

**Innovation in services:
how different from innovation in manufacturing?**

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Declaração

Declaro que o presente documento é um trabalho original da minha autoria e que cumpre todos os requisitos do Código de Conduta e Boas Práticas da Universidade de Lisboa.

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I declare that this document is an original work of my own authorship and that it fulfills all the requirements of the Code of Conduct and Good Practices of the Universidade de Lisboa.

Abstract

Services sector has been gaining importance over the years since economies are increasingly service based. This research work aims to make a comparison between innovation in the service and manufacturing sector, drawing data from CIS-2016 for Portugal.

The differentiation between sectors innovation was studied by researching various subjects which arouse interest and were discussed in the literature review being the basis to create the research hypotheses, such as the size of the company, the skill of the employees, the engagement in cooperation activities and the R&D investment. These subjects were dealt by creating a common model for the two sectors and then separate models for each sector (services and manufacturing) which were built using a logit regression and were used to make a comparison between sectors behavior towards innovation.

The results highlight differences between both sectors such as revenue being quite more important for manufacturing innovation and being part of a group significant only for services, the skills of the employees having a higher positive influence for services but having a college degree, engaging in cooperation and the expenditure in R&D playing a more important role in manufacturing. The two sectors also present similarities since only the revenue and being part of a group impact innovation on only one sector, the other differences impact both sectors only with different intensities corroborating the suitability of the integrative approach for understanding how differently the two sectors behave.

Keywords: Services Innovation; Manufacturing innovation; Innovation determinants; Integrative approach; CIS

Resumo

O sector dos serviços tem ganho importância ao longo dos anos visto que as economias são cada vez mais sustentadas neste sector. Esta dissertação pretende comparar a inovação no sector dos serviços com a da indústria partindo dos dados do CIS-2016 para Portugal.

A diferenciação entre inovação nos dois sectores foi estudada pesquisando vários tópicos que se mostraram de interesse e foram discutidos na revisão de literatura, servindo de base para criar as hipóteses, como a dimensão da empresa, as habilitações dos trabalhadores, as atividades de cooperação e o investimento em I&D. Estes tópicos foram tratados através da construção de um modelo comum para ambos os sectores bem como modelos em separado para serviços e indústria usando regressões logit, que foram usadas para fazer a comparação entre sectores o seu comportamento relativamente à inovação.

Os resultados enfatizam algumas diferenças entre sectores como o volume de vendas ser significativamente mais importante para inovação na indústria e fazer parte de um grupo ser significativo apenas para os serviços, as qualificações dos colaboradores terem uma maior influência positiva nos serviços, mas ter um curso superior, participar em atividades de cooperação e despesa em I&D ter um papel mais importante nas industriais. Os dois sectores apresentam também semelhanças sendo que apenas o volume de vendas e ser parte de um grupo influenciam inovação em apenas um sector, as outras diferenças influenciam ambos os sectores apenas com diferentes intensidades corroborando a pertinência da perspetiva integrativa para perceber as diferenças entre o comportamento destes dois sectores.

Palavras chave: Inovação nos Serviços; Inovação na Indústria; Determinantes da inovação Perspectiva Integradora; CIS

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List of Acronyms

AICEP – Agência para o Investimento e Comércio Externo de Portugal

CIS – Community Innovation Survey

CSF – Community Support Framework

DGEEC – Direção-Geral de Estatísticas da Educação e Ciência

EFIGE – European Firms in a Global Economy

EU – European Union

GDP – Gross Domestic Product

GVA – Gross Value Added

ICT – Information and Communication technology

IPR – Intellectual Property Rights

KIBS – Knowledge Intensive Business services

OECD – Organization for Economic Co-operation and Development

PI TEC – Panel de Innovación Tecnológica

R&D – Research & Development

SI4S – Services in Innovation, Innovation in Services

1 Introduction

The focus on this chapter will mainly be associated with the concept of innovation, the problem and matter of investigation will be clarified as well as the motivation for the study and the definition of the main goals to be explored.

This dissertation aims to study the differences between innovation in the service sector and manufacturing sector by using data on Portuguese companies from the Community Innovation Survey (CIS) between 2014 and 2016 which is the most recent one and the one which gathered data about a new cycle in Portugal. The Portuguese economy came from a profound crisis with highly restrictive measures almost stopping the development of the country to a time of progress and growth with innovation as an important player in this new cycle. Due to these reasons the different cycle Portugal is in and the evolution of the survey itself creates expectations of achieving different more actual results in relation to past studies in this topic, which will allow those who read it to obtain more accurate information.

The comparison of the two sectors and the understanding of their differences comes with the fact that manufacturing and services are different sectors which have their own particularities, yet they are somehow related. The main reason for the increasing importance of studying services is its growing significance in the world economy as wrote by Teixeira and Bezerra (2016), even though the service sector is growing in importance in developed countries the research of innovation in the service sector has only gained impetus for the past 20 years. This new focus on services is due mainly because of the shifting of the workforce from the manufacturing sector to the service sector. As Pires *et al.* (2008) stated the scarcity of studies in services is possibly justified due to the many specificities of this sector, for instance, its heterogeneity since this sector is composed by many sub-sectors with different levels of technology input and whose characteristics are very different. These authors also indicated that the intangible nature of most services, the overlap of the moment of production and consumption, non-storability, low tradability, and the strong user-producer links are some of the features that render measurement studies in services extremely difficult. This shows the difficulty in studying services innovation and since the two sectors are somehow related the starting point should be comparing it with manufacturing which has already been largely studied, then comprehend the knowledge from manufacturing that can be used for services too and what should be studied from scratch to services.

When the word innovation is mentioned, people tend to assume an intrinsic relation with new physical and technology advanced products leading to this delay in studying innovation in services. However, as Gallouj and Savona (2008) mentioned services are no longer seen as passive “laggards” or “passive recipients” of innovation from manufacturing. The meaning of the word innovation itself has changed to a far more reaching concept which now includes services since as the Organisation for Economic Co-operation and Development (OECD) (2005) describes every new or improved product or process which has significantly changes from the previous has the potential of being an innovation.

1.1 Problem definition

For Pires *et al.* (2008), the study of service innovation is recent, since in the 1990s it was still largely neglected, which makes it nowadays still underrepresented in literature concerning the innovation topic.

Service innovation is a complex subject to study due to as revealed by Pires *et al.* (2008), its heterogeneity, variation from sector to sector to its intangibility and interactivity, however, to measure service innovation there must be some common ground on which research can rely on. For this dissertation, the main source of data will be the Portuguese CIS 2016 (Community Innovation Survey).

As written by Grönroos (1990) services are intangible activities that are produced and consumed simultaneously and that change the conditions (e.g., physical, psychological, etc.) of users. The engagement of users through their time, availability, attention, transmission of information, or effort is often a necessary condition that leads to the cooperation between users and services firms. The attributes or experience of a service can therefore depend on the input of users. This makes evaluation of almost every service activity dependent on the people's experience which makes the answers much more unpredictable leading to an increase on the complexity when producing a survey and studying its results.

Services innovation as Pires *et al.* (2008) testified has many times throughout the years been in the shadow of manufacturing firms and their technological innovation since this was regarded as being the main engine of economic growth. The service sector was then left behind being less intensive in technological innovation.

As years past by and the world turns its attention to innovation in services, innovation is being acknowledged as an important matter to be studied not as having a secondary role on this increasingly innovative world but as being one of the main characters since there is a growth in service companies and competition is focused on the services they provide to the customer.

Nowadays, the problem relates to the lack of consensus about the subject and its definition as Witell *et al.* (2015) declared, to share knowledge a precise definition and label is fundamental. These authors also affirm that the different approaches contribute to development of the research of service innovation but the lack of consensus in the definition creates confusion as different perspectives lead to different actions and use different methods. There are three main perspectives concerning the research of service sector innovation, namely: i) assuming as the same way as manufacturing (assimilation perspective); ii) as a completely different subject (demarcation perspective); and iii) more recently, the interest turned to study services innovation not as a completely different area but by understanding that there are some similarities and some differences when comparing with manufacturing (integrative perspective) and so integrating some research on manufacturing which can be used on services and research about services only. This leads to questions such as "What are the differences and similarities between these two sectors?" or "Are services more innovative than manufacturing?". There is

research trying to answer these questions, yet the conclusions are somehow vague and demand more robust conclusions to future studies showing that there is still much research to do on this topic and since the services sector is the engine of our economy is of greater importance understand as best as possible its behavior and more precisely its behavior related with innovation which is too a significant matter in the modern world.

The Portuguese economy like most developed countries is service based, having 75% of its Gross Value Added (GVA) belonging to services, 68,6% of employees work on services (aicep Portugal Global, 2017) and so CIS-2016 will be used as database to set determinants and variables to afterwards test research hypotheses which will help to look more specifically to the differences between the manufacturing and services sectors and to better characterize each one. Portugal is an interesting market since it came from a deep crisis (big recession) and used innovation as a major player to get out of it, being nowadays according to data from CIS-2016 the second most innovative country in the EU just behind Belgium. (Eurostat, 2016)

1.2 Structure

The structure of this document is as follows: literature review in section 2 where the different types of innovation will be outlined, along with their drivers and barriers, review of empirical evidence followed by the formulation of hypotheses. On the third section (data and methodology) the data gathered from CIS will be analyzed and the methodology will focus on studying the innovations on the service sector, how different companies behave towards innovation, the impacts they have on companies, how different subsectors tend to innovate, the role it plays on the success of the enterprise and understand how the service sector behaves in relation to manufacturing. The fourth chapter will be responsible to show the results of the models tested and the discussion of those results. Lastly some conclusions will be drawn considering the main findings of the thesis which enrich the study of this subject, its limitations and future lines of investigation which would enhance the comprehension about this matter.

2.Literature Review

In this section it will be explained the concept of innovation in services, the reasons that make this kind of innovation difficult to research, the types of innovation applied in services, the reasons companies need to innovate focusing on the innovation of services and how the different types are interconnected and used together.

2.1 Innovation

Innovation is probably one of the words read and listened the most in current days. The world is living the fourth revolution, revolution based in the search for new technologies which are considered innovations. Portugal strives to be an important player on this fourth revolution and has invested heavily in new technologies making this word even more spoken. However, these innovations are often related with technology and the word innovation has a much more embracing meaning. The OECD created a definition widely accepted.

“An innovation is 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.” (OECD, 2005: p. 46).

Even though it took decades to get to a consensus since the first author to present a definition was Joseph Schumpeter, he defined in 1930's five types of innovation (OECD, 1997, p. 28):

- Introduction of a new product or a qualitative change in an existing product
- Process innovation new to an industry
- The opening of a new market
- Development of new sources of supply for raw materials or other inputs
- Changes in industrial organization.

Innovation definition suffered many changes throughout the years and different authors defined it differently. As observed on Table 1, Schumpeter's definition influenced other definitions, such as Dosi (1988), West and Farr (1990), Nohri and Gulati (1996), Porter and Stern (1999) or McKinley, Latham, and Braun (2014). Their innovation definitions divided innovation in different types just as Schumpeter, they divided as product, processes, procedures, organizational, services, and they all agree with Schumpeter that there has to be something new and relevant introduced to be considered an innovation. The definition of OECD comprises these two aspects, divides in four types: product, process, organizational and marketing innovations and accepts innovation as something new or significantly improved.

Table 1 Evolution of the innovation's definitions

Source	Definition
Zaltman, Duncan, and Holbek (1973, p. 10)	<i>"...any idea, practice, or material artifact perceived to be new by the relevant unit of adoption."</i>
Roberts (1988, p. 13)	<i>"Innovation = Invention + Exploitation"</i>
Dosi (1988, p. 222)	<i>"...the search for, and the discovery, experimentation, development, imitation, and adoption of new products, new production processes and new organizational set-ups."</i>
West and Farr (1990, p. 9)	<i>"...the intentional introduction and application within a role, group or organization of ideas, processes, products or procedures, new to the relevant unit of adoption, designed to significantly benefit the individual, the group, the organization or wider society."</i>
Nohri and Gulati (1996, p. 1251)	<i>"...any policy, structure, method or process, product or market opportunity that the manager of the innovating unit perceived to be new."</i>
Porter and Stern (1999, p. 12)	<i>"...the transformation of knowledge into new products, processes, and services..."</i>
Carlson and Wilmot (2006, p. 4)	<i>"...innovation is the process that turns an idea into value for the customer and results in sustainable profit for the enterprise."</i>
McKinley, Latham, and Braun (2014, p. 91)	<i>"...any novel product, service, or production process that departs significantly from prior product, service, or production process architectures."</i>
Cambridge Dictionary (2020)	<i>"(the use of) a new idea or method."</i>
Merriam Webster (2020)	<i>"the introduction of something new"</i>

Source: adapted from Shaver, (2014)

From the analysis of the Table 1 and its definitions we get to the conclusion that the definition of innovation was widely accepted as a new or improved product, process or organizational set-ups which had to be exploited and perceived as something new or improved. The most recent definitions since Porter and Stern (1999) started giving importance to the service sector referring directly service or focusing on customers as the biggest beneficiaries acknowledging an increase in importance of innovation in service sector worldwide.

2.2 Types of innovation

According to OECD (2005), innovation is divided in four types, three of these come from the very first definition of innovation by Joseph Schumpeter, product, process, organizational, more recently marketing innovation was added. This division within the word innovation is used in the own OECD definition as a mean to better define an otherwise very complex definition.

2.2.1 Product Innovation

“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” (OECD, 2005: p. 48).

Zucoloto and Nogueira (2016) declared as product innovation, a product whose fundamental characteristics significantly differs of all products previously produced by the company. This type of innovation can include the initiatives, methods, techniques, and processes for making incremental improvements to existing products and services. It involves making evolutionary changes to the products employing the prevailing technologies and organizational capabilities (Rainey, 2015).

2.2.2 Process Innovation

“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” (OECD, 2005: p.49).

Sedkaoui (2019) stated that is establishing a new production or distribution method, or significantly improving an existing one, involving significant changes in techniques, material, and/or software. Process innovation, mainly focus on the introduction of a new operating method, or on the improving of existing one in the production, dealing with commercial, administrative, and managerial area. Then it increases efficiency costs, quality, and service by generating a new way of using a production (Giacosa, 2017).

2.2.3 Organizational innovation

The implementation of a new organizational method in the firm's business, workplace organization and external relations (OECD, 2005: p.383).

Eraso and Gosálbez (2015) understood organizational innovation as involving processes leading to the establishment or adoption of new production and management models, not only for production but also for tangible and intangible resources. Organizational innovation is part of the concept of innovation and development and accentuates new ideas and the propensity for change within organizations. It can be called process innovation and includes expenditures for innovation and development

in the calculation of cost. Implementation of a new organizational method in the firm's business practices. Organizational innovation can be defined based on the definition of Zucoloto and Nogueira (2016) as the implementation of new organizational methods in the firms practices in the organization of its workplace, in its external relations, as an improvement in the use of knowledge, workflows efficiency or quality of goods or services.

2.2.4 Marketing innovation

There are some definitions concerning marketing innovation, however these definitions tend to be closely related with the most accepted definition of the OECD.

“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” (OECD, 2005: p. 49).

This type of innovation is an ability and the process followed by an organization to keep improving its products and services ideas as well as marketing process to satisfy the need of the customers (Nadda and Arnott, 2019). Naidoo (2009) defined marketing innovation as improvements in product design, placement, promotion or pricing, and the likelihood of survival.

2.3 Services innovation

Grönroos (1990) identified innovation in services as the new service product, the new procedure for producing or delivering a service, the new organizational form, and the introduction of a new technology; services in most cases cannot be stored and must be produced in the moment of consumption. Hauknes (1998) claimed that a significant part of the innovation patterns in services is 'soft', or non-technological, even when restricted to product and process innovations. Then services innovation was defined by Sundbo and Gallouj (1999) as more an incremental innovation based on small adjustments of procedures, and these are rarely radical and dimensional. Some years later, Van Ark *et al.* (2003) defined innovation in services as a multidimensional process, less technological compared with manufacturing but with more emphasis on the organizational aspect. Even the own definition of service innovation is biased, where some say that a small change may be considered an innovation and others require significant changes to regard it the same way. Some definitions of service such as the ones from Sundbo and Gallouj (1999) or Enz (2012) who said that services innovation is based in more continuous improvement, which is not even in agreement with the most accepted definition for innovation itself since for OECD (2005) to be an innovation it must be new or significantly improved.

Nonetheless as years past by researchers are getting to a consensus, where services innovation is based on small adjustments and less of technologically based and more organizational. However, getting to a completely consensual definition on this topic will be challenging because, as mentioned by Álvarez *et al.* (2015), significant amount of research has shown service sector as being

much more heterogeneous than manufacturing and the way innovation occurs is different from traditional technological innovation.

Table 2 Definitions for service innovation

Study	Definition
Oke (2007, p. 566)	"New developments in activities undertaken to deliver core service products for various reasons, e.g., to make those core service products more attractive to consumers."
Toivonen and Tuominen (2009, p. 893)	"a new service or such a renewal of an existing service which is put into practice, and which provides benefit to the organization that has developed it; the benefit usually derives from the added value that the renewal provides the customers. In addition, to be an innovation the renewal must be new not only to its developer, but in a broader context."
Cheng and Krumwiede (2010, p. 162)	"Fundamental change in services that represent revolutionary changes in technology or service benefits."
Lin, Chen, and Chiu (2010, p. 114)	"Manufacturer's engagement in various innovation activities to enhance customer satisfaction, including after-sale services, warranty policy, maintenance routines, and order placement systems."
Salunke, Weerawardena, and McColl-Kennedy (2011, p. 1253)	"As the extent to which new knowledge is integrated by the firm into service offerings, which directly or indirectly results in value for the firm and its customers/clients."
Enz (2012, p. 187)	"The introduction of novel ideas that focus on services that provides new ways of delivering a benefit, new service concepts, or new service business models through continuous operational improvement, technology, investment in employee performance, or management of the customer experience."
Jian and Wang (2013), p. 27)	"Enterprise's intangible activities formed in the process of service, using a variety of innovative ways to meet customer needs and maintain competitive advantage."
Giannopoulou et al. (2014), p. 25)	"A type of product innovation involving the introduction of a service that is new or significantly improved with respect to its characteristics or to its intended uses."
Breunig et al. (2014, p. 46)	"New service experience or service solution that consists of one or several of the following dimensions: a new service concept, new customer interaction, new value system/business partners, new revenue mode or new organizational or technological service delivery system."
Biemans, Griffin, and Moenaert (2015, p. 2)	"Process of devising a new or improved service, from idea or concept generation to market launch."

Source: adapted from Witell et al. (2016)

By analyzing the Table 2, we observe some similarities between the different definitions, some of those similarities derive from some already established assumptions like a service innovation being something new or significantly improved which come from the definition of innovation or being intangible, which is a characteristic of services. However, when comparing these newer definitions with the older ones, these modern definitions as being much more specific by defining the increase in value, the creation of benefits, or the enhancement of the experience for the users as the main objective and by being much more specific about how those improvements can be achieved. Even though the older definitions are much more abstract mainly due to the fact of services innovation being a relatively unexplored topic, modern definitions have much of the older ones implicit. By reading Table 2, services innovations are based as Hauknes (1998) found on softer innovation patterns, or as expressed by Sundbo and Gallouj (1999) incremental improvements, or even as Van Ark *et al.* (2003) stated on a multidimensional process as. The concept of services innovation has been evolving over the years and becoming more defined.

2.4 Reasons to innovate and barriers to innovation

Enterprises on the XXI century are very competitive and always looking for advantages relative to competitors since they are aware that it could be the difference between thriving or disappearing and in a fast-paced world like today's companies can easily miss the opportunity. Even though the main goal of companies either from the services sector or manufacturing when innovating is to maintain a competitive advantage against the competitors, as Michel *et al.* (2008) affirmed their target is completely different as services innovate in order to create value for the customer by enhancing the user's experience.

When trying to innovate, the two sectors share some barriers, Gault (2018) revealed in-house and external research and development (R&D), capital expenditure, human resource development, design and market development as activities which require financial efforts and training that some companies might have difficulty on fulfilling. Becheikh *et al.* (2006) concluded that the results of their study seem to suggest a positive correlation between firm size and innovativeness, making it a barrier for small firms to compete, even though, Scherer (1991), findings suggest small firms have management structures that are more flexible, less bureaucratic and with less inertia all of which favors innovation, but only in services innovation, size has a smaller role than in manufacturing firms. Firm age can be a barrier, younger firms are expected to be more innovative, older firms often get entrenched in established procedures that create a resistance to the integration of major external advances and thus represent a barrier to innovation (Freel, 2003). However, older firms may have benefits when entering new market or when trying to obtain finance or even by the know-how they gained over the years Pires *et al.* (2008).

Barriers identified, such as the lack of implementing good measures to improve innovation performance, the difficulty in employing an effective process to develop innovation, the difficulty in

protecting service innovations with patents, or developing ideas not easy to be copied appear to be related with services and its intangibility. However, companies which recognize the difficulty of having an effective innovation process as a barrier, tend to have better innovation performance (Oke, 2004). As mentioned, by Djellal *et al.* (2013), the obstacle of protecting services intangible innovation using IPR mechanisms like patents making sometimes the innovation not worth it, however creating some tangibility to the product (loyalty cards, media platforms) may be helpful.

2.5 Innovation Drivers

Innovation drivers are factors either internal or external which have influence on innovations development. There are almost infinite external factors and those are normally uncontrollable, the ones that a company can control are the internal, the focus will be on those. Knowing why you are innovating is what defining drivers is all about, which is a necessary condition for success (Baporikar, 2014). For Baporikar (2014), enterprises are driven to innovate when they need to get out of a crisis or respond to a threat which are straightforward drivers since companies can easily identify when it's time to make a change and innovate, costs get out of control, revenue decreases or shift in customer sentiment. Threats are normally seen as a new competitor entering the market, or the company losing some important personnel. Organizations that are very successful tend to have already a defined strategy concerning innovation since they know that on-going innovation is the key for success. Then there are the corporations which are generally successful and established that keep on looking for innovations keeping transformative growth or change to keep an advantage against the competitors and maintain the organization successful. Hauknes (1998) affirmed that two market forces shape innovation patterns, client intensity and participation and cost/price competition. Stating too that four actors define the market possibilities and are also sometimes involved in the development of the innovation, the customers are of major importance, the competitors creating pressure to innovate, suppliers are an important source of innovation too and lastly the public sector and public policy agents which play a multiplicity of roles, such as being competitor, customer, supplier and carrying out its role as a regulating authority. According to OECD (2018) the drivers for innovation are divided in competition, demand, and markets in which are inserted reasons such as products phasing out, increasing range of goods and services, increase or maintain market share or enter new markets. Production and delivery which is divided in improving the quality, the flexibility of production and capacity of production of goods or services and reduce costs. In the workplace organization segment, the drivers include improving the interaction between business, increase sharing knowledge, ability to adapt to clients demand or improve relationship with customer and improve working conditions. Other drivers may be reduction of environmental impacts or meet regulatory requirements. Table 3 shows internal determinants of innovation, adapted from the work of Becheikh *et al.* (2006), which serves to better understand and organize some of the important determinants which influence innovation on each company. It shows that many variables should be taken into account and played a role when trying to innovate.

Table 3 Internal determinants of innovation

Category	Subcategory	Variables
Firms' general characteristics		Size of the firm
		Country
		Part of a group
		Multinational
		Past performance
Firms' global strategies	Strategy definition	The firm has a defined strategic orientation
	Corporate strategy	Diversification strategy
		Export/internationalization
	Business strategy	Differentiation strategy
		Price strategy
		Improvement strategy
		Cost reduction strategy
		Intellectual property
Firms' structure	Organization	New/improved procedures
		Decision making methods
	Interaction	Cooperation between firm's units
		Interaction with customers
		Cooperation with other firms
		Cooperation with universities
Control activities		Financial or strategic control
		Security Control
		Environmental control
Firms' culture		Resistance to change
		Quality management /continuous improvement
		Culture of support for innovation
Functional assets and strategies	R&D	R&D assets and strategies
	Human resource	Personnel qualification/experience
		Human resource strategies
	Operation and production	Advanced equipment/technologies
		Degree of capacity utilization
	Marketing	Marketing strategies
		Monitoring of competitors
	Finance	Financial autonomy
		Profit/turnover
		Taxes
		Budget/funds availability

Source: adapted from Becheikh et al., (2006)

Polder and Leeuwen (2010) also pointed out some differences between manufacturing and services saying that R&D drives the output of product innovation and organizational and process innovation get affected too in the manufacturing sector. However, on services sector there is no evidence of R&D affecting the output on any type of innovation. In service innovation, ICT are most important for success since it was shown to have a positive effect on all types of innovation regarding this sector.

2.6 Services Innovation Approaches

For Gallouj *et al.* (2013), there are four different approaches used in literature about the innovativeness of services, the assimilation approach, then the demarcation approach, the synthesis or integrative approach and lastly the inversion approach which is the one not so widely used it studies some services industries as being the source of innovation across the whole economy. These perspectives aim to reflect different conceptions in the relationship of service innovation studies against the already established studies of services innovation emphasizing on the manufacturing sector and their products. Only the first three approaches used by Gallouj *et al.* (2013) were considered by Álvarez *et al.* (2015), Castro *et al.* (2011) and Witell *et al.* (2016) .

The first approach is the “assimilation approach” which considers services as being innovative, however this approach considers services innovation as being done in similar ways as manufacturing innovation making many of the knowledge from manufacturing innovation transposable to services. This perspective is mostly related with a science and technology focus the diffusion of ICT’s and sectoral technological taxonomies it can also be seen as technologist perspective since it focuses on their relationship with technological systems studying service innovation just being goods innovation (intangible goods).

The second approach is the “demarcation approach” which is based on the intangible and interactive nature of services, arguing that services innovation is quite distinct to manufacturing innovation leading to a need of new theories, instruments and measurements studying its features independently to manufacturing to better understand innovation in the service industry. It is often inspired by the case study work in service marketing, operations management and in new service development, identifying innovation activities where the assimilation perspective perceives nothing.

These two approaches have evolved into the “synthesis approach” or “integrative approach” which is the least developed, stating that these two sectors do not follow completely different paths and so there is no need to look at them by two completely distinct perspectives, however there are some differences between the innovation activities of each of them and so what has been studied concerning manufacturing can be analyzed and integrated with studies regarding services innovation from the “demarcation perspective”. This perspective is seen to be of great importance in a world where manufacturers are “servicising” and service firms “productizing” where major economic project and social functions involve combinations of goods and services, of technological and organizational change.

The fourth perspective used by Gallouj and Djellal (2013) the “inversion approach” which as he emphasizes is a “revenge” of the service sector. This sector is sometimes seen as the “laggards” of innovation meaning that they are much less innovative than manufacturing, yet this approach focuses on some services industries and its large firms as sources of innovation throughout the economy (e.g., retail, telecommunications).

CIS started on an era where service innovation was not widely studied and taken into account and so when services became part of the survey it started by an “assimilation approach” using manufacturing theories and measurements to services, yet Smith (2005) stated that the survey works well for manufactures, but not for the extremely heterogeneous services sector and its often intangible output since services innovation behave in a different manner are more incremental as Sundbo and Gallouj (1999) and as Van Ark *et al.* (2003) defined services innovation as multidimensional process, less technological and more organizational, making an use of the older CIS surveys not fit for the study of services. Nevertheless, it was acknowledged that a greater attention should be given to services and the survey approach started changing, considering services sector.

2.7 Empirical Evidence

Even though this survey is for EU and carried out with two years frequency, not all countries compile data on every survey meaning that different countries are involved on every publishing. Some of these countries even carry out their own surveys regarding their own companies. For example, in Spain there is PITEC, yet is based on CIS. Some use EFIGE which is related to the collection of data from seven European countries (Germany, France, Italy, Spain, United Kingdom, Austria, and Hungary) companies and their international activities. Deloitte also published a survey in 2019 on this topic regarding 760 European firms from 16 countries (Andersen *et al.*, 2019). Table A1 in the appendix synthesizes and organizes the empirical evidence gathered and studied in this dissertation.

By analyzing Table A1, Andersen *et al.* (2019) got to the conclusion that nine out ten are companies in Europe are keen to increase their budget in innovation. However, Andersen *et al.* (2019) found that businesses are focusing too much on technological innovation forgetting that good structure and personnel are essential to be successful “*Avoid the trap of focusing on technology alone*” (Andersen *et al.*, 2019, p 23). The multidimensionality of innovation is something worrying Andersen *et al.* (2019) since only 10% of companies in Europe are using the four different types of innovations showing that companies are missing opportunities by not trying to innovate in other aspects either organizational, process, marketing, or product. Andersen *et al.* (2019) also concluded that companies are not cooperating enough with universities for example, in the search for skilled employees which would benefit the search for innovation in services since this sector has a strong dependency on ICT and personal relations.

Being CIS the most used European database when studying innovation, evidence and conclusions related to the results of that survey are written as a summary and organized by iteration of the survey and author on Table A1, since 1993 there have been new iterations every two years. On CIS-1, as stated by Guellec and Pattinson (2001), the survey concentrated almost solely on measuring innovation in manufacturing sector. Services were completely excluded in CIS-1. However, on CIS-2 some service sector industries were included. Showing an increase in the recognition of services importance (Pires *et al.*, 2008). As Hauknes (1998) and Tether (2005) stated CIS-2 approach is an important ad-

vance towards a fuller and better mapping of innovation in services. Yet this survey only referred technological innovation using an assimilation perspective which for Tether (2005) is a narrow perspective as the own definition of innovation shows a much more embracing meaning than just related to technology. As shown in Table 4 innovation rate depends on the subsector. Each shows a different rate being generally manufacturing more innovative than services. Yet telecommunications and computer and related activities are the exceptions being as innovative as manufacturing firms. However, this table is from a time where the study of services innovation was almost solely made based on the assimilation perspective where services were “laggards” or “passive recipients” from the manufacturing industry (Gallouj and Savona, 2009). This table was then created probably with not the most fitting assumptions to the services sector.

Table 4 Share of innovative firms EU countries by industry (1994-1996)

Manufacturing	
Food, beverages, tobacco	50
Textiles, leather	35
Wood, pulp, paper, publishing	45
Coke, chemicals	70
Rubber, plastic	51
Basic metals and fabricated products	48
Machinery and equipment	68
Electrical and optical equipment	69
Transport equipment	56
Manufacturing,	48
Total manufacturing	51
Services	
Wholesale trade and commission trade	34
Transport	24
Telecommunications	65
Financial Intermediation	54
Computer and related activities	68
Engineering services	55
Water, gas and electricity	35
Total services	40

Source: Eurostat (1996) apud Guellec and Pattison, (2001)

Pires *et al.* (2008) found that more recent surveys have been paying more attention to services innovations which has been happening from survey to survey, just like on CIS-3 where the focus shifted from technological innovation and started focusing on a more embracing definition of innovation, closer to the one used today, yet mentioning only a new or improved product which as we know today mainly for service sector is a narrow definition due to dependency of service companies on every type of innovation. Hipp *et al.* (2005) showed based on CIS that German market was lacking in

skilled personnel which they concluded it was going to hinder the move towards a service society. Teixeira and Bezerra (2016) found when studying the Portuguese economy that human capital was an important determinant of innovation in services but only up to undergraduates, companies with a higher proportion of employees with PhD degrees tend to be less innovative and that the participation in cooperation activities has a positive effect on innovation.

This shift from sector has been exponential for past few years due to the advancements on the information and communication technologies made services nuclear and not seen any more as the “passive recipients” of technology coming from manufacturing made as Gallouj and Savona (2008) said, the service sector represents the core engine of a knowledge-based economy, but their most important analytical problem is the fuzzy nature of their products due to its intangibility. By observing Table A1 we can understand that these authors reviewed various papers about the three approaches of innovation and concluded that for them the integrative approach is the most promising in terms of theoretical advancement because of the boundaries between products and services which have been becoming more subtle, this has been happening with tangible and intangible products too. Van Ark *et al.* (2003) agreed with the subtleness of the boundaries since they mentioned that the distinction between the two sectors is increasingly disappearing.

When comparing manufacturing with services there is evidence from developed and some developing economies that service sector is as innovative as the manufacturing (Zahler *et al.*, 2014). The objective of both innovation strategies consists of improving service/product quality, increase market share and reduce costs (Sirilli and Evangelista, 1998). There are some differences concerning innovation between them such as what Hauknes (1998), Van Ark *et al.* (2003), Tether (2005) and Castro *et al.* (2010) stated that service innovations were less of technological than manufacturing but more innovative on organizational aspect.

Tether (2005) and Aboal *et al.* (2015) testified that services are often oriented to continuous change instead of a series step wise jump. Castro *et al.* (2010) also affirmed that services characteristics make innovations in systems and the ways of doing things more important than technological innovation, observing too, differences between services subsectors stating that financial sector is the most innovate in all types of innovation (product, process, organizational) but for the improvement of design and packaging (marketing innovation). Hipp (2005) said that data, information, and knowledge are intangible goods produced and traded especially by the service sector and that organizational and social aspects which are key drivers in services were increasingly being considered.

Size is one of the most studied variables as a determinant of innovation finding a positive correlation between firm size and innovativeness. Becheikh *et al.*, 2006 argued innovation costs are higher, in relative terms, for a small firm than for a large firm but small firms may have a more flexible management structure in favor of innovation. Pires *et al.* (2008) also concluded that only large firms with market power can get the return for the investment in R&D which is very risky for small and medium firms since they will spend a higher proportion of their resources being vulnerable to the uncertain outcome of the process. On the other hand, large firms may maintain a more diversified portfolio of

innovation projects. These authors also found that being part of a multinational group has an impact mainly in product innovation on services showing for multinational group is easier to service innovations to its subsidiaries. Concluding that being part of a group for a given size and level of R&D affects innovation. Zahler *et al.* (2014) said that services have a lower propensity to export than manufacturing, yet the size of the service firm has little correlation with the propensity to innovate due to the dependency of services on skills rather than scale he also stressed that only larger firms have the means to pay the high fixed costs for exportation saying too that taking into account that services are less standardized and more customizable need a close relationship with customers hence higher fixed costs to enter other markets. Álvarez *et al.* (2015) claimed too that size seems to be less important in the service sector than in manufacturing to engage in innovation and exports and that being an exporter, having some intellectual rights protection has positive effect on the probability of engaging in innovation investment but being foreign owned has no correlation with higher or lower innovation investment. Álvarez *et al.* (2015) also said that there is a positive relationship between expenditure on innovation and the size of the company. As a motivation to innovate Sirilli and Evangelista (1998) showed that the expenditure per employee in services is very close to manufacturing. These authors concluded that exporters have a much higher probability of innovating both in manufacturing and services.

Research shows that services are much more heterogeneous than manufacturing and innovation occurs in many ways from traditional technological innovation and that size is less important in services than in manufacturing and cooperation is more important for services (Álvarez *et al.*, 2015).

When engaging in cooperation for innovation activities, Faria *et al.* (2010) argued that companies from either services or manufacturing which take advantage of knowledge generated elsewhere improve the probability to be a successful innovator and show on average a higher level of performance. There are two types of partners, one which builds on the company existing knowledge and another which only provides the knowledge, normally governmental labs, or universities. It was also acknowledged that firms with higher levels of absorptive capacity, exports, innovation intensity, and are part of a group are more probable to participate in cooperation agreements. Camacho and Rodriguez (2005) stated that cooperation between companies and between other partners such as customers, suppliers, universities, and research institutes must be taken into account since cooperation is key for success in the innovative process due to the extreme complex environment and the demand for knowledge. Authors such as Hsueh *et al.* (2010) also stressed the importance of the cooperation with other entities by saying that companies which keep close links and mutually trust each other exchange knowledge create a positive effect in their innovative performance which is in accordance with Vermeulen *et al.* (2005) who expressed those other partners were affected in the way knowledge and information was exchanged. Hsueh *et al.* (2010) and Vermeulen *et al.* (2005) also declared that cooperation with suppliers and competitors was most relevant. Schmidt and Rammer (2006) claimed that companies that kept cooperating with external partners were more likely to introduce innovation. Arvanitis and Bolli (2012) indicated multinational cooperation as being more important to innovation in a globalized market as our world has been becoming. International cooperation as these last authors

suggest shows a positive influence whereas national cooperation has not so much relevance. For Portugal, services, and manufacturing show the same results, yet international cooperation is stronger in the manufacturing industry than in services.

There is evidence showing R&D as a major actor on a company's innovativeness as Pires *et al.* (2008) mentioned there is a positive correlation between innovation and R&D expenditure. These authors and Teixeira and Bezerra (2016) found for services that internal R&D has a bigger impact on innovation compared to manufacturing, cooperative R&D as being more important for pioneering innovation in services and acquisition of machinery and equipment as being relevant for internal and external R&D on both sectors. On the other hand, for Tether (2005) manufacturing was more likely to source advanced technologies through in house R&D to acquire advanced machinery and equipment yet still sourcing technologies through cooperation. Services place more emphasis on R&D from cooperation and less emphasis on acquired technologies being the skills and professionalism of the workforce crucial. In comparison services innovations tend not to require formal R&D since its innovations are incremental, yet ICT, telecommunications, software, training, and marketing are more important for services than manufacturing (Tether, 2005; Aboal *et al.*, 2015). However, evidence shows that companies in services which continuously invest in R&D activities are more innovative, yet these activities are not formally organized (Teixeira and Bezerra, 2016).

The capacity of the firm to absorb knowledge created elsewhere as Freel (2005) stated depends on the quality of the human resources stating too that companies that present novel innovation in product tend to employ more technicians' engineers and scientists even more in the case of services where training is greatly associated with the process of innovation.

Pires *et al.* (2008) use the number of higher educated employees as a measure of the absorptive capacity of the firm, expecting it to affect the probability of the company being an innovator. As they do with training activities, expecting the effect of the absorptive capacity and human capital to be stronger on service firms. Teixeira and Bezerra (2016) conclude that human capital is an important determinant of innovation but only to the 1st cycle (undergraduates), since companies in services with higher percentage of PhD employees were less innovative. They also concluded that services companies tend to employ more technicians and engineers/scientists providing intensive training which in the service sector is highly associated with innovation. For Pires *et al.* (2008) and Schmidt and Rammer (2006) the activities which help to enrich the expertise and knowledge of employees is meaningful towards innovation

These differences and similarities are summarized too on Table A1 which after scanning it, lead to the conclusion that service and manufacturing sectors show more similarities than differences, yet those differences do exist and must be considered regarding basic dimensions of the innovation process.

Even though as we observe in Table A1 not many papers base their study on the Portuguese market. However, on a paper based on CIS-3, services innovation in the Portuguese economy and the differences to the manufacturing sector, Pires *et al.* (2008) concluded that service firms are not behind

manufacturing in terms of innovation. Some differences were observed by these authors such as human capital being more important for innovation in the service sector. Size having a smaller impact on services than manufacturing. Continuous improvement and experience gained with practice has more importance in service companies process innovations which is in accordance with Tether (2005) and the absorptive capacity in service firms is positive for product and process innovation comparing to being positive just for process in manufacturing firms which allow us to conclude that the integrative approach is more suited for services innovation.

Table 5 Share of technological innovation (1994-1996)

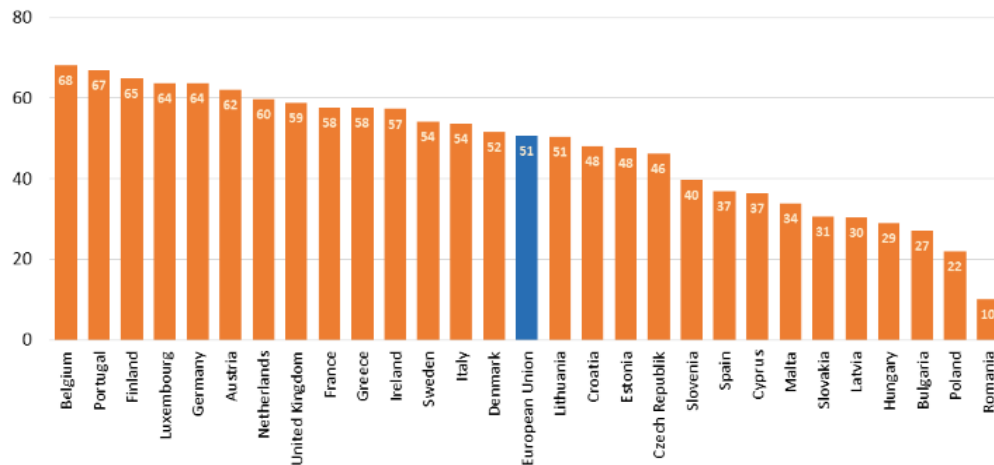
	Manufacturing	Services
Ireland	73	58
Denmark	71	30
Germany	69	46
Austria	67	55
Netherlands	62	36
Sweden	54	32
Italy	48	n.a.
Norway	48	22
France	43	31
Luxembourg	42	49
Finland	36	24
Belgium	34	13
United Kingdom	34	40
Spain	29	n.a.
Portugal	26	28
All countries	51	40

Source: Eurostat (1996) apud Guellec and Pattison, (2001)

Table 5 shows data from CIS-2 for Portugal showing that this country is the worst rated country in manufacturing innovation in the European Union of 15 countries. However, Portugal had already a higher service innovation rate than some countries and when comparing to manufacturing even though at that time the definition of innovation was almost solely related to technology which was then proven to be narrow.

André *et al.* (2002) asserted that in Portugal the number of companies have been increasing particularly in business services. Growth in this sector is reflection of the modernization of the economy by the increase in demand for specialized services form companies. Twenty years passed since CIS-2 and Portugal became one of the most innovate countries on EU-28 as seen in Figure 1.

Figure 1 Share of innovative enterprises 2016



Source: adapted from Eurostat CIS-2016 results

Despite being difficult to compare the data since over these two decades many changes have been made since CIS-2 which did not have much concern about services to CIS-2016 where services play a major role and from an EU of 15 to an EU of 28. These 67% of innovative enterprises as seen in Figure 1 makes Portugal the 2nd most innovative country only behind Belgium and puts Portugal as more innovative as the big powerhouses of Europe such as Germany, UK, and France and 16% higher than the UE average. As concluded in CIS-2016 58% were related only to product or process innovation, 32% related to organizational innovation and 37% to marketing innovation.

In summary, services were still in the 90's seen as having a secondary role in innovation, however during that decade services started to be more studied and increasingly being considered not only in CIS but in many papers. This sector has seen a great increase in importance since the turning of the century, as developed countries economy is based on services. However, focus on services innovation was soon understood as being difficult to study due to its intangibility and fuzzy nature. As years pass by, the integrative approach is being increasingly accepted as the one to follow meaning that services and manufacturing even though have differences, share some similarities. In the Portuguese market the differences and similarities are common with the remaining EU, on this country specifically the evolution in terms of innovation has been great from being the least innovative at the start of the CIS survey to being one of the most innovative, reflecting what is commonly seen daily about the strive of being on the vanguard of innovation.

2.8 Hypotheses

Innovation in services is a relatively new subject of study which was rapidly understood to be a complex topic to study. Two decades passed and there is no consensus about the definition of services innovation since as written above services are pretty much intangible, heterogeneous, behaving differently between subsector, and have a fuzzy nature making it difficult to make an unambiguous definition. This type of innovation is gaining importance since developed countries, in particular, Portugal has been shifting their economy to a service-based one and companies have been focusing more and more on the service they provide. However, after 20 years this subject is still complex mainly due to service sector as being much more heterogeneous than manufacturing and the way innovation occurs is different from traditional technological innovation (Álvarez *et al.*, 2015).

Several papers provide information about how the customer plays a major role in service innovation and how it impacts companies, as firms nowadays widely accept that the service a firm provides is based on the creation of value and give advantages over the competitors selling not only the product, but the experience (Fondevila, 2019). Giannopoulou *et al.* (2014) expressed that service innovation is based on human factors such as motivation, culture, or leadership and that the success of service innovation is largely dependent on creativity. As Lin *et al.* (2010) pointed out service innovation is the manufacturing approach to innovate by enhancing customer's satisfaction. Most authors showed that service innovation is multidimensional depending on all types of innovation (Van Ark *et al.* 2003; Breunig *et al.* 2014; Enz 2012; Sundbo and Gallouj, 1999). So, service innovation even though is mainly related with the service sector, companies from the manufacturing sector can gain advantage over the competitors by investing in services innovation, improving the experience they provide to customers.

The comparison of the two target sectors will depend on testing different hypotheses which will use CIS 2016 for the creation of new variables, joining variables already existing on the database which will give answers closer to what is needed to then test the hypotheses. Knowing the objective of this dissertation four hypotheses were created to be tested:

Hypothesis 1 will test if on each sector the size of the company has some impact in the propensity to innovate. Pires *et al* (2008) stated only larger firms with market power can get the return from the R&D investment and being part of a group impacts innovation. Álvarez (2015) discovered that there is a positive relationship between expenditure on innovation and the size of the company. For these two authors and Hipp and Grupp (2005), size has a greater impact in manufacturing companies and Zahler *et al.* (2014) found that in services size has little correlation with innovation and only large firms have the means to pay the fixed costs of exportation. Lastly, Becheikh *et al.* (2006) supported that innovation costs are higher for a small firm than for a large firm, but small firms may have a more flexible management structure in favor of innovation. This leads to the following hypothesis:

Hypothesis 1 (H1): Size positively influences innovation activities.

Hypothesis 1a (H1a): Size positively influences innovation activities in services companies.

Hypothesis 1b (H1b): Size positively influences innovation activities in manufacturing companies.

Andersen *et al.* (2019) concluded that especially service companies would benefit from more skilled employees, while Teixeira and Bezerra (2016) said that for the Portuguese services market employers' skills were important determinant of innovation but only until undergraduates. They concluded that services companies tend to employ more technicians and engineers/scientists providing intensive training which in the service sector is highly associated with innovation. For Pires *et al.* (2008) and Schmidt and Rammer (2006) human resource training is positive and significant for pioneering. Zahler *et al.* (2014) affirmed that services had a greater dependency on skills, so hypothesis 2 will test how the level of education of employees impacts each sector, and which one is more dependent on human graduated employees to innovate.

Hypothesis 2 (H2): Higher percentage of graduated employees positively influences innovation.

Hypothesis 2a (H2a): Higher percentage of graduated employees positively influences innovation in service companies.

Hypothesis 2b (H2b): Higher percentage of graduated employees positively influences innovation in manufacturing companies.

Cooperation is a subject studied by several authors. For example, Andersen *et al.* (2019) found a lack of cooperation between companies and other entities for example universities. For Teixeira and Bezerra (2016) and Schmidt and Rammer (2006), cooperation has a positive effect on innovation, while Álvarez *et al.* (2015) saw cooperation as more important in services. Camacho and Rodriguez (2005) claimed that cooperation between companies and between other partners such as customers, suppliers, universities and research institutes is crucial for the innovativeness of the company while Hsueh *et al.* (2010) and Vermeulen *et al.* (2005) sustained the cooperation with other entities saying that companies that keep close relationships exchange knowledge creating a positive effect in

innovativeness adding that cooperation with suppliers and competitors was most relevant. Given this information a hypothesis can be made:

Hypothesis 3 (H3): Engagement in cooperation activities positively influences innovation.

Hypothesis 3a (H3a): Engagement in cooperation activities positively influences innovations in service companies.

Hypothesis 3b (H3b): Engagement in cooperation activities positively influences innovation in manufacturing companies.

Hypothesis 4 will be tested based on the expenditure in R&D of companies which will lead to a conclusion on the impact of this on the innovativeness of a firm. Tether (2005) and Aboal *et al.* (2015) stated that services tend not to require formal R&D due to incremental nature of their innovations. Teixeira and Bezerra (2016) and Zahler (2014) found evidence which shows services companies investing more in R&D as being more innovative. Pires *et al.* (2008) found a positive correlation between innovation and R&D expenditure. These authors and Teixeira and Bezerra (2016) declared for services, internal R&D and cooperative R&D has a bigger impact on innovation compared to manufacturing, but the acquisition of machinery and equipment as being crucial for both sectors. On the other hand, for Tether (2005) manufacturing companies are more likely to source advanced technologies through in house R&D and to acquire advanced machinery and equipment while services place more emphasis on R&D from cooperation and less on acquired. Knowing this information, a fourth hypothesis can be formulated:

Hypothesis 4 (H4): Expenditure in R&D positively influences innovation.

Hypothesis 4a (H4a): Expenditure in R&D positively influences innovation in service companies.

Hypothesis 4b (H4b): Expenditure in R&D positively influences innovation in manufacturing companies.

3 Data and Methodology

The present chapter presents the source of data to be used in the study – CIS (Community Innovation Survey), as well as the variables it will consider and the proposed methodological approach.

3.1 Data

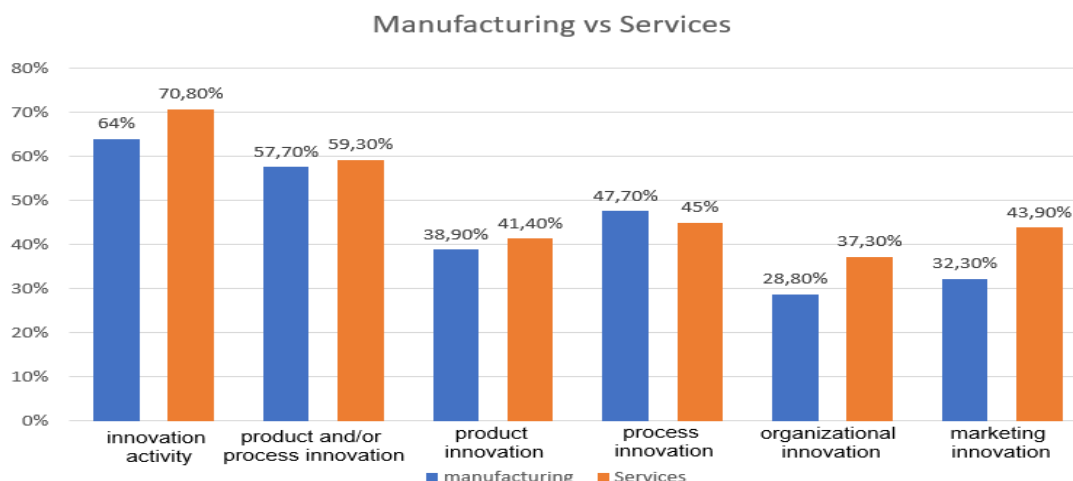
For the present dissertation, CIS will be the source of data, since this survey has been performed in European countries for almost 30 years and is widely used and accepted as being a trustworthy tool. When this survey started in 1992 it was based in the 1992 Oslo Manual and focused on manufacturing only. On CIS-2 in 1996 a big improvement was the inclusion of some industries from the service sector and the number of countries taking part increased (Guellec and Pattison, 2001). On CIS-3 started the concern about surveying service companies using a broader definition of innovation, which would suffer many changes (Pires *et al.*, 2008). This sector would soon become an important part of the survey. The results used will be from the CIS 2016 (2014-2016) referring to Portuguese companies only. Portuguese CIS data is supplied by DGEEC (Direção Geral de Estatísticas da Educação e Ciência) which presents statistical summaries from the innovation survey. From a starting sample of 9601 companies only 8934 (93,1%) were considered on a corrected sample. 667 companies were taken of the sample due to some temporal lag to not fulfilling the initial criteria or due to an ending on their activity. According to the data from the corrected sample from the 8934 considered companies 6775 answers were validated which makes it 75,8% of valid answers (DGEEC, 2018).

From the 6775 valid answers, 4526 (66,8%) Portuguese companies developed some innovation activity between the two years of the survey, these include the four types of innovation (product, process, organizational and marketing) and the unfinished or abandoned innovation activities count to this number. Regarding innovation activities, 3957 (58,4%) companies presented some product and/or process innovation but only 2195 (32,4%) companies presented organizational innovation and 2520 (37,2%) companies performed marketing innovation.

According to data from innovation activities in CIS 2016, service firms as shown in figure 2 implement more innovation than manufacturing firms, i.e., 70.8% comparing to 64%. However, within each sector some subsectors stand out such as oil, chemistry, and pharmaceutical industry where 79.6% of companies innovate and motorized vehicles electric equipment and ICT having 78.9% of companies innovating. However, on the contrary some subsectors tend to innovate much less such as electricity, gas, and water with only 51% of firm's innovation and textiles with just 51.8% having any activity towards innovation. The most innovative subsector belongs to services being the healthcare with 81,9% of firms innovating followed by telecommunications and ICT consultants with 78,6%. Despite the second and third more innovative subsectors being part of manufacturing the less innovate are too, since the less innovative companies from services are from the legal and accounting services with 59,1% innovating followed by 59,6% of transports (DGEEC, 2018).

When comparing the percentage of companies who use each type of innovation services have an advantage on all types but process innovation. However, the biggest differences occur on organizational and marketing innovation which are typically more service focused innovation activities.

Figure 2 Percentage of innovation activities per type and sector



Source: adapted from DGEEC, (2018)

The Portuguese economy is mostly a service-based economy like most developed countries, as 69,9% of the workforce belongs to services and 75,8% of the GVA comes from the service sector showing the importance of better understanding how to approach innovation in services.(aicep Portugal Global, 2017). This sector as revealed by Álvarez *et al.* (2015) is much more heterogeneous than manufacturing this is partly due to the distinct characteristics between each subsector. In CIS-2016 services sector are divided as indicated by CAE (Economic Activities Classification), this is dedicated to Portugal however this classification is harmonized with the European classification (NACE) and it was divided in 10 subsectors as shown in the Table 6 below:

Table 6 Services subsectors used in CIS

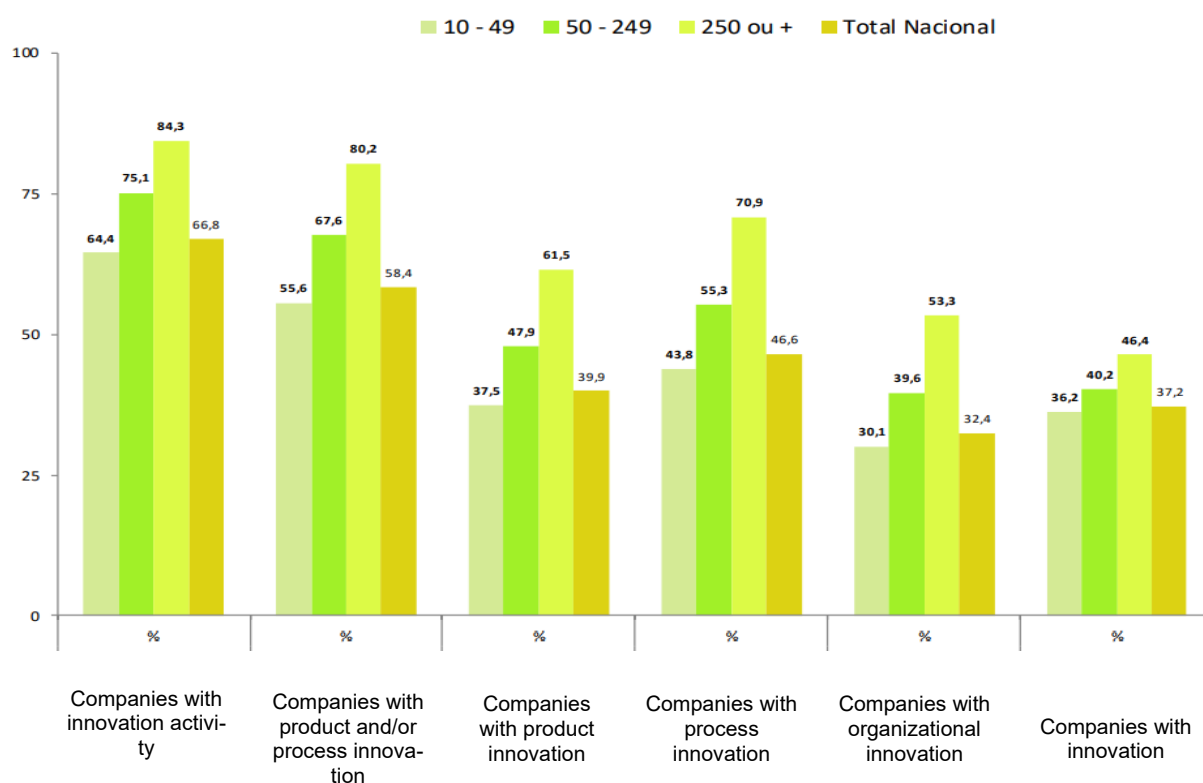
Wholesale and retail trade; repair of motor vehicles and motorcycles
Land transport and transport via pipelines, water transport and air transport
Warehousing and support activities for transportation and postal and courier activities
Publishing activities
Telecommunications and Computer consultancy
Financial and insurance activities
legal and accounting activities
Architectural and engineering activities; R&D and advertising
Other activities of consultancy, scientific and veterinary activities
Human health

Source: adapted from DGEEC, (2018)

Even though there are some subsectors which are substantially different from each other the definitions for service innovation still applies since their purpose is the same, creating value for the customer which leads to a pursuit of innovations aiming to have advantages over competitors.

According to CIS the large companies are more innovative (DGEEC, 2018). By looking at Figure 3, 84,3% of the firms with more than 250 employees presented some type of innovation between 2014 and 2016 followed by companies with an employee personnel between 50 and 249 employees (medium sized firms) with 75,1% innovating and lastly small companies having from 10 to 49 employees had an innovation activity rate of 64,4%. This trend is noticeable when looking to each type of innovation where large companies innovate more than small companies, even on the more service-oriented types (organizational and marketing). Yet on marketing innovation the differences are smaller between company sizes and process innovation is the activity with more expression between the three size classes.

Figure 3 Innovation activity by number of employees

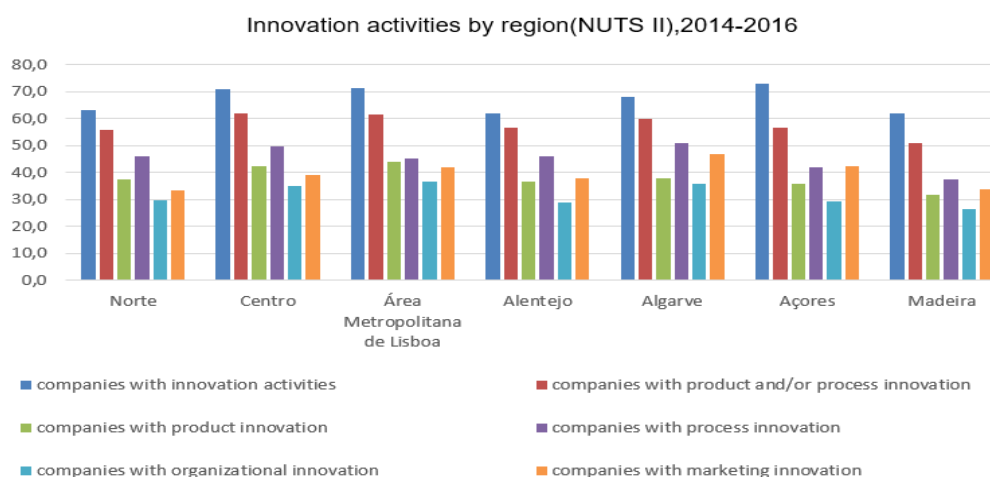


Source: adapted from DGEEC, (2018)

Although Portugal is a small country, it has relevant differences between regions including on innovation which is shown in figure 4. Being the Azorean archipelago with 72,7% and Lisbon metropolitan area with 71,4% the most innovative regions on the other side of the spectrum, according to CIS, is the Madeira archipelago with 61,7% and Alentejo with 61,8% the less innovative regions, corresponding to a 10-point difference between the most innovative region and the least innovative region. When looking closely the most and least innovative regions change according to the different types,

Madeira keeps the worst score in almost every type except for marketing innovation since 33,8% of companies innovate over the 33,5% of North companies innovating. The most innovative region in product and/or process activities is Center (61,8%) closely followed by Lisbon metropolitan area (61,5%) which is the region that has the top score in product (44,0%) and organizational (36,8%) innovation. When the subject is marketing innovation and process innovation, Algarve is in the lead since it has 46,8% and 50,8% respectively of company's innovation in these areas.

Figure 4 Innovation activities by region (NUTS II), (2014-2016)



Source: adapted from DGEEC, (2018)

3.2 Variables and model

On this section it will be explained why the variables were chosen and how they were used in the empirical research and a brief explanation about the logit model and why thus model was the chosen to be used on this dissertation.

3.2.1 Dependent Variables

A dependent variable relies on the answers of the independent variable and will be used to distinguish the companies which innovate from those which do not engage in innovation activities.

Table 7 List of dependent variables

Designation	Description	Values
IIN	Implemented innovation	0-No, 1-Yes

For this dissertation, as shown in Table 7, the only dependent variable is implemented innovation which will answer the question if the company has or has not implemented any type of innovation,

this variable will have a key role to test the hypotheses and then understand the differences between services innovation and manufacturing innovation. If the company implemented some type of innovation, then the answer is one, if the company did not implement any type of innovation the answer will be zero.

3.2.2 Independent variables

These independent variables represent basic information about a company, and all of them influence the implementation of innovation and consequently have some impact on the innovativeness of the company. These are closely related with the hypothesis and so will play an important role when testing those hypotheses. Table 8 presents all the independent variables used in this dissertation.

Table 8 List of independent variables

Designation	Description	Values
Research and Development		
HBRD	In-house or bought R&D	0-No, 1-Yes
HRDE	In-house R&D expenditure	Log (K€)
BRDE	External R&D expenditure	Log (K€)
IDEC	Innovation developed exclusively by the company	0-No,1-Yes
EIMC	External innovation modified by the company	0-No, 1-Yes
IP	Intellectual Property	0-No, 1- Yes
AET	Acquisition of advanced equipment/technologies	0-No, 1-Yes
IDIC	Innovation developed in cooperation	0-No, 1-Yes
Company Characteristics		
YREV	Yearly revenue	Log (K€)
LRG	Large company	0-Small or Medium, 1-Large
ITO	International orientation	0-National,1-International
CGE	College graduate employees	0-0%, 1-1%-15%,2-16%-30%,3-31%-45%,4-46%-60%,5-61%-75%,6-76%-90%,7-91%-100%
SERV	Services	0-Manufacturing, 1-Services

In-house or bought R&D is related to R&D which as Tether (2005), Aboal *et al* (2015) and Teixeira and Bezerra (2016) argued investment in R&D as being a main determinant to be innovative. If a company has engaged on in-house R&D activities or bought research and development, it will facilitate the creation of innovations and can be too a determinant of the size of the company. Then to

deepen the research variables In-house R&D expenditure and Bought R&D expenditure were used in order to understand if the company spends on R&D in house for the first or outsourced (bought) for the second these three variables are related with the R&D expenditure and indirectly related to size of a company since as Álvarez *et al.* (2015) expressed that there is a positive relationship between expenditure on innovation and the size of the company. In-house or bought R&D studies the engagement on R&D activities including those not yet finished or accounted for or activities which the companies preferred not to disclosure the amount invested in, and so the answer for the binary variable may be positive but the answer for the expenditure can be 0.

The two following variables are related with R&D. Innovation developed exclusively by the company objective is to understand if the innovation was developed in house, this variable will help understand that even if the firm does not have a dedicated R&D department, tries or not to create innovations. External innovation modified by the company variable is related with the predisposition to innovate, a yes answer means that the company is innovative, however creates their innovations based on other companies innovations, changing them for example to meet their reality, their customers, their employees or their goals, this can be due to the lack of resources to create their own innovations or simply because the company does not see a need to invest as much on innovativeness. Since as Sundbo and Gallouj (1999) claimed services innovation is more incremental based on small adjustments and rarely radical and dimensional.

The next variable Intellectual property aims to know if a company has had any kind of innovation activity which afterwards was protected or not, this can be seen as an indicator of the size of the company too, as proceeding to patent requires a certain amount of resources. Álvarez *et al.* (2015) found that size is highly important on having patent protection which then has a positive effect on the propensity to export and on the probability of engaging in innovation investment. For services, due to its intangibility which can make it difficult to protect (Oke, 2004). Acquisition of advanced equipment/technologies is equally binary, and its goal is to know if a company has dispended some of their budget in the acquisition of new equipment or technologies or even just upgrades for them which goes in accordance with Pires *et al.* (2008) who said that for services human capital is more important, and so it is expected that for manufacturing, equipment plays a more important role. This can be considered an expenditure in R&D and an indicator of the size of the company. The importance of this variable is related with future innovations, yet it can be considered an innovation for the company too.

The next variable concerns the cooperation of a company with others. Innovation developed in cooperation variable aims to answer if the company, when developing innovations creates ties with other entities to be successful on this quest. The cooperation with other entities can be a necessity due to the size of the firm or an option for reasons such as lack of expertise, efficiency of resources or even having a common goal. This way of innovating of taking advantage of knowledge generated elsewhere improve the probability of being a successful innovator (Faria *et al.*, 2010). As Camacho and Rodríguez (2005) reasoned cooperation between companies and other partners (customers, suppliers, universities, and research institutes) is key for success in the innovative process. This variable includes cooperation with entities such as with other institutions, government, public and private re-

search institutions, or customers. It includes the cooperation or not of the firm being studied with other units but belonging to the same firm or group. Then embraces too the answers about the existence or not of any kind of cooperation between the company being studied and its customers. It encompasses if the company object of study has any kind of cooperation with firms outside of the group, this helps to understand if a company when trying to innovate is open to help or be helped by others in a pursuit of a bigger cause. And lastly includes Universities which are great sources of knowledge and looks for any kind of cooperation with universities understanding which sector is more open to make use of theoretical knowledge to implement on innovations in the market. For Faria et al. (2010) there are different types of cooperation which depend on the company willing to cooperate and so this variable will test the differences from the two sectors being study concerning the entities they normally cooperate with.

Yearly revenue variable goal is to know about the company's state financially by using the logarithm base e. Large Companies will be responsible to test size by the number of employees, zero for small and medium companies and one for large companies it will answer which size of companies is more innovative. These two last variables will be indicators of the company's size since as Becheikh *et al.* (2006) asserted innovation costs are higher in small firms than for a large firm and Pires *et al.* (2008) affirmed only large firms with market power are able to get the return from the R&D investment. International orientation will answer which is the market plays a more important role in companies' sales, which is another variable related with size since a company to be an exporter has to have the resources to do so and compete with foreign firms just as Zahler (2014) declared only larger firms have the means to pay the high fixed costs for exportation and Álvarez *et al.* (2015) stated that size is more important in manufacturing to be a successful exporter. Teixeira and Bezerra (2016) and Sirilli and Evangelista (1998) argued that exporting firms have a higher probability of being innovative.

The following variable college graduated employees aims to understand how knowledge dependent is the company by answering between numbers zero to seven the percentage of percentage of college graduated employees since Andersen *et al.* (2019) said that the search of innovation would benefit from skilled employees and Zahler (2014) claimed that services are more dependent on skills and for Schmidt and Rammer (2006) human resource training is positive and significant for pioneering. This variable will be a key indicator to test the second hypothesis. Services variable will be used to understand if we are dealing with a company from the services or manufacturing sector, which is crucial to afterwards find the differences between the two, this is a binary variable which answers are zero for manufacturing or one for services.

All these independent variables try to define a general behavior for companies of each sector aiming to differentiate the two sectors in study.

3.2.3 Control Variables

Control variables help to mitigate the possible errors introduced in the equations and to help achieving more accurate results.

Table 9 List of control variables

Designation	Description	Values
POG	Part of a group	0-No, 1-Yes
SST	Services subsector	0-Wholesalers and vehicle maintenance, 1- Transports, 2-Postal activities, 3- Multimedia, 4- Telecommunications and ICT, 5- Financial activities and insurances, 6- Legal and accounting services, 7- Architecture, engineering R&D and marketing, 8- Consulting, scientific and vet activities, 9- healthcare
TRNA	Training activities	0-No, 1-Yes

Table 9 shows the three control variables which will be used to mitigate possible errors. The first variable part of a group is binary and dedicated to understanding if the firm is part of a larger group which is important to test the size hypothesis since as Pires *et al.* (2008) concluded for a given size and level of R&D being a part of a multinational group affects innovation and that it impacts more services firms. on their own. For Tether (2005) and Aboal *et al.* (2015) being part of a group is a main determinant to cooperate and for Pires *et al.* (2008), size has a smaller impact on services than manufacturing showing the importance of understanding if the company is small or part of a larger group of companies. Since the dissertation is more oriented towards services the importance of distinguish between subsectors is big and the innovation is different depending on each subsector. As mentioned, by Castro *et al.* (2010) there are differences between subsectors, being the financial sector the most innovative in all types of innovation but in marketing innovation and so the variable services subsector was created to differentiate from the 10 different subsectors found on CIS aiming to achieve more accurate results, it starts as zero and goes until nine each number between these correspond to a different subsector. The last variable is binary, training activities aims to measure if the company does engage in activities to qualify their employees and increase their skills since as stressed by Andersen *et al.* (2019) and Hipp (2005) companies were lacking in skilled personnel.

Table 10 Descriptive statistics for each variable

Variables	Manufacturing				Services			
	Mean	Std. Dev.	Min/Max	Observations	Mean	Std. Dev.	Min/Max	Observations
Implemented innovation	0.504	0.500	0/1	3732	0.490	0.500	0/1	3043
In-house or bought R&D	0.407	0.491	0/1	2360	0.375	0.484	0/1	1869
In-house R&D Expenditure	3.816	5.332	0/17.672	2360	3.481	5.251	0/17.672	1869
Bought R&D Expenditure	1.394	3.534	0/16.188	2360	1.345	3.533	0/16.188	1869
Innovation developed exclusively by the company	0.850	0.3571	0/1	2274	0.77	0.421	0/1	1820
External Innovation modified by the company	0.237	0.426	0/1	2274	0.280	0.449	0/1	1820
Intellectual Property	0.184	0.387	0/1	3732	0.203	0.402	0/1	3043
Advanced equipment/technologies	0.667	0.472	0/1	2360	0.558	0.497	0/1	1869
Innovation developed in cooperation	0.522	0.500	0/1	2360	0.581	0.494	0/1	1869
Yearly Revenue	14.695	1.689	0/22.067	3732	15.045	1.807	0/22.067	3043
Large Companies	0.584	0.234	0/1	3358	0.050	0.218	0/1	2833
International Orientation	0.278	0.448	0/1	3732	0.137	0.344	0/1	3043
College graduated Employees	1.760	1.363	0/6	3732	3.213	2.004	0/6	3043
Services	0	0	0/0	3732	1	0	1/1	3043
Part of a group	0.326	0.469	0/1	3732	0.326	0.469	0/1	3043
Services Subsector					2.317	2.794	0/9	3043
Training Activities	0.556	0.497	0/1	2360	0.594	0.491	0/1	1869

3.2.4 Model

The dependent variable being binary makes both probit and logit models applicable. The chosen model was logit since the two-output identical and accurate results and as Peng *et al.* (2002) mentioned logit regression model is superior since it can accept both discrete and continuous variables, is not constrained by normality or equal variance/ covariance assumptions for the residuals and is related to the discriminant function analysis through the Bayes theorem. The goal of logit regression is to correctly predict the category of outcome for individual cases using the parsimonious model. To accomplish this goal, a model is created that includes all predictor variables that are useful in predicting the response variable (Saha, 2011). For Cabrera (1994) a logit regression deals with two main assumptions the first is the nature of the distribution associated with the binary outcome and the second deals with the relationship between the independent variable and the dependent variable. The dependent variable (IIN) is binary assuming values zero or one varying as a function of the values of the independent variables. This can be expressed as:

$$E \left[Y_{ith} = \frac{1}{X} = X \right] = P(Y_{ith} = 1)$$

where $P(Y_{ith} = 1)$ is the probability of achieving success, (implementing innovation) for each i^{th} company given a particular value of X . These probabilities assume a binomial distribution. A unique characteristic of this type of distribution is that the probability distribution has an overall mean, P , which is the proportion of successes obtained, yet the variance, V , changes as a function of the company under consideration. This variance is expressed as follows:

$$V_{ith} = P(Y_{ith} = 1) * [1 - (P_{ith} = 1)]$$

where $P(Y_{ith} = 1)$ is the probability of obtaining success (implementing innovation) and $[1 - (P_{ith} = 1)]$ is the probability of not obtaining success (not implementing innovation).

Several independent variables will be used in this model so the generalized form will be a written below:

$$L = \ln \frac{P(Y)}{1 - P(Y)} = B_0 + \sum_{i=1}^n (B_i x_i) + \varepsilon$$

where L is the logit (natural logarithm of the odds), $P(Y)$ is the probability of Y succeed, B represents the weight of the control variables, x the control variables and ε the associated error.

Since the probabilities are the focus of the analysis rearranging the equation:

$$P(Y) = \frac{e^{B_0 + \sum_{i=1}^n (B_i x_i)}}{1 + e^{B_0 + \sum_{i=1}^n (B_i x_i)}}$$

This probability after being estimated will acquire a value between zero and one based on the weights (Cabrera *et al.*, 1994); Peng *et al.*, 2002; Saha, 2011). This logit model will be employed to transform $P(Y)$ into a continuous variable.

For a better and more organized understanding of the dissertation the independent variables will be compiled in different equations using different vectors:

$$\Lambda_1 (\text{Research and development}) \rightarrow B_1(\text{HBRD}) + B_2(\text{HRDE}) + B_3(\text{BRDE}) + B_4(\text{IDEC}) + B_5(\text{EIMC}) + B_6(\text{IP}) + B_7(\text{AET}) + B_8(\text{IDIC})$$

For the R&D group in house or bought R&D (HBRD) is to know if the company has tried to in-house or bought R&D, in-house R&D expenditure (HRDE) aims to know the expenditure on in-house R&D, bought R&D expenditure (BRDE) is the variable responsible to measure the expenditure on external R&D, innovation developed exclusively by the company (IDEC) aims to know if there is an innovation developed in-house by the company being studied, external innovation modified by the company (EIMC) if an innovation already existing was modified by the company, then intellectual property goal is to understand if the firm has created some type of intellectual property registration. Acquisition of advanced equipment/technologies (AET) is the variable to know if the company has invested in new equipment or technologies. Lastly innovation developed in cooperation (IDIC) studies if the company did implement the innovation in cooperation with entities from diverse fields.

$$\Lambda_2 (\text{Company Characteristics}) \rightarrow B_9(\text{YREV}) + B_{10}(\text{LRG}) + B_{11}(\text{ITO}) + B_{12}(\text{CGE}) + B_{13}(\text{SERV})$$

Yearly revenue (YREV) measures the company's revenue for the year, large companies (LRG) gives the number of big companies based on the number of employees, then international orientation (ITO) is the international orientation towards exportation, college graduated employees (CGE) corresponds to the percentage of college graduated employees and services (SERV) will define if the company operates in the services sector.

$$\Lambda_3 (\text{Control variables}) \rightarrow B_{19}(\text{POG}) + B_{20}(\text{SST}) + B_{21}(\text{TRNA})$$

These variables will be used to mitigate the possible errors introduced in the equations. Part of a group (POG) will denote if the firm is part of a bigger group of companies meaning that even if the company is considered small it may operate differently than other small firms. Services subsector (SST) will understand in which subsector a company in the service sector is inserted to better detail de information gathered. Training activities (TRNA) will answer if the company engages in activities to qualify the employees.

The equations all revolve around identifying if the company implemented any kind of innovation understanding the different approaches used to get there:

$$IIN = \lambda_1 + \lambda_2 + \lambda_3 + \varepsilon$$

where implemented innovation (IIN) represents the implementation of an innovation the λ_k represents the different vector written above and ε the associated error.

4. Results

By analyzing the data from CIS-2016 it was observed a maximum of 6775 observations meaning that an equal number of companies answered the survey and even though some variables retain the 6775 observations some others have less as the Table 11 shows:

Table 11 Number of observations for each variable

Variables	Number of observations
Intellectual Property; Yearly Revenue; Services; Part of a group; Implemented Innovation; International Orientation; College graduated employees	6775
Large Companies	6191
In-house or bought R&D; Innovation developed exclusively by the company; Advanced Equipment/Technologies; Training activities; In-house R&D Expenditure; Bought R&D expenditure	4229
External innovation modified by the Company; Innovation Developed in Cooperation	4094
Services Sub-sector	3043

Some of the discrepancies between the total of observations and the observations of some variables may have to do with companies not knowing, not willing to disclose that kind of information such as the In-house or bought R&D or the acquisition of advanced equipment/technologies. Services subsector variables have only 3043 answers due to being related only with services companies, and only companies of this sector have answers to this variable. This lower number of observations for many variables is also related with the structure of the survey since if the answer to a question is negative, the other questions related to the first one should be ignored, such as answering “No” to engaging in cooperation or to Implementing innovation leading to less observations on the variables directly related to the answers to these first two topics. This variables with less observations will restrict the estimation of the regressions.

The logit model which will be used in this dissertation will give a wide variation of number in the results, yet only the signal positive or negative is of interest defining if it positively influences or not the innovation. The coefficients of the logit model represent the relationship between the independent/control variables and the dependent variable. The marginal values represent the effect and independent variable has on the dependent variable which may or not be linear.

The p-value which shows the significance level, being usually compared to a chosen limit (5%) being the value from chi-square as a baseline. Then the pseudo R^2 which differently from the one used in ordinary least squares is not “real”. In the case of the logistic regression the R^2 represents the proportion of error variance between two models as said by Cabrera (1994). However, the pseudo R^2 used in this thesis is the McFadden’s R^2 (p^2), where and extremely good fit vary between 0.2 and 0.4 (McFadden, 1977). Lastly the correct prediction percentage event though is not widely used in literature it can be helpful to test the importance of the variables when predicting the outcome.

The dependent variable implemented innovation is characterized by having 6775 observations, being binary and 3404 (50.24%) observations were zero, meaning that the company has not implemented innovation, 3371 (49.76%) were one meaning there was an innovation implemented. In order to create this variable, the variables “*inpdgd*” (between 2014 and 2016 the company introduced new or significantly improved goods), *inpdsv* (between 2014 and 2016 the company introduced new or significantly improved services) and *inong* (between 2014 and 2016 the company developed innovation activities, not resulting in the introduction of innovations because of being still in progress) were assembled using the assumption that if the answer to one of the three variables was “yes” then IIN would assume the value one meaning the company implemented innovation or was in the process of implementing them.

4.1 Regression Results and Marginal Effects

The methodology used will be based firstly by making a base model with a logit regression between the dependent variable and four control variables. Then models for each of the four hypotheses will be created by adding variables specific to each hypothesis to the previous model. For each of the four hypotheses firstly there will be a common model between services and manufacturing and then starting from that model, it will be created another one differentiating manufacturing from services. The first table of each model which will be presented in the appendix tests a logit regression between the dependent variable and the independent variables where we can conclude if influence on innovation is positive or negative based on the coefficient. However, to understand the magnitude of that influence, increase or decrease (depending on signal), in percentage points a second table will be created with the marginal effects for each model.

Firstly, the base model will be tested with a logit regression between implemented innovation and part of a group, international orientation, acquisition of advanced equipment/technologies and intellectual property. Which will then be followed by a table with the marginal effects of that logit regression.

Table 12 Marginal effects of base model

Variables	Implemented Innovation		
	Manufacturing and Services (Base model)	Manufacturing (Base Model a)	Services (Base Model b)
Part of a group	0.063*** (0.014)	0.046* (0.020)	0.078*** (0.020)
International orientation	0.013 (0.015)	0.031 (0.185)	-0.011 (0.026)
Acquisition of advances Equipment/technologies	0.065*** (0.012)	0.061*** (0.017)	0.073*** (0.018)
Intellectual property	0.165*** (0.017)	0.143*** (0.023)	0.194*** (0.178)
Observations	4229	2360	1869
LR chi²	169.73	79.02	96.17
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.71%	79.66%	79.78%
Pseudo R²	0.0398	0.0331	0.0511

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A3 and Table 12 show the base model which will be used as a reference to the other models which will be built to test the research hypotheses. This table presents 4299 observations for the common model, which is a good number to obtain accurate results, this model's variables are mutually exclusive since the p-value is zero and the correct prediction is close to 80%. However, the pseudo R² presents a low number 0.04 which is explained by the lack of variables explaining what influences the dependent variables. This model shows that only international orientation has no statistical significance and no positive influence to implement innovation. The other three variables by looking at Table 12 have positive marginal effects meaning the influence of the independent variables increases the probability of innovation.

By looking at each sector separately, manufacturing and services present a good number of observations, for both the p-value is equal to zero as the common model, the correct prediction is almost 80% meaning these models present a good prediction of the outcome, yet the pseudo R² is 0.0331 for manufacturing and a bit better for services around 0.0511 but far from the extremely good fit interval of (0.2-0.4). When comparing each variable and each sector on Table 12 only international orientation has no significance. However, all the other three variables have a higher coefficient on services and the percentage of increase (marginal effect) is higher on services meaning that these

variables have a bigger influence on the innovativeness of the company on services than on manufacturing.

The first hypothesis to be tested will be the H1 which aims to test the correlation between a company innovating and its size.

Firstly, a logit regression between implemented innovation, yearly revenue and the variables used on the base model is going to be used, then another model taking yearly revenue and adding large companies' variable will be tested to understand the importance of each of the main determinants of size on the innovativeness of a company both followed by a table with the marginal values.

Table 13 Marginal effects of model 1, model 1a and model 1b

Variables	Implemented Innovation		
	Manufacturing and Services (Model 1)	Manufacturing (Model 1a)	Services (Model 1b)
Yearly Revenue	0.088* (0.004)	0.027*** (0.060)	-0.008 (0.058)
Part of a group	0.047** (0.016)	-0.062 (0.023)	0.090*** (0.022)
International orientation	0.011 (0.015)	0.015 (0.188)	-0.013 (0.026)
Acquisition of advances Equipment/technologies	0.063*** (0.012)	0.051** (0.017)	0.074*** (0.018)
Intellectual property	0.162*** (0.017)	0.130*** (0.023)	0.195*** (0.027)
Observations	4229	2360	1869
LR chi²	174.55	99.31	97.88
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.74%	79.66%	79.78%
Pseudo R²	0.0409	0.0417	0.0520

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table 13 shows 4229 observations for the common model meaning that the results have a high degree of accuracy, the p-value is zero meaning that the variables are mutually exclusive, the correct prediction shows a high percentage, the pseudo R² is of 0.04 still far from 0.2-0.4 (extremely good fit) but the correct prediction percentage is nearly 80% meaning this model has a good prediction

of the outcome and Table A2 shows a correlation matrix with generally low values between variables. By analyzing the results for each variable, only international orientation has no significance and no positive influence with the innovativeness of a company, the other four variables have positive marginal effects and so they the influence in the innovativeness of a company increases.

For model 1a and model 1b in terms of model fit the number of observations being 2360 for manufacturing and 1869 for services is already a good number to obtain accurate results. The p-values of manufacturing and services are zero and since any p-value less than 0.05 means that the variables are mutually exclusive the value is very good. The pseudo R^2 of 0.04 and 0.05 means the model is a better fit for services and the correct prediction shows that for services the model is predicted slightly better, but both have high percentages.

Table 13 shows already some key aspects about the relationship between implementing innovation and the size of the company, showing that intellectual property and acquisition of advanced equipment/technologies affect positively innovation on both sectors, even though with a higher coefficient and marginal values for services. International orientation has no positive effect on innovation neither on manufacturing nor services. By analyzing Table A4 and Table 13 some differences between sectors can already be drawn, such as yearly revenue being only significant for innovation on manufacturing meaning that the revenue has an increasing influence on innovation of manufacturing which goes in accordance with Álvarez *et al.* (2015) who claimed that size seems to be less important in the service sector than in manufacturing to engage in innovation, this is a key aspect to test the first hypothesis since revenue is one of the main determinants of the size of a company. These models also show that being part of a group is important for the innovativeness but only on services.

The model 1c, model 1d and model 1e will test the first hypothesis but taking yearly revenue variable and adding the large companies' variable this will test the role the number of employees has on the innovativeness of a company on both sectors firstly and then on each one of the two.

Table 14 Marginal effects of model 1c, model 1d and model 1e

Variables	Implemented Innovation		
	Manufacturing and Services (Model 1c)	Manufacturing (Model 1d)	Services (Model 1e)
Large Companies	0.028 (0.031)	0.010 (0.040)	0.066 (0.052)
Part of a group	0.064*** (0.016)	0.047 (0.056)	0.075** (0.022)
International orientation	0.005 (0.016)	0.018 (0.021)	-0.005 (0.028)
Acquisition of Advanced equipment/technologies	0.062*** (0.013)	0.061** (0.018)	0.067*** (0.189)
Intellectual Property	0.168*** (0.019)	0.148*** (0.026)	0.190*** (0.028)
Observations	3787	2062	1725
LR chi ²	143.82	62.24	85.81
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.17%	78.81%	79.59%
Pseudo R ²	0.0371	0.0292	0.0492

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

By analyzing Table 14, Table A5 and Table A2 the variables have low number of correlations between them, the common model has a good number of observations, a p-value of zero meaning that the variables are mutually exclusive, the pseudo R² is far from the 0.2-0.4 interval of the extremely good fit, but with a value of 79% meaning the model is good at predicting the outcome. It shows the number of employees (size) has no significance and so has no proven influence on innovation of a company the same for the control variable international orientation. The other three control variables Part of a group, Acquisition of advanced equipment/technologies and Intellectual property positively influence innovation. Table 14 shows that the three variables which are significant have positive marginal effects and so increasingly influence positively innovation.

When looking at each sector separately only acquisition of advanced equipment/technologies and intellectual property positively influence innovation, meaning that the number of employees (large companies) which is a main determinant of the company's size has no significance and therefore no proven positive influence on innovation for manufacturing. For services, acquisition of advanced equipment/technologies and intellectual property positively influence innovation just as manufacturing but with the difference that being part of a group does too. Table A5 and Table 14 show that between the two sectors the main difference is that being part of a group affects positively services innovation

and not manufacturing, however acquisition of advanced equipment/technologies and intellectual property influence both sectors innovativeness yet, they do have higher coefficients and marginal effects for services. This model shows that the number of employees has no proven influence on the innovativeness on either sector.

These results do not validate H1 (*Size positively influences innovation activities*) since only for manufacturing one of the main determinants of size, yearly revenue, influences positively innovation. Models 1, 1a and 1b test the influence of the revenue on the implementation of innovation, it shows that the revenue does influence innovation, however when looking specifically for each sector only for manufacturing this variable has significance and positive influence. The number of employees tested by the variable large companies has no significance on both sectors meaning that there is no proven influence of this variable on the large companies' innovation neither on the small companies. Despite these results for the main determinants of size, these models show that being part of a group influences services innovation and acquisition of advanced equipment/technologies and intellectual property influences both sectors innovativeness. Even though these other variables which are somehow related with size, influence innovation, the two main determinants tested have no influence on innovation in services and so H1a (*Size positively influences innovation activities in services companies*) cannot be validated as the number of employees and yearly revenue have no influence on innovation. H1b (*Size positively influences innovation activities in manufacturing companies*) validation is different since the number of employees have no influence on innovation but the yearly revenue has and so for this hypothesis the verdict is validation yet timid. Based on the arguments stated above hypothesis 1 must be considered rejected.

In order to test the second hypothesis, a model will be created taking into account the studies of Zahler *et al.* (2014), Teixeira and Bezerra (2016), and Schmidt and Rammer (2006) who showed the education level as a subject of interest towards innovation and so higher percentage of graduated employees positively influence innovation and compare between sectors a model will be created based on a logit regression between implementing innovation, the variables from model 1, now acting as control variables adding college graduated employees which is the percentage of graduated employees in the company and training activities acting as another control variable since an employee can have expertise and know-how acquired by other means than University. Afterwards, the model will be sorted by sector to obtain the differences between both, and the marginal values will be used to understand the behavior of each variable.

Table 15 Marginal effects of model 2, model 2a and model 2b

Variables	Implemented Innovation		
	Manufacturing and Services (Model 2)	Manufacturing (Model 2a)	Services (Model 2b)
College graduated employees	0.029*** (0.004)	0.033*** (0.008)	0.029*** (0.005)
Training activities	0.082*** (0.013)	0.078*** (0.017)	0.089*** (0.018)
Large Companies	0.019 (0.033)	-0.048 (0.043)	0.091 (0.537)
Yearly revenue	0.002 (0.004)	0.022** (0.007)	-0.012 (0.007)
Part of a group	0.018 (0.178)	-0.022 (0.026)	0.057* (0.024)
International orientation	0.018 (0.016)	0.009 (0.021)	-0.014 (0.028)
Acquisition of Advanced equipment/technologies	0.055*** (0.013)	0.040* (0.018)	0.063** (0.019)
Intellectual Property	0.132*** (0.019)	0.109*** (0.025)	0.150*** (0.028)
Observations	3787	2062	1725
LR chi ²	248.73	124.31	149.37
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.17%	78.81%	79.54%
Pseudo R ²	0.0642	0.0584	0.0856

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

By looking at Table 15 the common model shows a good number of observations, 3787, the p-value remains at zero on this model, the pseudo R² rose when comparing to model 1 meaning this model is a better fit than the previous and the percentage of correct prediction is 79% which means it predicts well the outcome and the correlation matrix show a small correlation between variables. Table A6 and Table 15 show that the level of education of the employees on the common model positively influences innovation, the percentage of graduated employees and the engagement on training activities are important for the innovativeness of a company. These two variables are the ones responsible for testing the second hypothesis, yet acquisition of advanced equipment/technologies and intellectual property are too significant on this model.

For the separate models 2a and 2b, the number of observations 2062 and 1725 allows to obtain accurate results and the p-value of both models is zero showing the variables are mutually exclusive the pseudo R^2 is 0.0584 for manufacturing and 0.0856 for services meaning a better fit for services. Analyzing each variable for each sector, the percentage of college graduated employees influences positively innovation on both sectors however, with a slightly higher coefficient and marginal effect for manufacturing. training activities does positively influence innovation on both sectors only with a higher coefficient and marginal effect for services, this means the expertise of the employees and the skills of them are more important for innovation in services which is in line with Zahler *et al.* (2014), Andersen *et al.* (2019) and Teixeira and Bezerra (2016) saying that services are more dependent on skills. Other control variables are significant on these models such as yearly revenue for manufacturing and being part of a group for services and acquisition of advanced equipment/technologies and Intellectual Property are significant for both.

These results validate H2 (*Higher percentage of graduated employees positively influences innovation*) since the two variables responsible to test this hypothesis are significant, percentage of graduated employees and training activities. H2a (*Higher percentage of graduated employees positively influences innovation in service companies*) and H2b (*Higher percentage of graduated employees positively influences innovation in manufacturing companies*) are validated since the percentage of graduated employees and training activities are significant on each sector, even though for H2b the need for graduated employees is slightly higher and engaging on educational activities is more important on H2a.

Hypothesis 3 which tests the influence of cooperation in the innovativeness of a company will be tested firstly by making a logit regression using implementing innovation as dependent variable and as covariates the same variables used in model 2 plus innovation developed in cooperation which allow us to test hypothesis 3. This variable embraces cooperation with diverse entities such as universities, other firms, customers, institutions, or different units of the same firm. This model will be created based on studies such as from Faria *et al.* (2010), Teixeira and Bezerra (2016), Camacho and Rodriguez (2005) and even the work of Tether (2005).

Table 16 Marginal effects of model 3, model 3a and model 3b

Variables	Implemented Innovation		
	Manufacturing and Services (model 3)	Manufacturing (Model 3a)	Services (Model 3b)
Innovation developed in co-operation	0.112*** (0.013)	0.130*** (0.019)	0.091*** (0.019)
College graduated employees	0.026*** (0.004)	0.027*** (0.008)	0.026*** (0.005)
Training activities	0.068*** (0.013)	0.059** (0.018)	0.081*** (0.018)
Large Companies	0.016 (0.032)	-0.053 (0.042)	0.087 (0.053)
Yearly revenue	-0.001 (0.005)	0.018* (0.007)	-0.014* (0.007)
Part of a group	0.003 (0.018)	-0.039 (0.026)	0.043* (0.023)
International orientation	0.010 (0.016)	0.002 (0.020)	-0.008 (0.028)
Acquisition of Advanced equipment/technologies	0.046*** (0.013)	0.032 (0.018)	0.055** (0.019)
Intellectual Property	0.117*** (0.019)	0.096*** (0.025)	0.134*** (0.028)
Observations	3787	2062	1725
LR chi ²	318.86	172.97	172.00
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.17%	78.81%	79.42%
Pseudo R ²	0.0823	0.0812	0.0985

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A7 shows the results for the logit regression of the third model and Table 16 shows the marginal effects for this model. By looking at Table A2 the variables present low values between them meaning small correlation between them. Firstly, analyzing the common model, the number of observations is good, and the p-value is zero, the correct prediction being 79% means the model predicts accurately the outcome and the pseudo R² becoming closer to 0.2 shows the model has a better fit than the previous. Innovation developed in cooperation the core of this model is significant for both sectors and positively influences innovation since the coefficient is positive and the percentage of increase too, the other variables which are now control variables maintained their behavior on this model meaning the same are still significant and contributed positively to innovation.

Considering the two sectors separately with the number of observations used to test the model the results are accurate, and the p-values are zero for both, with correct prediction percentages of 79% both models correctly predict the outcome. Pseudo R^2 of model 3b (0.0985) is slightly higher than model 3a (0.0812) which is in line with the last models meaning this model is a better fit for services. Examining the variables, engaging in cooperation is significant for both sectors, however it plays a more important role on manufacturing due to its coefficient and marginal effect. The control variables are in line with the results of the previous model except for the importance of the yearly revenue which on the services model became significant, but it negatively influences innovation since its coefficient and marginal value is negative. This may happen due to the higher the revenue and the larger the company the less they engage or need to engage in cooperation activities with others to be innovative, and so this model appear to indicate that cooperation makes companies more innovative than just having higher revenues, and that the two variables seem to present inverse proportionality.

After analyzing the results, the conclusion is that cooperation does influence the implementation of innovation when testing the two sectors together and when they are tested individually. These results validate H3 (*Engagement in cooperation activities positively influences innovation*), H3a (*Engagement in cooperation activities positively influences innovation in services companies*) and H3b (*Engagement in cooperation activities positively influences innovation in manufacturing companies*), however, manufacturing depends more on cooperation than services to be innovative. These results are in line with prior studies, such as Teixeira and Bezerra (2016), Schmidt and Rammer (2006), Álvarez *et al.* (2015), Camacho and Rodriguez (2005), Hsueh *et al.* (2010), and Vermeulen *et al.* (2005) who claimed that cooperation has positive effect on innovation.

For the fourth hypothesis the influence of R&D on the innovativeness of a company will be tested taking into account studies carried out by Teixeira and Bezerra (2016), Camacho and Rodriguez (2005) or Tether (2005) by estimating a logit regression of Implementing innovation using the same variables of the previous model plus variables concerning bought R&D, in-house or external R&D expenditure, innovation being developed exclusively by the company, and innovation modified by the company.

Table 17 Marginal effects of model 4, model 4a and model 4b

Variables	Implemented Innovation		
	Manufacturing and Services (Model 4)	Manufacturing (Model 4a)	Services (Model 4b)
In-house or bought R&D	0.043* (0.019)	0.041 (0.027)	0.045 (0.027)
In-house R&D expenditure	0.013*** (0.002)	0.014*** (0.027)	0.011** (0.003)
Bought R&D expenditure	0.002 (0.003)	0.005 (0.004)	0.001 (0.004)
Innovation developed exclusively by the company	0.189*** (0.013)	0.218*** (0.019)	0.165*** (0.018)
External Innovation modified by the company	0.164*** (0.018)	0.201*** (0.028)	0.133*** (0.025)
Innovation developed in co-operation	0.101*** (0.013)	0.127*** (0.019)	0.076*** (0.019)
College graduated employees	0.013** (0.004)	0.011 (0.007)	0.013* (0.005)
Training activities	0.045*** (0.012)	0.025 (0.017)	0.066*** (0.018)
Large Companies	-0.058 (0.032)	-0.088* (0.042)	0.003 (0.052)
Yearly revenue	0.000 (0.005)	0.011 (0.007)	-0.009 (0.007)
Part of a group	0.022 (0.017)	-0.039 (0.026)	0.070** (0.023)
International orientation	-0.016 (0.015)	-0.014 (0.020)	-0.026 (0.027)
Acquisition of Advanced equipment/technologies	0.027* (0.012)	0.027 (0.017)	0.030 (0.018)
Intellectual Property	0.084*** (0.018)	0.072** (0.024)	0.096*** (0.027)
Observations	3660	1983	1677
LR chi ²	742.31	434.91	332.04
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.97%	80.58%	80.38%
Pseudo R ²	0.1971	0.2105	0.1954

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A2 shows a low correlation between variables and Table 17 shows a good number of observations for the three models, naturally the common model shows a higher number, the p-values are zero for each of them and the correct prediction is about 80% on all three meaning the outcome is accurately predicted. The pseudo R^2 is substantially higher than for model 3, for the common and the services models is on the verge of entering the extremely good fit interval between 0.2 and 0.4 meaning these models are at least a very good fit and the manufacturing model is already an extremely good fit and so the model fits better the manufacturing sector than the services.

These models present results for each variable which show the coefficient for expenditure on bought R&D is not statistically significant and buying or engaging on R&D activities only statistically significant for the common model (all firms). The in-house R&D expenditure is positive statistically significant, meaning that in-house R&D expenditure has a positive effect on the innovativeness of the company. When analyzing the other two variables related to R&D both are significant and influence innovation on the two sectors but with higher coefficient and marginal values for manufacturing meaning the expenditure on R&D is more impactful towards innovation on this sector. This table also presents some interesting results for the control variables since cooperation is still more important for services innovation, the variables related to the employees' skills were significant on the other models but on model 4 only for services the skills of the employee are significant and still positively influences innovation. The number of employees (large companies) is now significant but with a negative coefficient and marginal effects for manufacturing which means innovation on small companies depends more on R&D expenditure. Being part of a group is still significant only for services and intellectual property has higher percentage of increase for services meaning this type of protection is more relevant to innovations on services.

These results show that both services and manufacturing innovativeness is influenced by R&D, yet generally manufacturing depends more on R&D than services. Consequently H4 (*Expenditure in R&D positively influence innovation*), H4a (*Expenditure in R&D positively influence innovation in services companies*), and H4b (*Expenditure in R&D positively influence innovation in manufacturing companies*) are supported.

4.2 Summary of the results

On this section a table summing the validation or rejection of the hypotheses will be summarized and the discussion of the results will be presented considering the previous analysis of the models.

Table 18 Summary of validated or rejected hypotheses

Hypothesis	Result	Observations
H1: Size positively influences innovation activities.	Rejected	
H1a: Size positively influences innovation activities in services companies.	Rejected	
H1b: Size positively influences innovation activities in manufacturing companies.	Validated	Weak validation from the two most important variables only one affects innovation (yearly revenue)
H2: Higher percentage of graduated employees positively influences innovation.	Validated	
H2a: Higher percentage of graduated employees positively influences innovation in service companies.	Validated	
H2b: Higher percentage of graduated employees positively influences innovation in manufacturing companies.	Validated	
H3: Engagement in cooperation activities positively influences innovation.	Validated	
H3a: Engagement in cooperation activities positively influences innovations in service companies.	Validated	
H3b: Engagement in cooperation activities positively influences innovation in manufacturing companies	Validated	
H4: Expenditure in R&D positively influences innovation	Validated	
H4a: Expenditure in R&D positively influences innovation in service companies	Validated	
H4b: Expenditure in R&D positively influences innovation in manufacturing companies	Validated	

By analyzing Table 18, the models used to test the hypotheses had a p-value of zero meaning that they are mutually exclusive. The pseudo R^2 according to McFadden (1977) should be between 0.2 and 0.4 to be considered an extremely good fit. The results show that the models R^2 tend to vary 0.03 and 0.2, being the lower value for the model 1d, which tested the influence of the number of employees on manufacturing and the highest on model 4a, which tested the R&D expenditure on manufacturing. When comparing the fitness between sectors the manufacturing one has better fit than services only on model testing H4, yet on this model manufacturing surpasses the lower boundary to the extremely good fit interval (0.2105) and services comes close to that boundary (0.1954). Services has a better fit on H1, H2 and H3 but even though the values increase from the first model to the fourth only for the fourth hypothesis the values are around the extremely good fit boundary. The last measure is the correct prediction percentage which purpose is to ease the interpretation of the accuracy of the model. These percentages vary between 78.8% and 81.8% . When comparing correct prediction in both sectors on all models the results are similar, and all have high percentages meaning a good prediction of the models. The results of these measures being in general similar on both sectors in all models mean that the models created to compare the sectors lead to a trustworthy and sensible comparison but with a slightly higher percentage for services on the models related to the first three hypotheses, the fourth hypothesis has a slightly higher percentage of correct prediction for services.

The pseudo R^2 values of the common models (manufacturing and services together) tend to be between the upper and lower pseudo R^2 values of the comparison models (manufacturing vs services) since these models are using all the same data and variables but using the variable services to distinguish between sectors. However, this does not happen in H1 where the common model has a slightly lower pseudo R^2 but with small deviation from the manufacturing which has the lower value. This metric is normally used to compare between similar models to understand which one has a better fit, when varying some variables. The results show that the values for this metric increases as variables are added into the models to test the different hypotheses getting to the last model with extremely good fit values. On this case taking into account the main topic of this thesis, the differentiation between services and manufacturing, its purpose can be too related to the comparison of fitness between each sector.

By looking at the dependent variable, the findings suggest that for services the percentage of graduated employees, the engagement in cooperation activities and the expenditure in R&D positively influence the implementation of innovation. Yet Size (H1) cannot be considered to have a positive effect on innovation mainly due the fact that the two main determinants of size have no impact on innovativeness. The four hypotheses also positively influence manufacturing. However, when looking closer to H1 model, only one of the main determinants, revenue, plays a role in manufacturing and so the H1b is valid but timidly making the rejection of H1 the most plausible answer.

An observation was made on hypothesis 1 since such as common determinants to establish the size of a company is by the number of employees and yearly revenue by looking just to those numbers only the second has a positive influence on innovation on manufacturing.

After testing twelve hypotheses ten were validated, H1b with some reservations, H1 and H1a were the rejected ones. When the results are scrutinized differences between sectors stand out the more evident are the ones where the variable is significant for one sector but not for the other such as the revenue, on the first model which is important for the innovativeness of a manufacturing company but not for services which is in line with Pires *et al.* (2008), Álvarez *et al.* (2015) and Hipp and Grupp (2005) who stated that size has greater impact in manufacturing companies and Zahler *et al.* (2014) who found that in services size has little correlation with innovation which is expected as manufacturing companies depend more on physical assets such as machinery or properties which have an high cost. However, the number of employees which is the other main determinant of the size of a company has no proven correlation with the innovativeness of a company. The second clear difference is the importance of being part of a group for services in contrast to manufacturing which shows no significant results for this variable contrary to what was expected since Pires *et al.* (2008) affirmed that being part of a group impacted innovation for both sectors. Yet this may be explained by services dependency on knowledge as being part of a bigger group may promote exchange of knowledge.

By looking at the marginal effects other differences can be observed such as for model 2 the even though timid, higher importance of having college graduated employees in manufacturing yet engaging in training activities and so investing in the skills of the employees being more important for services innovation. Teixeira and Bezerra (2016) found that human capital is an important determinant of innovation but only to the 1st cycle (undergraduates), since companies in services with higher percentage of PhD employees were less innovative. Pires *et al.* (2008) and Schmidt and Rammer (2006) found human resource training as being positive and significant for pioneering which is in accordance with the higher influence on innovation of the engagement on qualification activities in services. These results show a timid difference, however a deeper study on this matter may find great differences on the degrees and skills needed by each sector's employees to pursue innovation.

Another difference is related to the engagement in cooperation activities since the marginal effects are higher for manufacturing meaning this sector benefits more from cooperation than services these results validate the statements of Camacho and Rodriguez (2005), Vermeulen *et al.* (2005), Schmidt and Rammer (2006), Hsueh *et al.* (2010) and Teixeira and Bezerra (2016) which declared that cooperation has a positive effect on innovation since there is a difference between the two sectors but both innovativeness is influenced by cooperation, only Álvarez *et al.* (2015) results showed cooperation as more important in services which can be due to the country object of study by this author. These findings were expected since companies tend to cooperate to obtain some benefit the other company can provide in order to facilitate achieving their goals, yet if deeper research on this subject is done both sectors' companies could expect to find which are the best partners to pursue innovation with.

The marginal effects results show that in-house R&D expenditure, innovation developed exclusively by the company and external innovation modified by the company are more impactful on manufacturing innovation than on services. Tether (2005) identified that manufacturing is more likely to source advanced technologies through in house R&D the latter and Aboal *et al.* (2015) affirmed that

services tend not to require formal R&D due to incremental nature of their innovations. Teixeira and Bezerra (2016) and Zahler (2014) declared services companies investing more in R&D as being more innovative than those that do not invest. These results may be explained by the same reason as the manufacturing companies are more dependent on revenue to invest on innovation as these companies tend to require machinery and may even need to invest in new facilities to produce their new product or improve their processes which is known to normally present high costs. All the statements above are in line with the results since even though there is a difference between manufacturing and services both are positively influenced by R&D expenditure.

These results show that the areas tested in the hypotheses present some differences between sectors, yet they also show that these two sectors are closely related and similar, making the integrative approach the better fit approach to study services innovation. However, a more detailed analysis of the results shows that in order to be the most efficient and effective with the tools each company possesses to invest and pursue innovation they should start by looking at these differences before proceeding and deepen the research on the areas which are proven to influence innovation on the sector they operate and the areas which would bring the bigger benefits for them. These results are the starting point of the path to innovate successfully.

5. Conclusions

Innovation is a vast topic which has been increasingly studied. However, the study about innovation in the service sector is still a relatively new theme in comparison with manufacturing. Yet, since the market is becoming more and more service based more attention has been given to services.

Many studies focus on the behavior of services innovation comparing to manufacturing leading to three different possible approaches: the assimilation approach that considers service innovation as done in similar ways as manufacturing; the demarcation approach that considers innovation in the two sectors as completely different and so studies them as different matters; and, the integrative approach which studies the two sectors as comparable with each other, looking for some similarities and some differences between them. This was the focus on this thesis, since its goal was to compare the two sectors and understand how different service innovation is from manufacturing innovation. It was discovered that the integrative approach is becoming the most widely accepted perspective since these two sectors even though are different share similarities with each other. This led to the creation of hypotheses aiming to better differentiate the two sectors and their behavior innovation wise both in Europe and the world but focusing on Portugal by using CIS-2016.

The results go in accordance with the “integrative approach” since services and manufacturing share many similarities when looking at the size of the company, the percentage of graduated employees, innovation developed in cooperation and on the expenditure in R&D. However, some differences can be found by focusing on the specific needs to achieve innovation, such as services innovation depending on being part of a group and manufacturing depending on the revenue, or services innovation depending slightly less on graduated employees but more on skilled employees since training activities affects more this sector. Other results show that manufacturing innovation depends more on the cooperation with other entities and the R&D expenditure.

These results are in line with Pires *et al.* (2008), Hipp and Grupp (2005), and Álvarez *et al.* (2015) who concluded size has more impact on manufacturing innovativeness than on services, which can be considered true if we take into account that one of the major indicators of the size of a company is the revenue which has influence in manufacturing innovativeness but not in services or, as Zahler *et al.* (2014) found in services, size has little correlation with innovation.

Andersen *et al.* (2019), Teixeira and Bezerra (2016) and Zahler *et al.* (2014) argued that services would benefit from more skilled employees which is in accordance with the obtained results since having a higher percentage of graduated employees influences both sectors but having other skills influences more services. Andersen *et al.* (2019) emphasized that engaging in cooperation positively influences innovation. Faria *et al.* (2010) claimed that firms which take advantage of knowledge generated elsewhere improve the probability to be a successful innovator. The results related with cooperation and the expenditure in R&D are in accordance with Teixeira and Bezerra (2016) since they stated for them cooperation has a positive effect in innovation and that services companies which

continuously invest on R&D are more innovative than those that do not invest the same for Zahler (2014) who stated that services which invest in R&D are more innovative.

However, some research findings go against these results such as Álvarez *et al.* (2015) who sees cooperation in services as more important which from the results cannot be considered true, yet this statement cannot be discarded. The same for Tether (2005) and Aboal *et al.* (2015) whose findings suggested services tend not to need formal R&D.

As expected, this research like all has its limitations. Firstly, it only covers a small percentage of the number of Portuguese companies (6775) and on that universe of companies some would choose not to answer to certain questions making the number of observations even smaller, only two years (2014-2016) were considered and only considers the time the company answered the questions and not the time interval. The longitudinal analysis, using a panel data based on various CIS surveys, would benefit the study of innovation since it would be possible to better understand the evolution of the companies in the country concerning innovation and to better comprehend their decision-making process when looking to the future. However, this would only be possible if the survey between iterations stayed similar maintaining the same questions to make feasible a comparison between iterations. Even though a lot of progress has been made to include and collect more accurate and realistic data about the increasingly important services sector, some progress updates to the survey have still to be made, making it difficult to accurately trace the evolution of innovation in the country also because the last surveys were very different from CIS 2016.

Other limitation has to do with the heterogeneity of the services sector, since each sector has distinct characteristics from the other, this was considered in the variables with the variable Services subsectors but the lack of observations after creating the model made it extremely inaccurate and not trustworthy. The first solution would be the increase of the number of observations to maintain a high level of differentiation between subsectors. Other solution would be the segregation of services subsectors as perhaps KIBS (Knowledge Intensive Business services) and non-KIBS to aggregate observations obtaining more accurate results and to better understand the behavior of this sector since as mentioned before is highly differentiated embracing companies from extremely distinct environments. The study of the differences of the services sector alone could serve as the subject for a future study since it has shown to be of extreme complexity.

Another interesting approach to this topic would be to compare Portugal's innovativeness with other countries, mainly EU countries, since CIS gathers data from numerous European countries making it easier to compare as the survey is extremely similar for all countries.

Deepening the subject of cooperation activities could also be a topic of interest to understand which are the entities with whom cooperation is more advantageous towards innovation, yet there is another limitation with the number of observations when looking specifically into this subject. The last limitation has to do with the lack of studies regarding the Portuguese market since only André *et al.* (2002), Pires *et al.* (2008) and Teixeira and Bezerra (2016) wrote about this country's specificities

making it difficult to compare the already written literature about this country and the results based in CIS 2016 for Portugal.

With these results the conclusion is that further and deeper research can be made to better refine the results such as studying the subject of each hypothesis on its own, which may result in finding more differences or similarities between the two sectors characterizing better each one. This better characterization of each sector mainly focusing on the least studied, the services would highly benefit companies of that sector on the decision-making process and on how to approach innovation in the future since the different subsectors are highly differentiated.

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Appendix

Table A1 Relevant literature (research goals, findings), model and variables used

Authors	Study	Subject	Model/variable
Andersen et al. (2019)	Delloite	Studies innovation in Europe related to technology, human factor, and organization. The triggers of innovation. The types of innovation pursued by each company. Technology role in enhancing innovation. The impact of employees in innovation. The search for innovation ideas. The barriers when innovating. 9 out of 10 companies innovate. Too much focus on technological innovation.	Model: Survey key managers and innovation decision makers in 760 companies in 16 European Countries
Guellec and Pattison (2001)	CIS-1 CIS-2 CIS-3 Australia	Studies the characteristics of CIS and the issues which need to be addressed in order to improve future surveys. The purpose of the surveys and their goal. Compares manufacturing and services innovation in CIS-2 (Technological innovation). Finds similarities with other surveys (e.g., Australia). The determinants of innovation.	Model: Survey
Pires et al. (2008)	CIS-3 Portugal	Studies differences between service and manufacturing sectors innovation (product and process) using Portuguese data. Compares the determinants in order to find differences. Larger firms invest more in R&D and being part of a group influences innovativeness Number of higher educated or trained employees impacts innovativeness Finds some differences but overall, these sectors are not so different supporting the integrative approach.	Model: Logit Regressions Dependent Variable: PIONINOV, PRODINOV, PROCINOV. Independent Variable: INTRD, EX-TRD, RDCOL, MACH, TRAIN, HIEMP, SIZE, MNC, YOUNG, SERV, HTM, MTM, LTM, COM, KIBS, FIN.
Hipp and Grupp (2005)	CIS-2 CIS-3 German innovation survey	Studies the measurement concepts derived from manufacturing and introduces new typology to better understand services innovation. Finds lack of skilled personnel which would hinder the move towards a service society. Data, information, and knowledge are especially produced and traded by services.	Model: Survey

Gallouj and Savona (2008)	Various	Reviews the literature about three approaches of innovation in services. Services are the core engine of a knowledge-based economy. Difficult subject to study due to its intangibility Supports an integrative approach due to subtleness of the boundaries between products and services.	Model: Review, Compilation
Teixeira and Bezerra (2016)	CIS-2008 Portugal	Studies the determinants of innovation for the service sector (focus on Portugal). Finds that skilled human capital is important to be more innovative but only up to undergraduates. Companies with high proportion of PhD employees tended to be less innovative. Finds that service companies that invest more in R&D are more innovative.	Model: Survey (logit regressions) Independent variables: human capital, acquisition of knowledge, information sources for innovation, cooperation aimed at innovation Control Variables: size, group of companies, multinationality, location. Dependent Variables: product, process, organizational, marketing innovation, innovation.
Zahler et al. (2014)	Chile Technological innovation-2007	Studies services and manufacturing in an emerging economy. Larger firms have the means to pay the high fixed costs Exports perspective. Exporters innovate more. Services export less than manufacturing. Size in services has little correlation with exportation (skills are more important than scale).	Model: Survey (2933 plants, 51% manufacturing) weighted descriptive statistics and regressions Independent variable: manufacture exporter, tradable service non-exporter, tradable service exporter, manufacture non-exporter, manufacture innovator, tradable service non-innovator, tradable service innovator, manufacture non-innovator. Dependent variable: Sales, employment, skill intensity
Hauknes (1998)	CIS-2 SI4S	Understand the role of services and services innovation in Europe. Studies innovation in services as an explored field of research at a time when manufacturing innovation was a researched subject. CIS-2 is an improvement but far from complete Distinguishes 2 perspectives (demarcation and assimilation).	Model: Survey, Synthesis of national reports

Van Ark et al. (2003)	Various	Studies differences between services and non-services sectors. Deepening of existing innovation policies (service friendly focus on non-technological). Broadening innovation policies (subtleness of the boundaries). Horizontalization of innovation policies (policies no related to innovation as important to improve service innovation).	Model: Review, discussion
Tether (2005)	CIS-2 CIS-3 Innobarometer 2002	Studies innovation in services comparing with manufacturing. Services innovation based on continuous change and soft capabilities (workforce and cooperation). Finds issue with CIS approach leading to results stating services as less innovative than manufacturing. Manufacturing innovates more through R&D. services more through ICT. Services can use manufacturing sources and vice-versa.	Model: Logit regression Independent variables: new firms, firm size, service sector firms, engaging in exporting, proportion of exports in total sales, country, firm's employment; Services—product/process innovation, Services—organizational innovation. Dependent Variables: Product, process, organizational innovation; Supply chain cooperation Acquisition of adv. Equipment, Conducting in-house R&D, Cooperation with universities, Acquisition of external IP; Staff and their qualifications, Cooperation practices, Flexibility and adaptability, Leadership in market trends, Technology and R&D, Efficiency of production.
Castro et al. (2010)	PITEC (based on CIS) Spain	Compares the innovative behavior of services and manufacturing companies. Services and manufacturing innovate but display different behavior preferences. Services innovate more organizationally. Manufacturing innovates more technologically. Uses Synthesis (integrative) approach but takes into account assimilation and demarcation.	Model: Survey (11330 entities) binary logit regression Independent Variables: <u>Product</u> ; Innovation in goods, in services. <u>Process</u> ; Innovation in methods, in logistics, in support activities. <u>Organizational</u> ; Innovation in management systems, in work organization, in relations with other companies. <u>Commercial</u> ; Significant modifications of product design and packaging, modifications in sales/ distribution methods Control Variables: <u>Company ownership</u> ; Public, Spanish private International private, Research association. <u>Company set-up</u> ; Established, Start-up. <u>Size (number of employees)</u> ; Less than 200, Over 200 <u>Company market</u> ; Local market, Domestic market, EU market, Market in other countries. Dependent Variables: Manufacturing, %s/manufacturing, Services, %s/services

Álvarez et al. (2015)	Chile innovation survey, 5 th , 6 th rounds	<p>Studies productivity of innovation on services comparing it with manufacturing.</p> <p>Similar behavior between sectors in innovation.</p> <p>The determinants analyzed result in a similarity in technological innovation.</p> <p>Firm size has greater impact on manufacturing.</p> <p>Positive relationship between expenditure on innovation and the size of the company.</p> <p>Cooperation more important for services.</p> <p>Non technological innovation which was expected to have greater importance in services es strangely similar in manufacturing (variables possibly more related to technological innovation).</p>	<p>Model: multi equation model</p> <p>Independent variable: Export, firm size, foreign ownership, patent protection, cooperation, public finance, sources of information, Intensity, innovation output in product or process labor productivity, Non-technological innovation output</p> <p>Dependent Variables: Manufacturing, services, Traditional services, KIBS</p>
Aboal et al. (2015)	Various	<p>Studies the role of the service sector and its productivity.</p> <p>Finds services innovation as being more non-technical and based on incremental changes in processes and procedures.</p> <p>Services depend more than manufacturing on ICT.</p> <p>Lack of evidence about how to promote innovation, productivity growth and the effect on employment on services.</p>	Model: Review, compilation
Becheikh et al. (2006)	Various	<p>Studies technological innovation on manufacturing</p> <p>Study how variable innovation was approached</p> <p>Identify explanatory variables which determine innovative behavior</p> <p>Positive correlation between firm size and innovation but complex</p> <p>Policy makers banish barriers to promote competitiveness and innovation</p> <p>Size and industry two main variables</p>	Model: Systematic review

Sirilli and Evangelista (1998)	Italy survey	Studies technological innovation in services and manufacturing. Innovation expenditure per employee is similar between sectors. The most important objectives of innovation strategies are service/product quality, increase market share and reduction of costs.	Model: Survey
André, et al. (2002)	CSF	Studies the evolution of the Portuguese economy. Finds business services companies growing in Portugal (threats and opportunities of consultancies).	Model: Review
Faria et al. (2010)	CIS-3	Studies the importance of cooperation for the development of innovation activities Two types of partners one builds form existing internal knowledge, other provides the knowledge. Firms which take advantage of knowledge generated elsewhere improve the probability to be a successful innovator. Firms cooperating with others show on average a higher level of performance. Firms with higher levels of absorptive capacity, exports and innovation intensity and are part of a group are more probable to participate in cooperation agreements. Main determinants to engage in cooperation activities are being part of a group, invest in R&D, the innovation intensity and the management of spillovers.	Model: Probit Selection Independent variables: Number of employees, number of employees(log), exports share, part of a group, engagement R&D, employees' education, innovation intensity, incoming knowledge spillovers, appropriability, low-tech firm, medium-tech firm, high-tech firm, Non knowledge intensive service firm, knowledge intensive service firm, number of observations. Dependent variable: all innovative firms, firms engaged in innovation cooperation activities, firms not engaged in innovation cooperation activities, firms where cooperation had low or medium importance to innovation, firms where cooperation was highly important to innovation
Camacho and Rodriguez (2007)	CIS-3 Spain	Studies innovative characteristics of services in Spain Services play an active role in the innovation scope Service activities with higher number of innovating firms are the branches which cooperate most Concludes close relationship with high innovative services with universities and public research centers	Model: Factor and cluster analysis Variables: <i>Innovative character:</i> NONTECIN, TECIN <i>Intensity and sources of the innovation activity:</i> GTE, RD, INVES, PER, <i>Results:</i> PAT <i>Interaction with the public subsystem of innovation:</i> UNIVCO, PUB

Hsueh et al. (2010).	Independent	Studies network embeddedness relationship with service innovation Enterprises establish more network connections Enterprises improve strategic resource management Reach an intermediary position on their cooperative relationships Maintain good relationship with supplier and customer	Model: Survey
Vermeulen et al. (2005).	CATI (2001)- Netherlands	Study relationship between identified key factors and small service firms Small service firms engage in innovation boosting activities will more likely introduce new products long-term survival knowledge intensive services depend on co-worker' knowledge and relationships with of customers	Model: Survey
Schmidt and Rammer (2006)	CIS IV- Germany	Analyse the determinants and effects of non-technological innovations. Find the determinants of the technological and non-technological innovations very similar closely related technological innovators that combine their product and process innovations with marketing or organisational innovations perform better	Model: Probit Independent variables: Number of employees; Share of high skilled labor; Labor productivity; Turnover share of product with the highest turnover in 2004; Share of turnover with the three most important customers in 2004 Dependent variables: Non-technological Innovation ; Technological Innovation; Non-technological innovation conditional on having technological innovation; Technological innovation conditional on having non-technological innovation; Control variables: Exports; Part of a group
Arvantis and Bolli (2012)	CIS-3 Swiss innovative survey 2002	Studies the differences between national and international cooperation (Belgium, Germany, Norway, Portugal, Switzerland) Multinational cooperation to innovation important in globalized markets. National cooperation unaffected innovation performance	Model: Probit Independent variables: <i>Absorptive capacity:</i> FEPT, OSKILL <i>Incoming spillovers:</i> SPILLIN <i>Appropriability:</i> APPR <i>Proxies for risk- and cost sharing:</i> OFIN <i>Cooperation variables (for second equation):</i> NATCOOP INTCOOP Dependent variables: First equation: COOP_NAT_INT Second equation: NEWS Control variables: INVPT, PUBFIN, GROUP, FOREIGN, MARKET_2, MARKET_3, SIZE_2, SIZE_3
Freel (2003)	Survey of Enterprise in Scotland and Northern England- 2001	Investigate cooperation associated with firm level product and process innovativeness Caution when developing network strategies or policies increasing firms size and export	Model: logit Independent variables: Firm age; Size, R&D expenditure; %technicians; %QSE's; %professionals/managers; Export; Novel Products; Incremental products; Novel processes; Incremen-

		<p>propensity are positively associated with external linkages at a higher spatial level</p> <p>R&D expenditure and technical employment associated successful innovation</p> <p>Innovating firms need collaboration</p>	<p>tal processes.</p> <p>Dependent Variable: New to industry Products</p> <p>Control Variables: INN; RD; CUST; SUPP; COMP; UNI; PUB</p>
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Table A2 Correlation matrix

	Implemented innovation	In-house or bought R&D	In-house R&D expenditure	Bought R&D expenditure	Innovation developed exclusively by the company	External innovation modified by the company	Innovation developed in cooperation	Percentage of college graduate employees	Training activities	Large companies	Yearly revenue	Part of a group	International cooperation	Acquisition of advanced equipment/technologies	Intellectual property
Implemented innovation	1.000														
In-house or bought R&D	0.2478	1.000													
In-house R&D expenditure	0.2548	0.7207	1.000												
Bought R&D expenditure	0.1109	0.4022	0.2819	1.000											
Innovation developed exclusively by the company	0.2544	0.1331	0.2009	0.0047	1.000										
External innovation modified by the company	0.1912	0.1030	0.0672	0.0667	0.0423	1.000									
Innovation developed in cooperation	0.2076	0.2601	0.2253	0.2296	-0.0730	0.2460	1.000								
Percentage of college graduate employees	0.1642	0.3239	0.3639	0.1502	0.0044	0.0613	0.1952	1.000							
Training activities	0.1477	0.1043	0.1454	0.1111	0.0792	0.1339	0.1703	0.1025	1.000						
Large companies	0.0433	0.1627	0.2339	0.1560	0.0250	0.0141	0.1173	0.0830	0.0377	1.000					
Yearly revenue	0.0727	0.1952	0.2301	0.2134	-0.0574	0.0116	0.1996	0.2264	0.0360	0.4845	1.000				
Part of a group	0.0729	0.1790	0.1815	0.1498	-0.0927	0.0545	0.1971	0.2998	0.0386	0.3129	0.4663	1.000			
International cooperation	0.0284	0.1193	0.1574	0.0618	0.0631	0.0019	0.0416	-0.0248	0.0327	0.1503	0.0798	0.0602	1.000		
Acquisition of advanced equipment/technologies	0.0841	0.0437	0.0970	0.0754	0.0744	0.0978	0.1054	-0.0574	0.1598	0.0573	0.0350	-0.0682	0.0470	1.000	
Intellectual property	0.1591	0.2273	0.2657	0.1400	0.0699	0.0598	0.1662	0.1948	0.1195	0.0546	0.0854	0.0203	0.0893	0.0761	1.000

Table A3 Logit regression of base model, base model a and b

Variables	Implemented Innovation		
	Manufacturing and Services (base model)	Manufacturing (Base model a)	Services (Base model b)
Part of a group	0.404*** (0.090)	0.294* (0.126)	0.506*** (0.132)
International orientation	0.086 (0.095)	0.195 (0.118)	-0.071 (0.169)
Acquisition of advances Equipment/technologies	0.417*** (0.079)	0.386*** (0.107)	0.475*** (0.119)
Intellectual property	1.059*** (0.112)	0.908*** (0.146)	1.263*** (0.178)
Constant	0.784*** (0.067)	0.805*** (0.093)	0.737*** (0.098)
Observations	4229	2360	1869
LR chi²	169.73	79.02	96.17
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.71%	79.66%	79.78%
Pseudo R²	0.0398	0.0331	0.0511

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A4 Logit regression of model 1, model 1a and model 1b

Variables	Implemented Innovation		
	Manufacturing and Services (model 1)	Manufacturing (Model 1a)	Services (Model 1b)
Yearly Revenue	0.056* (0.025)	0.171*** (0.039)	-0.049 (0.038)
Part of a group	0.300** (0.102)	-0.040 (0.147)	0.586** (0.146)
International orientation	0.072 (0.095)	-0.097 (0.121)	-0.086 (0.133)
Acquisition of Advanced equipment/technologies	0.403*** (0.079)	0.326** (0.108)	0.481*** (0.119)
Intellectual Property	1.042*** (0.113)	0.838*** (0.147)	1.272*** (0.178)
Constant	-0.011 (0.366)	-1.567 (0.549)	1.447** (0.558)
Observations	4229	2360	1869
LR chi ²	174.55	99.31	97.88
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.74%	79.66%	79.78%
Pseudo R ²	0.0409	0.0417	0.0520

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A5 Logit regression of model 1c, model 1d and model 1e

Variables	Implemented Innovation		
	Manufacturing and Services (Model 1')	Manufacturing (Model 1'd)	Services (Model 1'e)
Large Companies	0.177 (0.194)	0.061 (0.802)	0.425 (0.337)
Part of a group	0.401*** (0.102)	0.209 (0.152)	0.487** (0.141)
International orientation	0.033 (0.102)	0.112 (0.127)	-0.030 (0.184)
Acquisition of Advanced equipment/technologies	0.390*** (0.082)	0.377** (0.112)	0.430*** (0.123)
Intellectual Property	1.058*** (0.121)	0.912*** (0.160)	1.227*** (0.187)
Constant	0.798*** (0.069)	0.814*** (0.096)	0.753*** (0.101)
Observations	3787	2062	1725
LR chi²	143.82	62.24	85.81
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.17%	78.81%	79.59%
Pseudo R²	0.0371	0.0292	0.0492

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A6 Logit regression of model 2, model 2a and model 2b

Variables	Implemented Innovation)		
	Manufacturing and Services (Model 2)	Manufacturing (Model 2a)	Services (Model 2b)
College graduated employees	0.189*** (0.027)	0.210*** (0.049)	0.193*** (0.034)
Training activities	0.592*** (0.084)	0.498*** (0.114)	0.601*** (0.126)
Large Companies	0.126 (0.212)	-0.308 (0.274)	0.609 (0.361)
Yearly revenue	0.014 (0.031)	0.138** (0.048)	-0.083 (0.045)
Part of a group	0.118 (0.115)	-0.141 (0.169)	0.380* (0.160)
International orientation	0.077 (0.104)	0.054 (0.131)	-0.094 (0.190)
Acquisition of Advanced equipment/technologies	0.353*** (0.085)	0.252* (0.116)	0.423** (0.127)
Intellectual Property	0.856*** (0.124)	0.696*** (0.163)	1.011*** (0.191)
Constant	-0.006 (0.439)	-1.566* (0.065)	1.167 (0.669)
Observations	3787	2062	1725
LR chi ²	248.73	124.31	149.37
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.17%	78.81%	79.54%
Pseudo R ²	0.0642	0.0584	0.0856

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A7 Logit regression of model 3, model 3a and model 3b

Variables	Implemented Innovation		
	Manufacturing and Services (model 3)	Manufacturing (Model 3a)	Services (Model 3b)
Innovation developed in co-operation	0.738*** (0.089)	0.848*** (0.124)	0.619*** (0.131)
College graduated employees	0.168*** (0.027)	0.174*** (0.049)	0.180*** (0.035)
Training activities	0.452*** (0.085)	0.388** (0.116)	0.557*** (0.127)
Large Companies	0.109 (0.213)	-0.343 (0.277)	0.592 (0.363)
Yearly revenue	-0.008 (0.032)	0.119* (0.048)	-0.097* (0.046)
Part of a group	0.020 (0.117)	-0.256 (0.172)	0.295 (0.162)
International orientation	0.067 (0.105)	0.014 (0.133)	-0.053 (0.190)
Acquisition of Advanced equipment/technologies	0.304*** (0.086)	0.207 (0.117)	0.373** (0.129)
Intellectual Property	0.775*** (0.125)	0.623*** (0.165)	0.917*** (0.193)
Constant	0.144 (0.452)	-1.440* (0.652)	1.202 (0.679)
Observations	3787	2062	1725
LR chi ²	318.86	172.97	172.00
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.17%	78.81%	79.42%
Pseudo R ²	0.0823	0.0812	0.0985

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001

Table A8 logit regression of model 4, model 4a and model 4b

Variables	Implemented Innovation		
	Manufacturing and Services (Model 4)	Manufacturing (Model 4a)	Services (Model 4b)
In-house or bought R&D	0.319* (0.143)	0.309 (0.200)	0.341 (0.209)
In-house R&D expenditure	0.095*** (0.178)	0.106*** (0.025)	0.080** (0.026)
Bought R&D expenditure	0.177 (0.211)	0.034 (0.030)	0.054 (0.303)
Innovation developed exclusively by the company	1.414*** (0.108)	1.636*** (0.160)	1.258*** (0.150)
External Innovation modified by the company	1.230*** (0.142)	1.502*** (0.216)	1.017*** (0.192)
Innovation developed in co-operation	0.755*** (0.102)	0.952*** (0.146)	0.577*** (0.146)
College graduated employees	0.097** (0.030)	0.079 (0.056)	0.096* (0.039)
Training activities	0.335*** (0.092)	0.186 (0.127)	0.502*** (0.136)
Large Companies	-0.433 (0.238)	-0.661* (0.317)	0.022 (0.396)
Yearly revenue	-0.029 (0.036)	0.079 (0.055)	-0.069 (0.051)
Part of a group	0.164 (0.130)	-0.292 (0.194)	0.538** (0.177)
International orientation	-0.123 (0.115)	-0.101 (0.147)	-0.199 (0.208)
Acquisition of Advanced equipment/technologies	0.205* (0.093)	0.205 (0.129)	0.229 (0.139)
Intellectual Property	0.628*** (0.136)	0.539** (0.182)	0.736*** (0.209)
Constant	-0.127* (0.514)	-2.454** (0.770)	-0.193 (0.768)
Observations	3660	1983	1677
LR chi ²	742.31	434.91	332.04
p-value	0.0000	0.0000	0.0000
Correct Prediction	79.97%	80.58%	80.38%
Pseudo R ²	0.1971	0.2105	0.1954

Standard error in parentheses

*p>0.05; **p>0.01; ***p>0.001