtain related information to the above dimensions is often from financial statements. However, the usefulness attached to the accounting information about a company's R&D investments is generally limited (Geoffrey, 2015). Apart from that, a more important aspect is related to the accounting treatment of R&D spending, as some states are legally required to completely expense the cost in the year incurred (Dugqui *et al.*, 2011). Other countries are allowed to capitalize these expenses only under very specific conditions (Geoffrey, 2015). The accounting treatment of R&D undertaking has direct effects on a company financial performance (Geoffrey, 2015). As noted by the author, if the R&D cost materializes within the incurrence period, it will diminish the net income and the profitability indicators (ROA and ROE) for the given period. In the case of the diference of R&D costs to future periods as intangible assets, they would not harm the current period net income and return on equity, but might put pressure on ROA (Das *et al.*, 2009), given that total assets will be enhanced by capitalization of the R&D spending as an intangible asset (Geoffrey, 2015).

Even if the accounting treatment of Research and Development is the same, however, additional considerations must be considered. Empirical studies use two general approaches to measure innovation. As mentioned by Waqar and Azam (2018), the first approach uses patents as a proxy for innovation output where a patent is defined as a formal means of protecting intellectual property rights associated with invention. However, the authors claim that the problem associatied to this approach is that not all innovations are pateneted and firms, depending on their type of business and innovations, have different propensities to patent. Therefore, they mention an alternative approach as a proxy for innovation: R&D expenditure. The main problem attached is that R&D is the measurement of input into the innovation process rather than the output (Waqar and Azam, 2018). However, the majority of the empirical studies (Crépon *et al.*, 1998; Mohnen and Dagenais, 2002; Lööf and Heshmati, 2002; Janz *et al.*, 2004; Criscuolo, 2009; Hashi and Stojcic, 2013) have found a positive impact of innovation effort on innovation output. However, these authors warn that innovation outputs show mixed results depending firm size, country and sectors.

In any case, scholars' stress both positive and negative linkage between R&D intensity and profitability indicators (Geoffrey, 2015). Chen *et al.* (2005) suggested a positive relationship among R&D intensity and ROE and ROA, which highlights its importance for the

organization future profitability and revenue increase. Lau (1998) argued that the difference in ROA among that the difference in ROA among high and low R&D intensity business is marginally significant, although not as powerful as revenue growth. From the opposite perspective, Kotabe *et al.* (2002) documented a non-significant negative connection between ROA and R&D intensity. Quo *et al.* (2004) highlighted that R&D intensity adversely influences the business profitability. According to Sougiannis (1994), the reported earnings after adjustments are beneficial for the R&D efforts. Similarly, Lev and Sougiannis (1996) highlighted a positive correlation between operating income and current and lagged R&D figures. Additionally, the findings revealed that the impact of R&D on current operating results varies depending on the industry sector. However, some studies showed that different profitability levels among companies in a specific industry are not the necessaritly the effects of R&D investments and advertising (Megna and Mueller, 1991).

An array of circumstances explains the direct impact of R&D undertaking on a company's profitability level (Geoffrey, 2015). The implications may arise from the accounting alternatives to capitalize or expense the R&D efforts; a business strategy to increase or gain market share or income; the number of R&D activities that lead to the issuance of patents, or the speed or skills to market the innovations into the offerings that capture consumer needs and preferences (Das *et al.*, 2009).

Extensive analyses in economics, finance and accounting describe how stakeholders consider R&D undertakings as investements that are predicted to return future monetary benefits (Geoffrey, 2015). The literature includes extensive studies that document a positive linkage between R&D spending and revenue growth (Geoffrey, 2015). The work of Dave *et al.* (2013) highlighted that financial sustainability is powerfully influenced by gross margines, which in turn are strongly dependent on R&D intensity. They explained that there is a powerful connection between the gross margins and the financial sustainability, calibrated by the return on assets (ROA). However, they stated that the implications of the time lag between the moment of the R&D spending incurrence and the point at which it improves the financial sustainability varies from business to business, making the exploration of the impact of the R&D efforts on financial stability a difficult process. As suggested by the findings of Rivette and Kline (2000), IP investments allow firms to improve their potential future earnings and in line with other structural capital, enhance the achievement of essential strategic and financial performance (Edvisson and Malone, 1997). A study performed by Bublitz and Ettredge (1989) concluded that on average, R&D has a significant influence in the long-run.

On the other hand, Mohnen and Hall (2013) state that innovation per se does not increase the amount of productive resources, so it affects company growth mainly through total factor productivity. As mentioned by the authors, with multiple factors of production, more could be produced by putting more units of each factor to work or by increasing the amount produced with the same amount of inputs. In their analysis, they conclude that innovation leads to a better productivity performance, or to be more precise to a better revenue per employee performance. They explain that some of the effect of innovation goes to real output, and some of it to the price at which the output is sold.

A great deal of reasons help to explain how innovation affects either positively or negatively firm performance. Some of the motives for product innovations, and marketing innovation in some cases, are mentioned in the Oslo Manual (2005), which are shown in figure 3 in the appendix: short product life spans that necessitate the development of new products (replacement of products being phased out, developing environmental-friendly products); the need to diversify product portfolios (increasing the range of goods and services); or efforts to increase or avoid a decline in market share (enter new markets, increase visibility or exposure for products, reduced time to respond to customer needs). In addition, a number of factors aim to identify the main motives for changes in production and delivery, i.e. whether their main intent is to improve quality, flexibility or efficiency/ cost reduction (reduce unit labour costs, consumption of materials and energy, production lead times, operating costs for service provision, improve IT capabilities, increase efficiency or speed of supplying and delivering goods or services). In particular, factors relating to cost reduction are made specific to enable better interpretation of results. Factors concerning workplace organisation identify the main forces behind organisational change: whether they are oriented towards customer relations (increase the ability to adapt to different client demands, develop stronger relationships with customers), operational efficiency (improve communication and interaction among different business activities, improve working conditions) or improving the capture and sharing knowledge (increase sharing or transferring of knowledge with other organisations). Additionally to that, there are other reasons why firms my carry out innovative activities: reducing environmental impacts or improving health and safety, meeting regulatory requirements, and so on.

Nevertheless, the Oslo Manual (2005) also warns that innovation activity may be hampered by a number of factors. There may be reasons for not starting innovation activities at all, or factors that slow innovation activity or have a negative effect on expected results. These

include economic factors, such as high costs or lack of demand, enterprise factors, as a lack of skilled personnel or knowledge, and legal factors, such as regulations or tax rules. Figure 4 in the appendix gives detailed reasons which explain these possible negative results. First, cost factors include: excessive perceived risks, too high costs, lack of funds within the enterprise, lack of finance from sources outside the enterprise (venture capital and public sources of funding). Possible knowledge related factors are: insufficient innovation potential (R&D, design, etc.), lack of qualified personnel within the enterprise or in the labour market, lack of information on technology or markets, deficiencies in the availability of external services, difficulties in finding co-operation partners, organisational rigidities within the enterprise (attitude of personal and managers towards change, managerial structure of the firm), inability to devote staff to innovation activity due to production requirements. Then, market factors involve: uncertain demand for innovative goods or services, and potential market dominated by established enterprises. Institutional factors are referred to: lack of infrastructure, weakness of property rights, and legislation, regulation, standards and taxation. Finally, other reasons leading firms not to innovate are the lack of necessity to innovate due to earlier innovations, and because of lack of demand for them.

5 DATA SOURCES

The aim of this work is to study the effect of innovation on firm performance. For that purpose, a sample of 498 firms in Nordic countries over the period 2008-2016 is taken. In fact, two analyses are considered: First, the overall effect of innovation on firm performance is studied. Second, the same analysis is performed, but differences by firm size (European Commission criteria, 2005) and by sectors (NACE Rev. 2 industry classification, 2017) are evaluated aiming to obtain a more detailed view of such relationship.

The estimation uses data provided by AMADEUS from Bureau Van Dikj. As noted by the Moody's Analytics Company (2018), AMADEUS is a database containing comprehensive information (company financial statements in a standard format; financial strength indicators; directors; images of report and accounts for listed companies; stock prices for listed companies; detailed corporate structures; market research; business and company-related news; M&A deals and rumours; maps etc.) on around 21 million companies across Europe.

The information for the empirical analysis carried out in this work has been downloaded for the period 2008-2016 for Nordic Countries (Sweden and Denmark). Ideally, the study of the

relationship between innovation and firm performance would have been preferable in the marketplace in which Zabala Innovation Consulting, S.A. operates more intensively, Spain. However, data for firms in Spain are not available in AMADEUS database, since these firms do not report their innovation related activities according to international standards. Instead, they capitalize all Research and Development expenditures. Because of that, data on Spanish companies provided by alternative databases, such as SABI were not considered appropriate for the analysis. Thus, Nordic countries have been selected both because they report R&D expenses according to international standards and because they have a high national R&D intensity. Therefore, it has been considered interesting the analysis of relation between innovation and firm performance in firms operating under this framework.

Of the total of firms, 498 firms reporting R&D expenditures in their financial statements have been selected for the period 2008-2016. These firms are categorized by sectors according to the statistical classification of economic activities in the European Community (Eurostat, 2008). As defined in its last version, NACE Rev 2 (2008), "an economic activity takes place when resources such as capital goods, labour, manufacturing techniques or intermediary products are combined to produce specific goods or services. Thus, an economic activity is characterised by an input of resources, a production process and an output of products (goods and services)". This way, it is mentioned that "if the production process is organised as an integrated series of elementary activities within the same statistical unit, the whole combination is regarded as one activity". Table 1 shows the high-level aggregation in the classification:

Table 1: *NACE Rev. 2/ ISIC Rev. 4 Industry Classification*

A*38 code	Divisions	Description
A	01-03	Agriculture, forestry and fishing
B, C, D and E	05-09, 10-33, 35 and 36-39	Manufacturing, mining and quarrying and other industry
F	41-43	Construction
G, H and I	45-47, 49-53 and 55-56	Wholesale and retail trade, transportation and storage, accommodation and food service activities
J	58-63	Information and communication
K	64-66	Financial and insurance activities
L	68	Real estate activities
M and N	69-75 and 77-82	Professional, scientific, technical, administration and support service activities
O, P and Q	84, 85 and 86-88	Public administration, defence, education, human health and social work activities

R, S, T and U	90-93, 94-96, 97-98 and 99	Other services

Source: Own Elaboration. Data from Eurostat - NACE Rev. 2., 2008

The variables of interest in this work are those referring to innovation and firm performance. As stated in the literature review section, Research and Development expenditure is widely accepted as a proxy for innovation. Therefore, this data is obtained from the income statement's disclosure notes is AMADEUS database (expressed in thousands of Euros of each year). Firm performance measures have been calculated from data provided by AMADEUS database (all of them expressed in thousands of Euros of each year). Hence, data for the return on assets (ROA) is was available in the income statement and balance sheet, as well as data for the return on equity. Labour productivity (LP) is computed dividing Sales (income statement information) by the number of employees (AMADEUS database, each unit referring to a single person). Capital productivity (CP) is calculated with the ratio of sales divided by total assets. Debt to equity ratio (DOE) is obtained with the ratio of debt (total liabilities) by equity. Finally, the working capital (current assets – current liabilities) divided by total assets reflects firms' ability to further invest in the future. Finally, it needs to be mentioned that AMADEUS database also provides data on the corresponding sector to each firm selected, both expressed in the NACE and NAICS industry classifications.

6 EMPIRICAL ANALYSIS

6.1 Effect of innovation on firm performance:

Taking the model used by Corredor and Goñi (2011) as a reference, a general model is constructed for the study of the effect of Research and Development efforts overcomed by companies on performance.

$$\textbf{Model 1}: Performance_{it} = \beta_0 + \beta_1 Performance_{t-1} + \beta_2 (Size)_{it} + \beta_3 RD\ Ratio_{i,t-1} + \alpha_i + u_{it}$$

$$\textbf{Model 2}: Performance_{it} = \beta_0 + \beta_1 Performance_{t-1} + \beta_2 (Size)_{it} + \beta_3 RD\ Ratio_{i,t-2} + \alpha_i + u_{it}$$

The dependent variable, $Performance_{it}$, captures the several performance measures considered in the study of firm i in period t: return on assets, return on equity, labour productivity, capital productivity, debt to equity, and working capital/total assets. The one-period lagged performance variable, $Performance_{t-1}$, is included as a way to capture all other factors that affect the dependent variable others than the explanatory variables of interest in the model (RD ratio), since factors affecting one year performance may probably affect next

year's. The number of employees (log) is used as a proxy to control for the firm size. As recommended by the European Commission (2005), firm size is measured either by the number of employees, total assets or sales. However, because many variables in the model are constructed by some derivation of sales or total assets, the number of employees has been selected as the most appropriate classification.

As for the explanatory variable, recent studies, as the one of Geoffrey (2015), incorporate new variables for the study of the relationship between R&D spending and performance, such as the R&D expense to operating income, arguing that it offers more valid and strong outcomes. In this work, the ratio between R&D expenditures to total assets has been considered the most appropriate, since it shows the innovative inputs over the productive capacity of a firm, which is typically more stable than sales. Therefore, the $RD\ Ratio_{it}$ variable is used as a way to better represent the innovation effort a company makes. Innovation effort provides a stronger interpretation than innovation inputs carried out in absolute terms, and it is used as the explanatory variable of the model. This general model must consider that the effect of Research and Development efforts may take time. Given the uncertainty as to the exact moment at which the impact on firm performance happens, the study estimates two models. $Model\ 1$ analyses the effect of R&D expenses of one year on next year's firm performance, whereas $Model\ 2$ analyses the effect of R&D expense of one year on firm performance after two years. Table 2 summarizes the variables used in this general model:

Table 2*: Summary of the variables used in the study of the effect of innovation efforts on firm performance*

ROA	Dependent variable	Measures the economic profitability of a firm referring to the assets potential to generate earnings.
ROE	Dependent variable	Measures the financial profitability of a firm comparing the net income to its shareholder's equity.
LP	Dependent variable	Measures how efficient a company's employees are in generating sales.
CP	Dependent variable	Measures how efficient a company's investments are in generating sales.
DOE	Dependent variable	Measures the financial source of the firm, comparing the external financial source with the internal one.
WC/TA	Dependent variable	Measures the firm's ability to overcome its current obligations (liquidity) in relation to its assets. Therefore, it refers to the firm's investment capacity in the future.
Size (log)	Control variable	Represents the firm size by the number of employees it has. The logarithm allows to mitigate large variations within firms.

RD Ratio (lag 1 or 2)	Explanatory variable	Represents the innovation effort of a company in the last year (lag 1) or two years ago (lag 2), since it relates the R&D expense to the firm's assets.
Performance (lag 1)	Control variable	It reflects firms' performance of the last year.

A panel data model is used for this analysis. The reason for that is that the variables of interests for the analysis are available for a number of 498 firms over several years. This implies that OLS models are not appropriate. Besides, because the number of firms (498) is larger than the periods observed (9 years), panel data models – and not pooled data – are the most appropriate. On the other hand, since the effect of research and development expense on profitability may not be immediate, it is important considering time lags between an innovation and its impact when analysing the effect of innovation (Oslo Manual, 2005). As noted there, some effects materialise over the course of the observation period, while others may take longer. Therefore, evaluating both individual heterogeneity and its dynamics over time is more appropriate. As mentioned in the Oslo Manual (2005), the availability of innovation data on a large cross-section over time (i.e. panel data) is of great value for such analyses. Therefore, the same 498 firms (sample size) are analysed over 9 periods (2008-2016).

The common assumptions for the fixed or random effects panel data models are considered (Jeffrey, 2010): i) Firms are randomly selected, ii) Perfect linear combinations within the explanatory variables do not exist and of them present changes over time (at least in some of them), iii) The estimator is consistent at least when N tends to infinity (the expected value of the idiosyncratic error, given the explanatory variables in all years, and the unobservable effect is zero), iv) Homoscedasticity, v) The explanatory variables are independent and identically and normally distributed.

Apart from Research and Development efforts of a firm, other factors may affect how firms perform. These variables correspond to the error term of the model. Some of them are controlled in the model, since previous years' performance levels and firm size are incorporated. In any case, because panel data are used, the individual and temporal effects of the error term are taken into account. As explained in (Jeffrey, 2010), the individual effect (α_i) considers that the error term among individuals varies (while time differences in the error term are taken constant). The temporal effect (v_t) takes error term variations across

individuals as constant, while it measures error term differences across time. Because the dimensions considered in the error term vary from firm to firm, and since there is no reason to think that there exist significant temporal differences in the error term, individual effect are assumed to be prevalent in the model. Therefore, the individual effect term, (α_i), is the one included.

In order to conclude whether the model of individual effect has to be estimated by fixed or random effects the Haussmann test is evaluated. Random effects estimation uses the same transformation as fixed effects estimation but taking into consideration that the term α_i is not correlated with any of the explanatory variables for any period. This test (directly provided by Gretl) tests the null hypothesis that the individual effect α_i is independent form all the explanatory variables and for any period.

The results for this estimation are presented in table 3 and 4. Table 3 presents the ceteris paribus mean causal effects of increasing each variable in the first column on the dependent variables in the first row. It is observed that Research and Development efforts only affect significantly the economic and financial profitability of both the first and the second year after the raise of these practices. The effects are higher for the year after the increases in innovation efforts are carried out, though. Additionally, capital productivity two years after innovation efforts are raised also increases significantly. On the other hand, control variables appear to be significant in the model in most cases (both firm size and the performance level obtained in the previous year), so it is appropriate including them in the model. Additionally, it is observed that when last year's performance is improved in one unit, performance in the year after increases too, as one would expect. In contrast, when an additional employee is incorporated, the model expects that firm performance is reduced. In fact, the estimation concludes that this effect is significant for most of the ways in which performance is measured.

Table 3: *Panel data analysis of the effect of innovation efforts in (t=0) on firm performance in (t=1),*

Analysis 1: Effect of R&D expenditure (t-1) and Firm Performance (t)

	ROA	**ROE**	**Labour Productivity**	**Capital Productivity**	**Debt to Equity**	**WC/TA**
Perfroman. (lag 1)	0.603733*** (0.0137227)	0.613233*** (0.0135510)	0.725829*** (0.00632858)	0.493386*** (0.0136616)	0.867547*** (0.0119734)	0.515103*** (0.0151258)

Size	−24.8827***	−19.7108***	−33.7867***	−1.48587	−9.85723***	−1.11926
	(6.06200)	(5.93906)	(10.7224)	(2.02006)	(3.51534)	(0.762635)
Innovation	0.161672***	0.160359***	−0.00963341	0.00610924	−0.00060393	0.00223254
effort	(0.0176905)	(0.0169452)	(0.0273919)	(0.00387899)	(0.00539378)	(0.00195847)

*Note that the independent variable "dependent variable" corresponds to the control variable (lagged one year) included in the model. The control variable "size" is expressed in logarithm. The coefficient provided in the first row corresponds to the ceteris paribus mean causal effect of the explanatory variables of the model. The significance level is expressed by *** (1%), ** (5%), * (10%). The value in the parenthesis is the standard deviation of the estimator.*

Source: Own Elaboration

Table 4: *Panel data analysis of the effect of innovation efforts in (t=0) on firm performance in (t=2),*

Analysis 2: Effect of R&D expenditure (t-2) and Firm Performance (t)

	ROA	**ROE**	**Labour Productivity**	**Capital Productivity**	**Debt to Equity**	**WC/TA**
Perfroman.	0.655732***	0.648310***	0.724980***	0.640375***	0.889946***	0.519930***
(lag 1)	(0.0136537)	(0.0140185)	(0.00623740)	(0.0134451)	(0.0124307)	(0.0160748)
Size	−21.9082***	−21.6393***	−23.4683**	−1.60655	−9.9152***	−1.27469
	(5.80458)	(5.81966)	(11.1651)	(1.58871)	(3.64924)	(0.849546)
Innovation	0.0450209***	0.0412857***	−0.0204012	0.00708081*	−0.0067869	0.00261041
effort	(0.0154811)	(0.0153637)	(0.0277677)	(0.00395565)	(0.0060611)	(0.0021265)

*Note that the independent variable "dependent variable" corresponds to the control variable (lagged one year) included in the model. The control variable "size" is expressed in logarithm. The coefficient provided in the first row corresponds to the ceteris paribus mean causal effect of the explanatory variables of the model. The significance level is expressed by *** (1%), ** (5%), * (10%). The value in the parenthesis is the standard deviation of the estimator.*

Source: Own Elaboration

The analysis of the effect of innovation on firm performance is more detailed if differences between sectors and firm size are evaluated. Therefore, it has been considered interesting studying the existence of differences between firms, depending on their size and the sector they belong to, since they may mitigate the global effect of innovation efforts on firm performance. In fact, with the aim of providing an analysis of the effect that innovation practices have at the firm level, the Oslo Manual (2005) suggests two interesting ways in which companies can be grouped when talking about innovation. The most important classification is the principal economic activity of the statistical unit ("industry). The International Standard Industrial Classification (ISIC) and the statistical classification of economic activities in the European Community (NACE) are appropriate international classifications for this purpose. It also mentioned that for innovation surveys, size is the other essential classification of statistical units. Although different variables can be used to define size of a statistical unit in innovative surveys, it is recommended that size should be measured on the basis of number of employees.

6.2 Effect of innovation and firm performance by firm size:

As for the case of innovation effects on firm performance by differences between firm sizes, the structure of the previous analysis is followed. Hence, a panel data model for the 498 Nordic firms over the period 2008-2016 is carried out. The classification by firm size is divided into micro, small, medium and large firms as suggested by the European Commission (2005). This way, firms are grouped as micro firms [1,9], small firms [10, 49] workers, medium size firms [50, 249] workers, and large firms whenever they have more than 250 workers. Table 5 below shows the number of firms corresponding to each type of firm in the sample observed:

Table 5: *Number of firms belonging the classification by firm size in the period under study, 2008-2016*

Firm Size:	2008	2009	2010	2011	2012	2013	2014	2015	2016
Large	297	283	279	284	253	245	222	226	228
Medium	137	146	149	150	170	175	197	196	188
Small	48	53	56	54	65	69	67	65	71
Micro	11	13	9	6	6	6	11	10	10
NA	5	3	5	4	4	3	1	1	1
Total	**498**	**498**	**498**	**498**	**498**	**498**	**498**	**498**	**498**

For the purpose of analysing the effect of innovation efforts on firm performance by firm size, a new variable is added to the model. It is computed by multiplying the RD Ratio variable by a dummy variable (Dsize), which takes the value equal to 1 when it belongs to a specific firm size and 0, otherwise. This variable allows observing the difference in the relationship between performance and innovation efforts corresponding to a firm type with respect to the rest of the firms. The coefficient of that variable, β_3, shows how different the effect of RD efforts (one or two years before) on performance (in t) is between firms with different sizes under study. Bearing in mind that the coefficient β_2 represents the mean ceteris paribus effect of RD efforts (one or two years before) on performance (t) of all the rest of the firms, the sum of $\beta_2 + \beta_3$ represents the effect of RD efforts (one or two years before) on performance (t) in the type of firm of analysis. In addition, it needs to be mentioned that the size variable is not included in this estimation, because the dummy variable specifically refers to the number of firms included in the firm.

$$\textbf{Model 1}: \; Performance_{it} = \beta_0 + \beta_1 Performance_{t-1} + \beta_2 RDRatio_{i,t-1} + \beta_3 RDRatio_{i,t-1} * Dsize_{it} + \alpha_i + u_{it}$$

$$\textbf{Model 2}: Performance_{it} = \beta_0 + \beta_1 Performance_{t-1} + \beta_2 RD\ Ratio_{i,t-2} + \beta_3 RDRatio_{i,t-2} * Dsize_{it} + \alpha_i + u_{it}$$

Table 6 below shows the results obtained by the model estimation. First, it need to be noted that the results for micro firms are not described, because only a few firms compose the group. Hence, it can not be assumed that the results are unbiased. As for the rest of the groups, it is observed that there regarding profitability measures, all firms show positive effects of innovation efforts, but there are not significant differences between them. In contrast, significant differences are observed in the case of capital productivity. Medium size firms present positive significant differences after increases in innovation efforts in both years, while large firms show negative significant differences. Note, however, that the overall effect is positive for all cases. Therefore, the results only imply that the effect of innovation efforts on capital productivity are significantly higher in medium size firms, while they are significantly lower (but positive) in large firms. One posible reason for that is that is that large firms are mostly involved in innovative activities, and hence the benefits obtained from their productive capacity may not be extraordinary. In the same vein, it is observed that significant positive differences on the future investment ability on medium size firms exist, whereas large firms are significantly wore off. Hence, the results obtained at the general level may be counterbalanced by positive and negative results got in different firms.

Table 6: *Analysis of the effect of innovation efforts on firm performance one and two years after by firm size (ROA, ROE, Labour productivity, capital productivity, debt to equity, and working capital over total assets).*

ROA				Capital Productivity		
Lag (1) / Lag (2)	**Small**	**Medium**	**Large**	**Small**	**Medium**	**Large**
Performance (lag 1)	0.622958*** / 0.668805***	0.622090*** / 0.668982***	0.621572*** / 0.668200***	0.502343*** / 0.622783***	0.503359*** / 0.620639***	0.500847*** / 0.621434***
RD ratio (lag 1/2)	0.169521*** / 0.0435255***	0.158941*** / 0.0440855***	0.175528*** / 0.0517466***	0.00677059* / 0.00900117**	0.000760267 / 0.00348022	0.0103837** / 0.0105563**
RD ratio (lag 1/2)* Dsize	−0.00401342 / 0.0202980	0.0220326 / 0.00628615	−0.0176614 / −0.0133714	−0.00210055 / −0.00474911	0.0133540*** / 0.00996462**	−0.00988471** / −0.00707040*
ROE				**Debt to Equity Ratio**		
Lag (1) / Lag (2)	**Small**	**Medium**	**Large**	**Small**	**Medium**	**Large**
Performance (lag 1)	0.613069*** / 0.649726***	0.613025*** / 0.650195***	0.612797*** / 0.649350***	0.879933*** / 0.902581***	0.880041*** / 0.902558 ***	0.880095*** / 0.902704***
RD ratio (lag 1/2)	0.158401*** / 0.0323977**	0.157197*** / 0.0388831**	0.164284*** / 0.0454362***	0.00309310 / −0.00534567	−0.000285223 / −0.00271704	0.00274731 / −0.00429253
RD ratio (lag 1/2)* Dsize	0.0117096 / 0.0397767*	0.00700709 / 0.00109628	−0.0111595 / −0.0179164	−0.00950482 / 0.00565111	0.00473361 / −0.00399069	−0.00257958 / −0.000413644
Labour Productivity				**WC/Total Assets**		
Lag (1) / Lag (2)	**Small**	**Medium**	**Large**	**Small**	**Medium**	**Large**
Performance (lag 1)	0.727946 *** / 0.726412 ***	0.727759*** / 0.726318***	0.727870*** / 0.726414***	0.516006*** / 0.520766***	0.513610*** / 0.518500***	0.514317*** / 0.519513***
RD ratio (lag 1/2)	−0.00353427 / −0.0152006	0.0163052 / −0.00478617	0.00741217 / −0.0130514	0.00296053 / 0.00342872	−3.41774e-05 / 0.000736221	0.00410558** / 0.00410415*
RD ratio (lag 1/2)* Dsize	0.0271138 / 0.00927110	−0.0331718 / −0.0187122	−0.0180026 / −0.00157460	−0.00205774 / −0.00252489	0.00576080*** / 0.00475383**	−0.00432102** / −0.00336167

Source: Own Elaboration

6.3 Effect of Innovation and performance by sectors:

With the objective of studying the relationship between innovation efforts and firm performance by sectors, the highest general industry classification level in NACE Rev. 2 (2017) is followed. As in the above section, the same panel data model as the previously estimated one is analysed, but taking data corresponding to each firm sector into account. In this case, however, the control variable of firm size is added since it does not present problems in the model estimated.

It is observed that some sectors are composed by a small number of firms. This makes the estimation not to be appropriate, since the assumptions are not properly satisfied. Therefore, differences in sectors composed by a small number of firms are not estimated. Table 7 below shows the number of firms in each sector, at the most general classification level provided by NACE Rev. 2 Industry classification (2017). The sectors whose differences are not estimated are: "agriculture, forestry and fishing", "construction" and "real estate activities".

Table 7: *Number of firms belonging to each sector under NACE Rev. 2 Industry Classification*

Sector (NACE Rev. 2 Industry Classification)	**Number of Firms**
Agriculture, forestry and fishing	3
Construction	4
Financial and insurance activities	43
Information and communication	18
Manufacturing, mining and quarrying and other industry	255
Professional, scientific, technical, administration and support service activities	109
Real estate activities	3
Wholesale and retail trade, transportation and storage, accommodation and food service activities	63
Total	**489**

In any case, table 8 provides the average means computed for each performance proxy in every sector, so that a global view of the way all different sectors perform is shown. Moreover, aiming to see how different performance is between sectors, the standard deviation is computed in each case.

Table 8: *Average firm performance within sectors (2008-2016) and standard deviations between them (Source: Own elaboration)*

Average firm performance within sectors (2008-2016) and deviations between them:

	ROA	ROE	LP	CP	DOE	WC
Agriculture, forestry and fishing	3,02	10,31	324,07	1,35	1,74	1,07
Construction	3,11	8,52	267,94	67,52	14,76	1,14
Financial and insurance activities	2,96	10,11	269,20	2,20	-0,59	0,41
Information and communication	2,99	10,21	1078,15	25,62	4,05	4,53
Manufacturing, mining and quarrying and other industry	2,96	10,12	372,68	8,69	3,79	1,79
Professional, scientific, technical, administration and support service activities	2,96	10,10	687,54	15,22	149,04	4,33
Real estate activities	2,98	10,18	322,90	1,85	2,64	0,44
Wholesale and retail trade, transportation and storage, accommodation and food service activities	2,98	10,20	748,39	118,61	-0,30	38,02
Standard Deviation	0,05	0,59	296,68	41,98	51,60	12,85

Source: Own Elaboration

Regarding profitability measures, it is observed that the sector of "construction" is the one which obtains the highest benefits from its productive capacity, whereas the "financial and insurance activities", "manufacturing mining and quarrying and other industry", and the "professional, scientific, technical, administration and support service activities" sectors are the least profitable ones (measured by the return on assets). The highest profits for shareholders belong to "agriculture, forestry and fishing", whereas the "construction" sector has the lowest return on equity. Additionally, it is observed that the return on equity varies much greatly than the profits generated by the assets invested in the firm. However, these results can not be interpreted as being these sectors the most and the least profitable ones, since the number of firms included in each sector may not be representing the whole population.

As for productivity measures, it is observed that the highest labour productivity corresponds to the sector of "information and communication", whereas the "construction" sector presents the lowest labour productivity values. On the other hand, the highest capital productivity belongs to the sector of "wholesale and retail trade, transportation and storage,

accommodation and food service activities", whereas "agriculture, forestry and fishing" is the sector which is less productive with its assets. Besides, the first is the one with the greatest variations within the sector, whereas the other has the smallest ones. The variations within labour productivity are much greater than capital productivity variations.

Last but not least, the sector with the highest debt to equity ratio is the "professional, scientific, technical, administration and support service activities" (in fact, it has the highest variations within the sector), whereas the "Wholesale and retail trade, transportation and storage, accommodation and food service activities" is the one with the lowest value. The "agriculture, forestry and fishing" sector is the one with the lowest changes. In line with that, the sector of "wholesale and retail trade, transportation and storage, accommodation and food service activities" presents the strongest ability to overcome short run liabilities, so it is the one with the highest capacity to further invest in the future. However, it is also the sector with the largest variations. The opposite situation occurs for the case of "financial and insurance activities", but the sector of "real estate activities" is the one changing less within the sector.

With all these considerations in mind, the model used for the study of the effect of innovation efforts on firm performance by firm size is followed. However, in this case differences by the sector to which firms belong are observed. For that purpose, a dummy variable for each of the sectors under study is included (Dsector). In addition, the firm size is included as a control variable for the model, since in this case it does not present estimation problems.

The results for the estimated model are presented in the table 9 below. These coefficients represent the mean ceteris paribus causal effect of increases on innovation efforts on firm performance two years after. Table 3 in the appendix provides these values for the estimation when both a one-year lag and two years lag are used for the variable associated to research and development. It is observed that profitability measures (ROA and ROE) present a positive and significant relationship with increases in innovation effort in all sectors. However, it is observed that there are not significant differences between them. On the other hand, it is observed that the sector of information and communication has positive differences in the way innovation efforts affect labour productivity as compared with the rest of the sectors. In fact, this relationship is present in both years. This means than innovation practices make these firms increase their sales with the same number of workers in a greater way than in the rest of the sectors. The reason for that can be linked to the fact that these

firms' activities are directly related to innovative activities. Hence, the same number of workers may be the ones in charge of increasing sales. However, related to capital productivity and working capital over total assets, it is observed that the wholesale and retail activities present positive and significant differences, whereas the manufacturing sectors shows negative ones. The larger increase in capital productivity in the wholesale and retail sector can be related to the rise of the e-commerce, which may have implied an optimization of the productive capacity. The fact that manufacture related firms present negative differences, can reflect that innovation efforts have concentrated in increasing the efficiency of operating costs and not in sales. The reason for this statement is that the return on assets does not show significant differences, in contrast to capital productivity (sales over total assets). In any case both the capital productivity and the working capital over total assets show the earnings obtained from the productive capacity. Hence, it is consistent that both measures are affected in the same direction. Besides, it needs to be noted that innovation efforts similarly affect firm performance one and two years after. The only significant and negative difference corresponds to the return on assets of the "financial and insurance activities" sector, but because financial statements in these firms commonly vary from the rest of the firms, academic research often do not take this sector into account when comparing such firms with rest of the sectors.

Table 9: *Effect of innovation effort (t=0) on firm performance (t=2).*

lag (2)	Professional	Financial and Insurance activities	Manufacturing	Information and Communication	Wholesale
	ROA				
Performance (lag 1)	0.655776***	0.656312***	0.656102***	0.655636***	0.655715***
log (size)	−21.9247***	−22.5957***	−21.7253***	−21.8687***	−21.6973***
RD Ratio	0.0444030***	0.0440125***	0.0520853***	0.0432948***	0.0443352***
RD Ratio* Dsector	0.00287030	0.0246045	−0.0133915	0.0264955	0.00498850
	ROE				
Performance (lag 1)	0.648365***	0.647893***	0.648369***	0.648221***	0.648284***
log (size)	−21.6988***	−20.5323***	−21.6111***	−21.6055***	−21.7214***
RD Ratio	0.0393117 **	0.0426391***	0.0424143**	0.0398496**	0.04156 ***
RD Ratio* Dsector	0.00935040	−0.0383781	−0.00213277	0.0220288	−0.00190858
	Labour Productivity				
Performance (lag 1)	0.725069***	0.724983***	0.724924***	0.724458***	0.724976***
log (size)	−23.1200**	−23.1435**	−23.3542**	−23.2536**	−22.7934**
RD Ratio	−0.0124294	−0.0200523	−0.0148742	−0.0313391	−0.0224781
RD Ratio* Dsector	−0.0385650	−0.0106214	−0.0102621	0.160770**	0.0149648
	Capital Productivity				
Performance (lag 1)	0.639746***	0.640263***	0.636973***	0.640366***	0.625451***
log (size)	−1.56624	−1.45872	−1.48557	−1.60862	−0.161314
RD Ratio	0.00831130**	0.00724092*	0.0130209***	0.00714551*	0.00243275
RD Ratio* Dsector	−0.00594156	−0.00482801	−0.0109658***	−0.000955250	0.0343342***
	Debt to Equity				
Performance (lag 1)	0.888392***	0.889631***	0.889383***	0.889624***	0.889449***
log (size)	−9.99371***	−9.92995***	−9.88096***	−9.93097***	−10.2177***
RD Ratio	−0.00946737	−0.00679059	−0.00453111	−0.00657952	−0.00580954
RD Ratio* Dsector	0.0131687	0.000184800	−0.00412893	−0.00398960	−0.00736171
	WC/Total Assets				
Performance (lag 1)	0.519709***	0.519858***	0.516918***	0.519860***	0.506980***
log (size)	−1.26524	−1.21598	−1.20503	−1.27799	−0.561732
RD Ratio	0.00293230	0.00267492	0.00563324 **	0.00273092	0.000342755
RD Ratio* Dsector	−0.00153790	−0.00194518	−0.00560882***	−0.00179059	0.0166539***

Source: Own Elaboration

7 CONCLUSIONS

The present study has englobed a general view of the impact of innovation in today's society. As part of a final degree project, the idea was originally oriented towards a work linked to a six months internship in an innovation management consultancy firm, Zabala Innovation Consulting, S.A. Because the firm operates under the conviction that innovation is the key competitive driver, a deeper evaluation of this statement has been considered of interest, due to the increasing importance of these practices. Hence, this empirical work has analysed the relationship existing between the innovation efforts carried out by companies and their performance. In fact, because of the complexity involved in measuring firm performance, several dimensions have been evaluated: return on assets, return on equity, labour productivity, capital productivity, debt to equity ratio, and the future investment ability. With that purpose, a panel data model of 498 Nordic firms over the period 2008-2016 has been estimated, and differences among firm size (micro, small, medium and large) and sectors have been considered.

The most important conclusion extracted is that the largest significant effect of innovation practices corresponds to both economic and financial profitability. In fact, the effect is larger for the year after increasing innovation efforts than for the following two years. These results have been further evaluated by taking differences between firm sizes and sectors into account. In this line, it has been observed that increases in innovation do not present significant differences for profitability measures. The largest differences between firms are observed in the capital productivity, so the effect of innovation on this measure may be mitigated by such differences. As for the ability to increase future investment capacity, medium size firms and the wholesale and retail sector present the highest positive results in both years, whereas large firms and the manufacture sector show the negative and significant differences in the first year. Additionally, to that it is observed that the sector of information and communication presents significant positive differences with respect to others in relation to the relationship of innovation efforts increases and labour productivity.

This analysis has been limited to the selection of firms which presented their financial statements under international standards, since this work considered R&D expenses as an input of innovation practices. Hence, further analysis carried out in different countries could provide further insights on the relation between innovation and firm performance. Indeed, in case that data for a larger sample of firms is available, differences between sectors could also be considered. This would be interesting, since trends in the most innovative sectors are

changing form pharmaceutical and automobile sectors, to the incorporation of ICT related firms.

In any case, this work has contributed to the evaluation of the way innovation works in the firm context. The importance attached is that, despite difficulties in measuring how innovation affects firms results, it is there where innovation happens. Hence, because today innovation is the may contributor to economic and social development in advanced societies, it is important understanding why firms may or may not be willing to take the risk involved on this practice.

This study has been part of a degree final project and it has been of much help in the internalization of diverse competences. Regarding specific competences acquired throughout this work, the empirical analysis (section IV, V, and VI) has been performed bearing theoretical techniques acquired in the International Business Administration degree. Regarding the data used, different financial analysis ratios have been considered and computed from the financial statements obtained for each firm under the analysis. Additionally, to that, the difference in the accounting treatment of Research and Development expense (a proxy reflecting innovation in this) between national and international standards must have been taken into account in the country selection for the analysis. Then, the appropriateness of the theoretical model studied different econometrical models into account (cross-sectional OLS model, pooled-data panel data model, fixed or random effects panel data model). Finally, knowledge acquired in econometrics were used to properly interpret the results obtained: ceteris paribus mean causal effect interpretation of the parameters, dummy variables, multicollinearity problems, control variables, lagged variables. As for general abilities developed, the capacity for analysis and synthesis has been of great importance when dealing with the revision of previous literature on the issue (section II). Finally, organizational and planning skills acquired through the years of study have been applied in a way to more efficiently solving new problems. In relation to that, critical thinking has been essential in the analysis of the results obtained (section VI).

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9 APPENDIX

Figure 1: *Innovation and Unemployment in Europe. 2015 (Source: Guillermo Dorronsoro)*

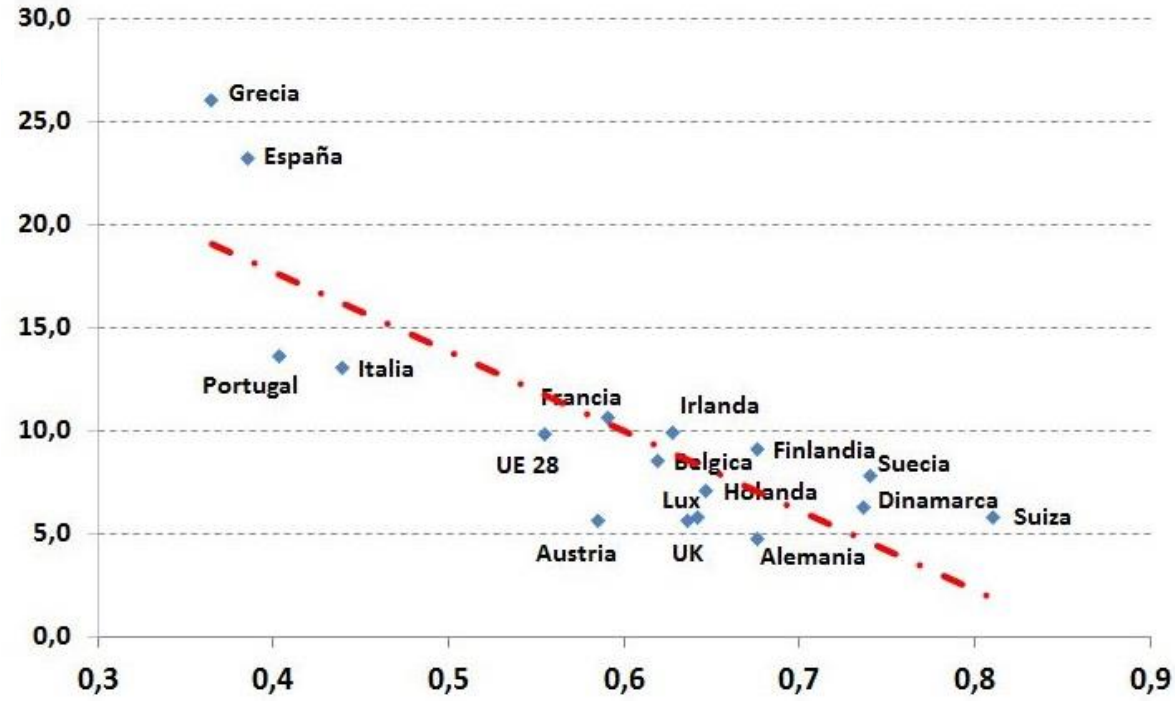

Figure 2: *Innovation and Unemployment in Spanish Regions. 2018 (Source: Own Elaboration)*

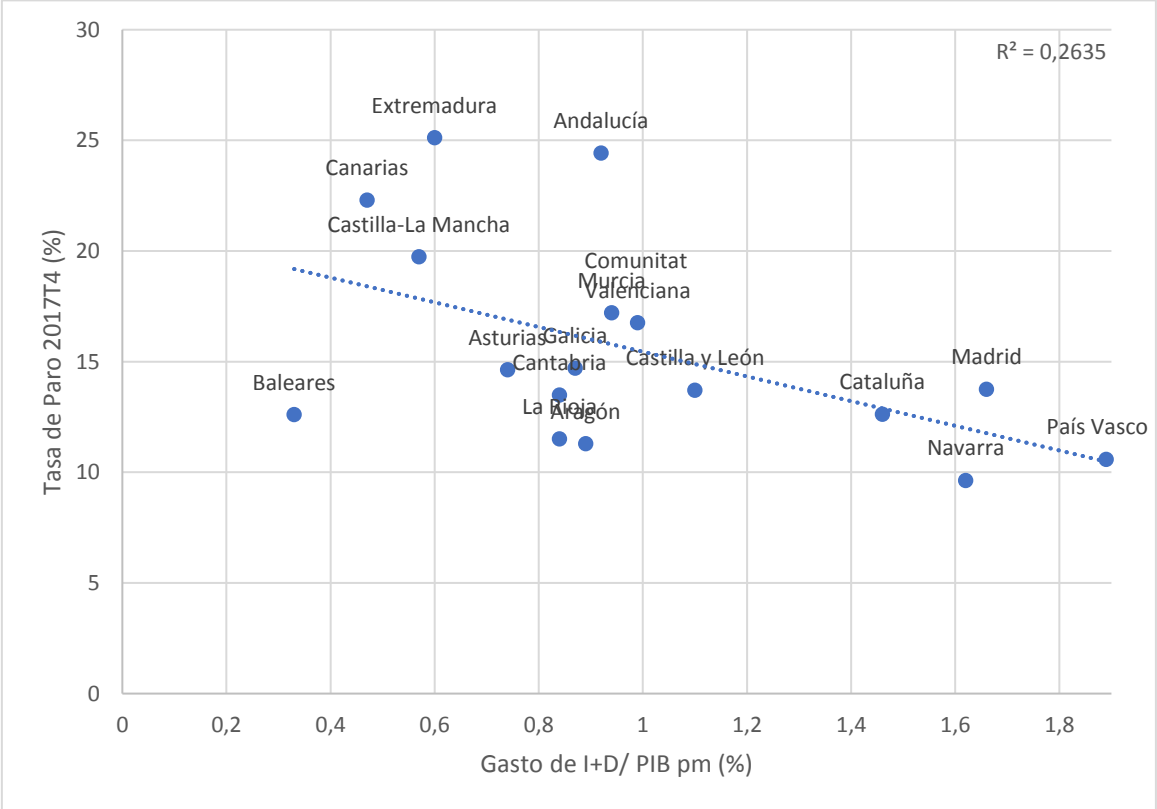

Table 1: *Ranking of the 1000 Largest Publicly Listed Corporate R&D Spenders. 2017 (Source: The Global Innovation 1000. Own Elaboration)*

2017 Rank	Company Name	Industry sector	Industry group	R&D Expense 2017 (USD billions, income statement exchange rate)	Total Revenue (USD billions, income statement exchange rate)
1	Amazon.com, Inc.	Consumer Discretionary	Retailing	16,09	135,99
2	Alphabet Inc.	Information Technology	Software and Services	13,95	90,27
3	Intel Corporation	Information Technology	Semiconductors and Semiconductor Equipment	12,74	59,39
4	Samsung Electronics Co., Ltd.	Information Technology	Technology Hardware and Equipment	12,72	167,68
5	Volkswagen Aktiengesellschaft	Consumer Discretionary	Automobiles and Components	12,15	229,35
6	Microsoft Corporation	Information Technology	Software and Services	11,99	85,32
7	Roche Holding AG	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	11,35	51,82
8	Merck & Co., Inc.	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	10,12	39,81
9	Apple Inc.	Information Technology	Technology Hardware and Equipment	10,05	215,64
10	Novartis AG	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	9,57	49,39
11	Toyota Motor Corporation	Consumer Discretionary	Automobiles and Components	9,31	247,51
12	Johnson & Johnson	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	9,10	71,89
13	General Motors Company	Consumer Discretionary	Automobiles and Components	8,10	166,38
14	Pfizer Inc.	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	7,87	52,82
15	Ford Motor Company	Consumer Discretionary	Automobiles and Components	7,30	151,80
16	Daimler AG	Consumer Discretionary	Automobiles and Components	6,86	161,79
17	Oracle Corporation	Information Technology	Software and Services	6,82	37,73
18	Cisco Systems, Inc.	Information Technology	Technology Hardware and Equipment	6,30	49,25
19	Honda Motor Co., Ltd.	Consumer Discretionary	Automobiles and Components	6,20	125,55
20	Facebook, Inc.	Information Technology	Software and Services	5,92	27,64
21	AstraZeneca PLC	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	5,89	23,00
22	International Business Machines Corporation	Information Technology	Software and Services	5,75	79,92
23	Siemens Aktiengesellschaft	Industrials	Capital Goods	5,53	89,52
24	Sanofi	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	5,46	36,64
25	Eli Lilly and Company	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	5,24	21,22
26	QUALCOMM Incorporated	Information Technology	Semiconductors and Semiconductor Equipment	5,15	23,55
27	Gilead Sciences, Inc.	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	5,10	30,39
28	Exor N.V.	Financials	Diversified Financials	5,08	147,86
29	Bristol-Myers Squibb Company	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	4,94	19,43
30	Bayer Aktiengesellschaft	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	4,93	49,37
31	General Electric Company	Industrials	Capital Goods	4,79	120,27
32	Nokia Corporation	Information Technology	Technology Hardware and Equipment	4,66	24,93
33	The Boeing Company	Industrials	Capital Goods	4,63	94,57
34	Bayerische Motoren Werke Aktiengesellschaft	Consumer Discretionary	Automobiles and Components	4,53	99,40
35	GlaxoSmithKline plc	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	4,48	34,43
36	Celgene Corporation	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	4,47	11,23
37	Nissan Motor Co., Ltd.	Consumer Discretionary	Automobiles and Components	4,40	105,11
38	AbbVie Inc.	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	4,37	25,64
39	Sony Corporation	Consumer Discretionary	Consumer Durables and Apparel	4,01	68,19
40	Panasonic Corporation	Consumer Discretionary	Consumer Durables and Apparel	3,91	65,86
41	Amgen Inc.	Healthcare	Pharmaceuticals, Biotechnology and Life Sciences	3,84	22,99
42	DENSO Corporation	Consumer Discretionary	Automobiles and Components	3,67	40,60
43	Telefonaktiebolaget LM Ericsson (publ)	Information Technology	Technology Hardware and Equipment	3,49	24,52
44	Fiat Chrysler Automobiles N.V.	Consumer Discretionary	Automobiles and Components	3,46	117,19
45	Airbus SE	Industrials	Capital Goods	3,36	70,29
46	SAP SE	Information Technology	Software and Services	3,21	23,29
47	Toshiba Corporation	Industrials	Capital Goods	3,21	50,45
48	LG Electronics Inc.	Consumer Discretionary	Consumer Durables and Apparel	3,10	45,99
49	Continental Aktiengesellschaft	Consumer Discretionary	Automobiles and Components	3,03	42,81
50	Hitachi, Ltd.	Information Technology	Technology Hardware and Equipment	2,90	82,17

Figure 3: *Factors relating to the objectives and effects of innovation (Source: Oslo Manual, 2005)*

Relevant for:	Product innovations	Process innovations	Organisational innovations	Marketing innovations
Competition, demand and markets				
Replace products being phased out	*			
Increase range of goods and services	*			
Develop environment-friendly products	*			
Increase or maintain market share	*			*
Enter new markets	*			*
Increase visibility or exposure for products				*
Reduced time to respond to customer needs		*	*	
Production and delivery				
Improve quality of goods and services	*	*	*	
Improve flexibility of production or service provision		*	*	
Increase capacity of production or service provision		*	*	
Reduce unit labour costs		*	*	
Reduce consumption of materials and energy	*	*	*	
Reduce product design costs		*	*	
Reduce production lead times		*	*	
Achieve industry technical standards	*	*	*	
Reduce operating costs for service provision		*	*	
Increase efficiency or speed of supplying and/or delivering goods or services		*	*	
Improve IT capabilities		*	*	
Workplace organisation				
Improve communication and interaction among different business activities			*	
Increase sharing or transferring of knowledge with other organisations			*	
Increase the ability to adapt to different client demands			*	*
Develop stronger relationships with customers			*	*
Improve working conditions		*	*	
Other				
Reduce environmental impacts or improve health and safety	*	*	*	
Meet regulatory requirements	*	*	*	

Figure 4: *Factors hampering innovation activities (Source: Oslo Manual, 2005)*

Relevant for:	Product innovations	Process innovations	Organisational innovations	Marketing innovations
Cost factors:				
Excessive perceived risks	*	*	*	*
Cost too high	*	*	*	*
Lack of funds within the enterprise	*	*	*	*
Lack of finance from sources outside the enterprise:				
Venture capital	*	*	*	*
Public sources of funding	*	*	*	*
Knowledge factors:				
Innovation potential (R&D, design, etc.) insufficient	*	*		*
Lack of qualified personnel:				
Within the enterprise	*	*		*
In the labour market	*	*		*
Lack of information on technology	*	*		
Lack of information on markets	*			*
Deficiencies in the availability of external services	*	*	*	*
Difficulty in finding co-operation partners for:				
Product or process development	*	*		
Marketing partnerships				*
Organisational rigidities within the enterprise:				
Attitude of personnel towards change	*	*	*	*
Attitude of managers towards change	*	*	*	*
Managerial structure of enterprise	*	*	*	*
Inability to devote staff to innovation activity due to production requirements	*	*		
Market factors:				
Uncertain demand for innovative goods or services	*			*
Potential market dominated by established enterprises	*			*
Institutional factors:				
Lack of infrastructure	*	*		*
Weakness of property rights	*			*
Legislation, regulations, standards, taxation	*	*		*
Other reasons for not innovating:				
No need to innovate due to earlier innovations	*	*	*	*
No need because of lack of demand for innovations	*			*

Table 2: *Variations within each sector in firm performance*

Standard Deviation	**ROA**	**ROE**	**LP**	**CP**	**D**	**WC**
Agriculture, forestry and fishing	69,39	294,20	72,26	1,15	0,23	1,29
Construction	71,85	264,32	107,84	200,67	23,20	8,20
Financial and insurance activities	68,65	291,10	159,92	2,29	55,84	0,77
Information and communication	69,02	292,69	2647,55	67,08	10,81	12,06
Manufacturing, mining and quarrying and other industry	68,69	291,24	328,33	75,45	6,35	14,62
Professional, scientific, technical, administration and support service activities	68,64	291,02	6349,09	159,24	1002,64	41,24
Real estate activities	68,89	292,10	248,22	2,53	0,57	0,50
Wholesale and retail trade, transportation and storage, accommodation and food service activities	68,97	292,43	1348,85	522,27	129,56	234,99

Table 3: *Analysis of the effect of innovation efforts on firm performance one and two years after by sectors*

lag (1) lag (2)		**Professional**	**Financial and Insurance**	**Manufacturing**	**Information and Communication**	**Wholesale**
		ROA				
Performance (lag 1)		0.603754*** 0.655776***	0.602811*** 0.656312***	0.603512*** 0.656102***	0.603774*** 0.655636***	0.603756*** 0.655715***
log (size)		−24.8881*** −21.9247***	−22.8414*** −22.5957***	−25.0919 *** −21.7253***	−24.8895*** −21.8687***	−25.0862*** −21.6973***
RD Ratio (lag 1/ 2)		0.161372*** 0.0444030***	0.164799*** 0.0440125***	0.153674*** 0.0520853***	0.162117*** 0.0432948***	0.162351*** 0.0443352***
RD Ratio (lag 1/ 2)* Dummy		0.00135406 0.00287030	−0.0753793** 0.0246045	0.0151916 −0.0133915	−0.00709164 0.0264955	−0.00505868 0.00498850
		ROE				
Performance (lag 1)		0.613299*** 0.648365***	0.613250*** 0.647893***	0.613150*** 0.648369***	0.613277*** 0.648221***	0.613063*** 0.648284***
log (size)		−19.7420*** −21.6988***	−19.7534*** −20.5323***	−19.7516*** −21.6111***	−19.6773*** −21.6055***	−20.8948*** −21.7214***
RD Ratio (lag 1/ 2)		0.158822*** 0.0393117 **	0.160297*** 0.0426391***	0.158851*** 0.0424143**	0.158647*** 0.0398496**	0.164438*** 0.04156 ***
RD Ratio (lag 1/ 2)* Dummy		0.00707653 0.00935040	0.00155921 −0.0383781	0.00289926 −0.00213277	0.0255221 0.0220288	−0.0291224 −0.00190858
		Labour Productivity				
Performance (lag 1)		0.725853*** 0.725069***	0.725831*** 0.724983***	0.725651 *** 0.724924***	0.725388*** 0.724458***	0.725822*** 0.724976***
log (size)		−33.7207*** −23.1200**	−33.5516*** −23.1435**	−33.4278*** −23.3542**	−33.6550*** −23.2536**	−32.5083*** −22.7934**
RD Ratio (lag 1/ 2)		−0.00785681 −0.0124294	−0.00935736 −0.0200523	0.00655205 −0.0148742	−0.0185749 −0.0313391	−0.0137145 −0.0224781
RD Ratio (lag 1/ 2)* Dummy		−0.00833915 −0.0385650	−0.00830086 −0.0106214	−0.0302807 −0.0102621	0.132431** 0.160770**	0.0298516 0.0149648
		Capital Productivity				
Performance (lag 1)		0.492753*** 0.639746***	0.493170*** 0.640263***	0.494227*** 0.636973***	0.493201*** 0.640366***	0.491243*** 0.625451***
log (size)		−1.47610 −1.56624	−1.29737 −1.45872	−1.29590 −1.48557	−1.49147 −1.60862	0.277674 −0.161314
RD Ratio (lag 1/ 2)		0.00753587* 0.00831130**	0.00640035 0.00724092*	0.0145507*** 0.0130209***	0.00629413 0.00714551*	4.22328e-05 0.00243275
RD Ratio (lag 1/ 2)* Dummy		−0.00693797 −0.00594156	−0.00633293 −0.00482801	−0.0154968*** −0.0109658***	−0.00329293 −0.000955250	0.0461311*** 0.0343342***
		Debt to Equity				
Performance (lag 1)		0.864842*** 0.888392***	0.867226*** 0.889631***	0.866528*** 0.889383***	0.867207*** 0.889624***	0.866997*** 0.889449***
log (size)		−9.86651*** −9.99371***	−9.87864*** −9.92995***	−9.73744*** −9.88096***	−9.86956*** −9.93097***	−10.2284*** −10.2177***
RD Ratio (lag 1/ 2)		−0.00576152 −0.00946737	−0.000622357 −0.00679059	0.00517951 −0.00453111	−0.000335963 −0.00657952	0.000730149 −0.00580954
RD Ratio (lag 1/ 2)* Dummy		0.0251879*** 0.0131687	0.000442836 0.000184800	−0.0106028 −0.00412893	−0.00514713 −0.00398960	−0.0100855 −0.00736171
		WC/Total Assets				
Performance (lag 1)		0.514905*** 0.519709***	0.515036*** 0.519858***	0.512546*** 0.516918***	0.515045*** 0.519860***	0.503974*** 0.506980***
log (size)		−1.11173 −1.26524	−1.06347 −1.21598	−1.04705 −1.20503	−1.12162 −1.27799	−0.437370 −0.561732
RD Ratio (lag 1/ 2)		0.00257091 0.00293230	0.00230175 0.00267492	0.00527836** 0.00563324 **	0.00234048 0.00273092	−2.94479e-05 0.000342755
RD Ratio (lag 1/ 2)* Dummy		−0.00157990 −0.00153790	−0.00195380 −0.00194518	−0.00570983*** −0.00560882***	−0.00161890 −0.00179059	0.0167419*** 0.0166539***

Source: Own Elaboration