The role of organisational innovation in technological innovation

Gabriel Norberto Correia Guerra Franco

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Orientador: Prof. Miguel Simões Torres Preto

Júri

Presidente: Prof. Rui Miguel Loureiro Nobre Baptista
Orientador: Prof. Miguel Simões Torres Preto
Vogais: Prof. António Miguel Areias Dias Amaral

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Abstract

This work aims to identify how organisational innovation and its individual subdivisions affect technological innovations (product/service and process) by using data on Portuguese companies from the Community Innovation Survey (CIS) carried out between 2012 and 2014. In this research, logistic regression was used to test the hypotheses and by using two types of models. Traditional models using variables that are common in the literature and exploratory models that contain more variables seldom found in the literature. The analysis shows that the exploratory models have marginally better fit and are better at predicting the values of the dependent variables than the traditional model. The results show that organisational innovations have a significant positive effect in the introduction of both service and process innovations, but not product innovations. For the subdivisions of organisational innovation, new business practices and new methods of workplace organisation have a positive effect in service and process innovations, while new methods of handling external relations only positively affect the introduction of service innovations.

Keywords: Organisational innovation; Technological innovation; Organisational practices; CIS

Resumo

Este trabalho tenta identificar como inovações organizacionais e as suas subdivisões podem afectar inovações tecnológicas (produto/serviço e processo) utilizando dados de empresas Portuguesas provenientes do Inquérito Comunitário à Inovação (CIS), levado a cabo entre 2012 e 2014. Nesta pesquisa, a regressão logística foi usada para testar as hipóteses e utilizando dois tipos de modelos. Os modelos tradicionais usam variáveis normalmente encontradas na literatura e os modelos exploratórios que contêm variáveis que são menos usadas na literatura. A análise mostra que os modelos exploratórios têm um ajuste marginalmente melhores que os modelos tradicionais e são melhores a prever o resultado das variáveis dependentes.. Os resultados mostram que as inovações organizacionais têm um efeito significativo e positive na introdução de inovações de serviço e de processo, mas não nas inovações de produto. Para as subdivisões de inovação organizacional, novas práticas de negócio e novas formas de organizar o local de trabalho têm um efeito positivo na introdução de inovações de serviço e processo, enquanto que novo método para gerir relações externas apenas afecta positivamente a introdução de inovações de serviço.

Palavras chave: Inovação organizacional; Inovação tecnológica; Práticas organizacionais; CIS

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1 Introduction

In this chapter the focus of the document will be defined and associated to the larger picture of innovation, and some common problems and difficulties will also be presented. The underlying problem of the document will be outlined and explained, followed by the structure of the document.

This dissertation focuses on organisational innovations[1] and how they can affect technological innovations (product and process innovations). Organisational innovations are changes in business practices, management processes, communication and company structure. This type of innovation has existed for decades, but authors and researchers started studying it later than other types of innovations. Organisational innovations were not recognized as such due to their sometimes informal nature (Crossan & Apaydin, 2010) and to the delay of their effects (Gunday, Ulusoy, Kilic, & Alpkan, 2011). However, when implemented correctly and given enough time to mature, organisational innovations can bring a plethora of benefits, such as efficiency increases and improved communication, they can be used as foundations to implement other innovations, and even contribute to sales performance, more productivity and employment growth (Klomp & Van Leeuwen, 2001).

The interactions between innovations are not completely understood (Carboni & Russu, 2018), meaning that managers have trouble identifying which combinations are needed to improve the company's performance. Lately researchers have started paying more attention to organisational innovations and how they interact with technological innovations, but there is still no consensus on what their effects are. Some studies point to organisational innovation bringing significant benefits (Camisón & Villar-López, 2014; Gunday et al., 2011), while others state that the effects are moderate or indirect (Foss, Laursen, & Pedersen, 2011).

1.1 Problem definition

The study of organisational innovation has led to a solid theoretical foundation, however, on the empirical side, research is still mainly focused on the effects on company performance. While this information is necessary, the effects that innovations have on each other are still not fully understood (Guisado-González, Wright, & Guisado-Tato, 2017), with some of the most relevant research on the problem being that of Camisón & Villar-López (2014), Gunday, Ulusoy, Kilic, & Alpkan (2011), Mothe & Thi (2010) and Schmidt & Rammer (2007). They all try to either link innovation drivers between technological and non-technological innovations or to ascertain how non-technological or organisational innovations can affect the development of technological innovations and company performance. Furthermore, the effects of innovations differ between countries (Ballot, Fakhfakh, Galia, & Salter, 2015; Carboni & Russu, 2018; Guisado-González et al., 2017), meaning that the same innovations can be implemented in different countries but the results can differ due to country regulations and/or culture. This only adds to the difficulty in understanding the

[1] Implementation of a new organisational method in business practices, workplace organization or external relations (OECD, 2005).

complementarities shared by innovation types, since the studies performed in one country may not be relevant in other countries. For a more complete understanding, studies need to be made for specific countries. Not understanding the interrelationships of organisational innovations and technological innovations (in specific countries) leads to subpar company performance, with managers left guessing as to what organisational changes are necessary in order to create synergistic combinations or facilitate later innovation attempts.

Papers studying effects between innovations in Portugal are very rare, with Marques & Ferreira's (2013) being the only relevant one (and therefore the only possible comparison to this study), meaning that a more detailed analysis of the effects of organisational innovation in technological innovations in Portuguese companies using more recent data is necessary.

The main goal of this research is to identify how organisational innovation (and its subdivisions) can affect technological innovation (product and process innovations), by using data from the Community Innovation Survey (CIS) on Portuguese companies between 2012 and 2014.

By understanding the current complementarities between innovations in Portugal, a baseline for the country can be created. This can be used by managers to identify which form of organisational innovation is expected to create the best synergy with their future technological innovations, or to help them start to innovate from a solid foundation. By doing so, the overall company performance, or at least, the innovative performance, will likely increase (Hervas-Oliver, Sempere-Ripoll, Boronat-Moll, & Rojas, 2015; Marques & Ferreira, 2013; Sapprasert & Clausen, 2012). The results can also be important to policy making decisions, possibly facilitating and/or encouraging future innovations.

1.2 Structure

This document is structured as follows: In section 2 (Literature review) the different types of innovation will be outlined, along with their drivers and common issues, followed by the review of empirical evidence and formulation of hypotheses. In section 3 (Data and methodology), the methodology for studying how organisational innovations affect technological innovations will be presented. In the final section, pertinent conclusions will be drawn given the present state of available information.

2 Literature review

In this section the basic concept of innovation will be explained, the main types of innovation will be described, with a greater focus on organisational innovation, the common problems that hinder innovations will also be approached, as well as the reasons companies have to innovate and the representation of innovation drivers. Then, the interplay between innovations will be presented, followed by a collection of empirical evidence and finishing in the proposed research hypotheses.

2.1 Innovation

Innovation is the engine of progress, being necessary for technological advancement and used by companies to create competitive advantage, enter new markets, or increase market share (Gunday et al., 2011). Its definition is complex, uncertain, disorderly and subject to change (Kline & Rosenberg, 1986). The first author to formally define innovation was Joseph Schumpter, stating that an innovation is "*the commercial or industrial application of something new"* (Schumpeter, 1934, p. 4). While this remains the core definition, it has evolved and has been adapted to fit many fields. Recently, the OECD created a definition that is very well accepted by both companies and researchers:

"An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." (OECD, 2005, p 46)

2.2 Types of innovation

2.2.1 Product innovation

A product innovation is characterized by significant changes to the capabilities of products/services, including improvements in materials, components or user friendliness (OECD, 2005). These changes can be improvements to existing offerings or the creation of entirely new ones, by using new technologies or by adapting/expanding existing ones, and are usually implemented in an attempt to satisfy customer demand or to create a temporary monopoly position (Tavassoli & Karlsson, 2015).

2.2.2 Process innovation

Process innovations refer to the implementation of a new or significantly improved production or delivery method, including changes to equipment, techniques or software (OECD, 2005). The usual goals are to reduce production costs or to improve a product's quality. If the goal is to cut costs, then the preservation of the product's quality is also paramount (Tavassoli & Karlsson, 2015).

2.2.3 Organisational innovation

Organisational innovations revolve around changing routines within the organization with the goal of improving the profitability, efficiency and productivity, or flexibility and creativity by using tacit knowledge (Tavassoli & Karlsson, 2015). There are many examples of what a company can change internally, such as defining procedures for better communication between functional areas, steering training focus, implementation of practices to increase employee retention, introducing methods to facilitate decision-making, improve accountability and encourage autonomy, or creating new types of relationships (or expand existing ones), with the aim of improving external relations. This type of innovation usually comes from a strategic management decision, focusing on how the company operates internally. However, the strategy by itself is not the innovation, but rather the implementation of said strategy. The exception being mergers and acquisitions, even if it is the first time a company acquires another (OECD, 2005).

As for a formal definition, several exist, each with a slightly different focus or application. Camisón & Villar-López (2014) have outlined some of the most used and accepted definitions and arranged them in a sort of evolutionary timeline, which is presented in Table 1:

Table 1 - Evolution of the definition of organisational innovation

Study	Terminology	Definition
Daft (1978)	Administrative innovation	Concerns organisational structure and administrative processes
Kimberly & Evanisko (1981)	Administrative innovation	Adoption of electronic data processing for a variety of internal information storage, retrieval and analytical purposes, indirectly related to the basic work activity of the hospital and more immediately related to its management
Damanpour & Evan (1984)	Administrative innovation	Innovations introduced into the organisational structure, into administrative processes and/or human resources
Damanpour, Szabat, & Evan (1989)	Administrative innovation	Innovations in the administrative component that affect the social system of an organization
Hwang (2004)	Managerial innovation	Design of an appropriate organisational structure and processes, and a human resource system
OECD (2005)	Organisational innovation	Implementation of a new organisational method in business practices, workplace organization or external relations
Hamel (2006)	Management innovation	A marked departure from traditional management principles, processes and practices or a departure from customary organisational forms that significantly alters the way the work of management is performed
Armbruster et al (2006, 2008)	Organisational innovation	Changes in the structure and processes of an organization due to implementation of new managerial and working concepts and practices, such as teamwork in production, supply chain management, or quality management systems
Birkinshaw, Hamel, & Mol (2008)	Management innovation	Invention and implementation of a management practice, process, structure or technique that is new and is intended to further organisational goals
Mol & Birkinshaw (2009)	Management innovation	Introduction of management practices that are new to the firm and intended to enhance firm performance
Battisti & Stoneman (2010)	Organisational innovation	Innovation involving new management practices, new organization, new marketing concepts and new corporate strategies
Damanpour & Aravind (2012)	Managerial innovation	New approaches in knowledge for performing management functions and new processes that produce changes in the organization's strategy, structure, administrative procedures, and systems
Tavassoli & Karlsson (2015)	Organisational innovation	Changes in the routines of firms aiming at improving the efficiency, productivity, profitability, flexibility and creativity of a firm using disembodied knowledge.

Source: Camisón & Villar-López (2014)

In terms of the evolution of the definition, the first ones focused on the organisation's structure and processes, with information storage and communication improvements being considered later. After that, human resources were incorporated, followed by workplace organisation and external relations. Later, corporate strategies are included, finishing with the definition of improvements in efficiency, productivity, profitability, flexibility and creativity as end goals. There is a lot of overlap in the definitions, even when they refer to different organisations, with the differences being a necessary specialization for the definition's intended field.

The definitions encompass changes in administrative processes, digitization of information for better access, organisational structures, human resources, business practices, external relations, and management practices. Despite the variations in the contents and nomenclature, all definitions revolve around changes in the organisation's structure, management, processes, communication and decision making. All of which being intended to improve firm performance and outside relations.

Organisational dimension can be used to differentiate between organisational innovation types, being either intra or inter-organizational (Figure 1). Intra-organisational innovations are self-explanatory, and inter-organizational innovations refer to changes in organisational structures outside the company's boundary, usually in new or revised communication methods with other organizations (partnerships, R&D cooperation with customers, supplier practices' management, etc.).

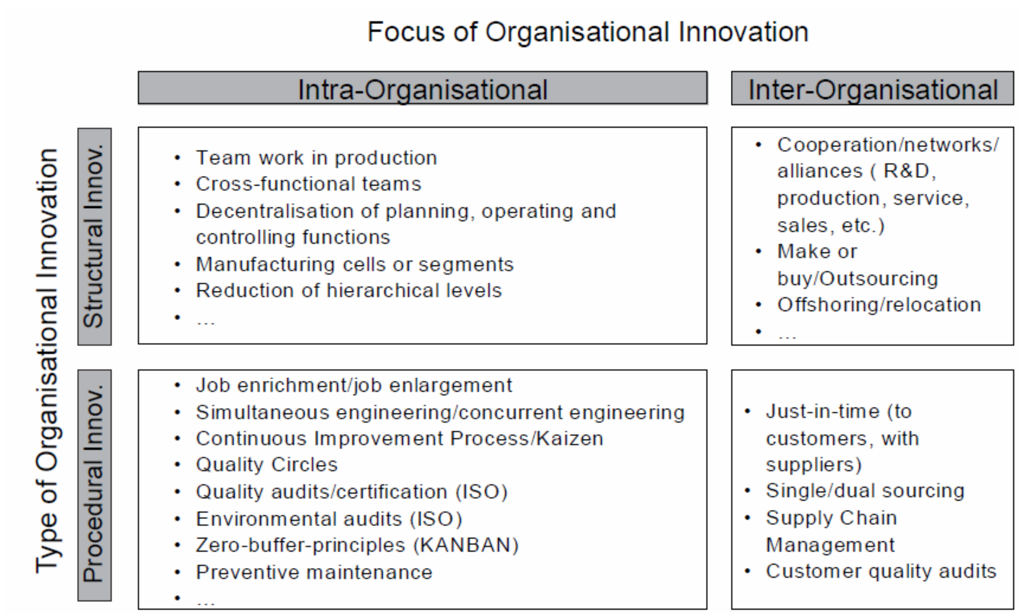

Figure 1 - Classification of organizational innovations (adapted from Armbruster et al., 2006)

This is not the only way to differentiate between types of organisational innovation, while being perfectly valid, it is not used by researchers, since there are better/more widespread options. The most common and accepted one being that of the Oslo Manual (OECD, 2005), which is used as the baseline for the Community Innovation Survey (CIS) (Eurostat). The CIS is used to collect data on innovation in European companies and defines organisational innovation in three distinct classes:

- New business practices for organising procedures;
- New methods of organising work responsibilities and decision making;
- New methods of organising external relations with other enterprises or public organisations.

According to Lam (2005), organisational innovation may be a precondition to technological innovation, meaning that a company can be more successful when attempting to implement an innovation if it can focus in reforming its inner workings beforehand. More specifically, Camisón & Villar-López (2014) and Gunday et al. (2011) state that organisational innovation favours the development of both product and process innovations, while positively impacting overall company performance (including workplace satisfaction) and reducing administrative and supply costs. This is made possible by improving how information is exchanged and by learning how to use new tools (software, technology, etc.). These ideas are also recognised by Armbruster et al. (2006), Haned, Mothe, & Nguyen-Thi (2014), Hervas-Oliver, Sempere-Ripoll, Boronat-Moll, & Rojas (2015), C. Mothe, Nguyen-Thi, & Nguyen-Van (2015), stating that organisational innovations enable and facilitate the development of technological innovations, which need organisational innovations to be fully exploited. Furthermore, organisational innovations can provide an immediate source of competitive advantage.

Company size and region also affect the results obtained by introducing organisational innovations, as well as affecting the introduction of organisational innovations (Carboni & Russu, 2018). While bigger companies have the means to innovate more, smaller companies can reap more benefits from implementing organisational innovation (Gallego, Rubalcaba, & Hipp, 2013; Sapprasert & Clausen, 2012). Furthermore, Ballot, Fakhfakh, Galia, & Salter (2015) have stated that the relationship between organisational innovations with other innovations depends on the country where they are developed. Their findings show that, in the UK, organisational innovations work very well when paired with product innovations, with opposite results in French companies. The positive effects of organisational innovation have become apparent mainly in developed countries, but according to Masso & Vahter (2008), organisational innovation can have a more pronounced impact for companies in developing or transition countries, however, due to the lack of resources and knowledge, it seldom happens.

2.3 Reasons to innovate and barriers to innovation

Companies are constantly competing, and innovations have the potential to tip the scales, giving a competitive advantage over rivals. However, companies can come across roadblocks when developing or implementing an innovation. A company may avoid launching a new product due to high production costs or demand changes (for example). These are called barriers to innovation. These barriers can originate inside a company (e.g. lack of skilled professionals) or outside (e.g. extreme competitive pressure, lack of outside funding) that can render a company incapable of carrying out the desired innovation activities (D’Este, Iammarino, Savona, & Von Tunzelmann, 2012). Another specific reason for not innovating comes from how easy it is to imitate a particular innovation. If any competitor with better investment capabilities can just copy and implement an innovation, that will negate the competitive advantage to the developing company. Imitation may also work in favour of a company, if a competitor develops an innovation that is easily replicated, a company can try to implement it. The added benefit being that the cost of imitation is usually significantly lower than the development cost (OECD, 2005).

2.4 Innovation as a process or outcome

Companies can have different goals in mind when trying to develop/implement an innovation. A certain innovation may be a revolutionary product (innovation as an outcome), or a necessary change to allow for more efficiency or flexibility. Sometimes, an innovation may be necessary to implement another innovation (innovation as a process). For this reason, innovations are classified as a process or an outcome, with the former trying to answer the question of “how” and the latter attempting to answer the question of “what” (Crossan & Apaydin, 2010). For organisational innovation in particular, it can be a process if its implementation allows for subsequent changes within the company (e.g. implementing another organisational innovation), or an outcome, if it is implemented to improve workplace efficiency, for example.

It is important to note that innovations as an outcome should not be evaluated based on market performance. An innovative product can be successfully deployed to the market but still be a failure. This can happen due to poor marketing or bad timing, such as if another company introduces another, more appealing substitute (not necessarily an innovation) around the same time. A good example would be Microsoft’s attempt at introducing a tablet to the market in 2001. The product failed despite being the first tablet PC, with the iPad being the first successful tablet in 2010 (Gralla, 2011).

2.5 Innovation drivers

Innovation drivers are internal or external factors that influence the development of innovations. External factors, besides being too numerous to list, are not controllable, but can be predicted. Internal factors are more controllable, but their effects can vary from company to company. They are much easier to understand and can be mitigated, should the factor hamper the innovation process. For the purposes of this paper, only the drivers that are expected to have some impact on organisational and technological innovation, according to the CIS (Eurostat), are presented in Table 2.

Table 2 - Internal factors affecting innovation

<table>
<tr><th>Category</th><th>Subcategory</th><th>Variables</th></tr>
<tr><td>General company Characteristics</td><td>-</td><td>Company size</td></tr>
<tr><td rowspan="5">Company global Strategies</td><td>Strategy definition</td><td>Strategic orientation</td></tr>
<tr><td>Corporate strategy</td><td>Exports/Internationalization</td></tr>
<tr><td rowspan="3">Business strategy</td><td>Differentiation</td></tr>
<tr><td>Cost reduction</td></tr>
<tr><td>Protection mechanisms</td></tr>
<tr><td rowspan="5">Functional assets and strategies</td><td>R&D</td><td>R&D assets and strategies</td></tr>
<tr><td>HR</td><td>Employees’ skill</td></tr>
<tr><td>Operation and production</td><td>Advanced equipment/technologies</td></tr>
<tr><td rowspan="2">Finance</td><td>Financial autonomy</td></tr>
<tr><td>Turnover/profit</td></tr>
</table>

Source: Adapted from Becheikh et al. (2006)

2.6 Complementarities between innovations

According to Ennen & Richter (2010), complementarity is the beneficial interplay of the elements of a system where the presence of one element increases the value of others. In this case, when one innovation increases the value of another. Complementarities can be significant performance drivers, with the performance being measured, in part, by the competitive advantage added by innovations. The synergy created by complementarities can be tremendously helpful to companies, but the possible complementarities may not be identified by the company, leading to loss of value and sub-optimal performance (C. Mothe et al., 2015). In order to identify the complementarities, several investigative approaches can be used (Drazin & de Ven, 1985). One commonly used method is the interaction approach, since it can be used to analyse interaction effects between a few well identified factors. This approach can yield detailed results by using categorical variables as independent variables, usually by employing regression analysis. However, external influencing conditions tend to be somewhat downplayed with this approach. Another option is the systems approach, which is better are identifying complementarities, but requires much more specific data (Ennen & Richter, 2010).

There are few papers focused in complementarities between innovations, the brunt of the research seems to be on the effects on performance. The most relevant findings come from C. Mothe et al. (2015), who studied companies in Luxembourg stating that the complementarities between organisational practices (new business practices, new methods of organising work responsibilities and decision making, and new methods of organising external relations) will be different according to the innovation stage. Their results show that if a company introduces product innovations along with new business practices the innovative performance is usually higher, and higher still when all three types of organisational practices are introduced simultaneously. Guisado-González et al. (2017) on the other hand, used data from Spanish companies and found that organisational and process innovations are complementary but organisational and product innovations are not (however there are no downsides for joint implementation). Carboni & Russu (2018) have also verified the strong complementarity between organisational and process innovations in seven European countries (including Spain). Complementarity between organisational and both product and process innovations has been identified in the research of Polder & Leeuwen (2010), who focused on companies in the Netherlands. They also specify that these effects are present in both services and industrial sectors, with the services sector seeing a higher magnitude of the complementarity effects. The findings on complementarities differ with the country where the study is performed. This disparity is well accepted and supported by several authors, such as Ballot et al. (2015), Carboni & Russu (2018) and Guisado-González et al. (2017).

2.7 Empirical evidence

The following studies tend to use CIS[2] data, which is widely accepted and used throughout Europe. However, some researchers resorted to other databases, such as PITEC (based on CIS, but only for Spanish companies), EFIGE, which collects data from companies in seven European countries (mostly focused on international competitiveness), the Korea Innovation Survey (KIS), or to their own custom surveys, which was the method chosen by Camisón & Villar-López (2014), who used the SABI database to contact Spanish companies, the OSKARI questionnaire, which was used by Ali-Yrkkö & Martikainen.O (2008) to survey Finnish companies, finally, Gunday et al. (2011) and Foss et al. (2011) have surveyed Turkish and Danish companies, respectively.

While the focus of research differs in these papers, some findings are supported by all, or at least, most researchers. The effect that organisational innovations have on technological innovations is positive (Camisón & Villar-López, 2014; Carboni & Russu, 2018; Guisado-González et al., 2017; Haned et al., 2014; Le Bas, Mothe, & Nguyen-Thi, 2015; Marques & Ferreira, 2013; Caroline Mothe & Thi, 2012; Schmidt & Rammer, 2007), and generally there is at least one complementarity present. This positive effect has been shown in different ways, with Haned et al. (2014), having used three waves of CIS in France, found that organisational innovation favours technological innovation development and persistence (particularly on the

[2] CIS (Community Innovation Survey) – Survey for European companies on their innovation activities.

short term). Mothe et al. (2015) have gone a step further and differentiated the effects of organisational practices on technological innovation (again using CIS in France), showing that the effect of complementarities depends on the stage of innovation, as well as that complementarities are more frequent between organisational practices and product innovation. Sapprasert & Clausen (2012) have used CIS data from Norway to show that organisational innovation and technological innovations are complementary, improving company performance, particularly in small companies. Their findings were later validated by Gallego et al. (2013), who have presented the most extensive research on the subject in terms of countries studied, having used CIS data from eighteen countries. Polder & Leeuwen (2010) have used data from three waves of the community innovation survey in the Netherlands to show that organisational innovation has considerable productivity effects with product and process innovations. Camisón & Villar-López (2014) partly validate these findings, stating that organisational innovation only directly affects the introduction of process innovations, while its relationship with product innovations is indirect.

Marques & Ferreira (2013) have studied Portuguese companies and found that the effects of organisational innovation on technological innovations are greater in the services sector than on the industrial sector, being in agreement with Mothe & Thi (2012), who studied companies in Luxembourg. The work of Mothe & Thi (2010) states that the effects of organisational innovation vary with the stage of the innovation process. This finding was validated and further specified by Haned et al (2014), where the effects of organisational innovation were shown to be stronger on the short term, and that the successive implementation of new organisational practices increases the likelihood of a company remaining an innovator.

Ballot et al. (2015) and Guisado-González et al. (2017) agree that the effects of organisational innovations on technological innovations differ between countries, which helps explain some discrepancies in several papers relevant to this research. These differences are usually in the complementarities between innovations, with some studies showing that the effects are similar between organisational innovations and technological innovations (Haned et al., 2014; Sapprasert & Clausen, 2012), while other results seem more skewed towards product innovations (Mothe et al., 2015), or only directly with process innovations (Camisón & Villar-López, 2014).

Some of the most curious findings refer to effects on market success (if an innovation sells well) and to customer feedback. Organisational innovations do not guarantee an innovation's success in the market, they help the implementation, but timing and marketing are more important to generate revenue (Mothe & Thi, 2010, 2012). Even when the innovations are successful, profits tend to be lower than normal due to the innovations' implementation costs (if organisational innovation was implemented recently), the exception being when organisational and process innovations are implemented simultaneously (Schmidt & Rammer, 2007). Finally, organisational innovations can also be used to translate customer feedback into innovations and company performance (Foss et al., 2011). If a company has good communication systems in place, the information coming from customers can be used more effectively when designing new products, services, or even to improve marketing.

All the information presented above can be consulted in the Appendix, where the information on the most relevant papers was collected and simplified.

2.8 Hypotheses

After taking into account the previous information (definitions and empirical evidence) some observations can be made. The literature on organisational innovation is not extensive enough to cover every detail, particularly the effects on other innovations. Furthermore, the effects of organisational innovation on technological innovations differ from country to country (Ballot et al., 2015), meaning that cultural differences are translated into varying effects between innovations. Hence the need to connect both remarks: using an agreed upon definition on organisational innovation types to study the effects of specific types of organisational innovation on technological innovation in Portuguese companies.

As a reminder, and following the division presented in CIS (Eurostat), organisational innovation is separated in *new business practices*, *new methods of organising work responsibilities and decision making* and *new methods of organising external relations* (Table 1). The effects of organisational innovation will be tested on technological innovations. The study will also cover the services industry, which is expected to add more depth to the research, and since this particular type of innovation seems to have been overlooked by researchers (or at least has always been bundled together with product innovations). Product innovations are separated in both *product innovation* and *service innovation*, in addition to *process innovations*. This differentiation along with that of organisational innovation follow the widely accepted Oslo Manual's (OECD, 2005) terminology.

Several papers provide evidence that organisational innovation can positively affect the implementation of other types of innovation. The most commonly seen results show that companies that implement organisational innovations are more likely to implement technological innovation in general (Camisón & Villar-López, 2014; Gunday et al., 2011; Haned et al., 2014; Marques & Ferreira, 2013; Mothe et al., 2015; Ryu & Lee, 2015), other papers show they are more likely to implement product innovations (Le Bas et al., 2015; Mothe & Thi, 2012) and others show that they are more likely to implement process innovations (Camisón & Villar-López, 2014; Le Bas et al., 2015). Out of all of these, only one has addressed Portuguese companies (Marques & Ferreira, 2013), whose findings state that introducing non-technological innovations increased the probability of implementing other innovations (particularly in the services sector) and that organisational innovations are more beneficial for companies operating in the industrial sector, making them more likely to continue to innovate. This paper will expand upon their work, providing a higher level of detail using more recent data. The variations between their findings and those of other researchers are likely explained by the different countries being studied, which was a key finding of Ballot et al. (2015), Carboni & Russu (2018) and Guisado-González et al. (2017).

The main goal of this research is to identify how organisational innovation (and its subdivisions) can affect technological innovation. Having technological innovation separated in three components (product, service and process innovations) allows for a more detailed analysis of the effects, since some studies have shown that different types of technological innovation have varying outcomes when paired with organisational innovation (Ballot et al., 2015; Guisado-González et al., 2017). An example being the relationship between organisational innovation and product and process innovations, Marques & Ferreira (2013) state that organisational innovation positively affects the introduction of product innovations, Mothe & Thi (2012) also defend that organisational innovation affects product innovation, more so in the services sector. Given this information the following hypothesis can be made:

Hypothesis 1 (H1): The introduction of organisational innovation favours the implementation of product innovations.

As this study also pretends to ascertain the effects of organisational innovation on the services sector, and since CIS (Eurostat) subdivides product innovation in product and service innovations the following hypothesis will also be tested:

Hypothesis 2 (H2): The introduction of organisational innovation favours the implementation of service innovations.

The other component of technological innovation is process innovation, with several researchers having identified a connection between it and organisational innovation. There is evidence for complementarity between the two (Carboni & Russu, 2018; Polder & Leeuwen, 2010), as well as for organisational innovation having a positive effect on process innovation (Camisón & Villar-López, 2014) and on its persistence (Le Bas et al., 2015). Based on this information, the following hypothesis can be proposed:

Hypothesis 3 (H3): The introduction of organisational innovation favours the implementation of process innovations.

Given the amount of papers that show a positive effect of organisational innovation on technological innovation, it is expected that Portuguese companies share similar outcomes. But since the effects of innovations have been shown to vary between countries (Ballot et al., 2015; Carboni & Russu, 2018; Guisado-González et al., 2017), differences are expected, but cannot be predicted. To further specify the effects of organisational innovations, they were separated in three sub-types according to the Oslo Manual (OECD, 2005). These will be used to identify which specific organisational changes affect the different types of technological innovations in Portugal. The literature in this case is less abundant, with the subdivisions being used as variables (Haned et al., 2014; Le Bas et al., 2015; Mothe et al., 2015; Caroline Mothe & Thi, 2010), but only being specified in two papers. First, Meroño-Cerdán & López-Nicolás (2017) identified that the implementation of new methods of workplace organisation has a very strong cost reduction effect for Spanish companies in the services sector. Secondly, Mothe et al. (2015), stated that the joint implementation of new business practices and new methods of organising work responsibilities and decision making can substitute (in effect) the probability to innovate in products, but has no discernible effect on the probability of being a process innovator. Furthermore, their findings also show that the joint implementation of new business practices and new methods of organising external relations is complementary to introducing both product and process innovations. Finally, they concluded that all three types of organisational practices are complementary to product innovations' performance.

Given this small amount of evidence on the topic, it is apparent that the testing of subdivisions of organisational innovation has been poorly explored in the literature. This separation and the effects of said subdivisions on technological innovation will be tested, and the hypotheses being proposed are as follows:

Hypothesis 4 (H4): The introduction of new business practices favours the implementation of technological innovations.

Hypothesis 4A (H4A): The introduction of new business practices favours the implementation of product innovations.

Hypothesis 4B (H4B): The introduction of new business practices favours the implementation of service innovations.

Hypothesis 4C (H4C): The introduction of new business practices favours the implementation of process innovations.

Hypothesis 5 (H5): The introduction of new methods of organising work responsibilities and decision-making favours the implementation of technological innovations.

Hypothesis 5A (H5A): The introduction of new methods of organising work responsibilities and decision-making favours the implementation of product innovations.

Hypothesis 5B (H5B): The introduction of new methods of organising work responsibilities and decision-making favours the implementation of service innovations.

Hypothesis 5C (H5C): The introduction of new methods of organising work responsibilities and decision-making favours the implementation of process innovations.

Hypothesis 6 (H6): The introduction of new methods of organising external relations favours the implementation of technological innovations.

Hypothesis 6A (H6A): The introduction of new methods of organising external relations favours the implementation of product innovations.

Hypothesis 6B (H6B): The introduction of new methods of organising external relations favours the implementation of service innovations.

Hypothesis 6C (H6C): The introduction of new methods of organising external relations favours the implementation of process innovations.

3 Data and Methodology

In this chapter, the Community Innovation Survey will be explained, along with the relevant data to be used in the analysis. Then, the different variables will be presented, followed by the methodology and ending with the obtained results and their analysis.

3.1 Data

The data for this research comes from the Community Innovation Survey, being voluntarily performed in European countries and for which Eurostat is responsible. The first CIS survey was performed in 1992 with some complications due to lack of standards. The following rounds were also somewhat problematic, but since CIS4 (2002-2004), the survey has been performed every 2 years, with a few modifications being applied in later rounds (such as the introduction of organisational innovation in CIS4). The results are used to compare innovation results across Europe, being available in the European Innovation Scoreboard. The data comes from CIS 2014 (2012 to 2014) and refers exclusively to Portuguese companies (in an anonymised form). The data was obtained from DGEEC, which provides all CIS data for Portuguese companies (DGEEC, 2014). From the 8736 surveyed companies, 7083 were considered (81.1%), this will be Sample 1. Since several responses on company size make some observations useless, after removing these from the sample, the number of observations is 6347 (72.7%), this will be Sample 2. This removal method is also used by Cesário & Fernandes (2018), for the same reason.

According to the data from Sample 1, 58.8% of companies were innovation active, with technological innovation (product and process innovation) being more developed than non-technological innovation (organisational and marketing innovation), having been implemented by 3539 companies (49.9%), as seen in Figure 2. The data shows that approximately 2087 companies (29.5%) introduced some form of organisational innovation and marketing innovation was implemented by 2059 companies (29.1%). Marketing innovation[3] is not present in this study, it is only represented here to highlight that almost the same amount of companies implements marketing innovations or organisational innovations.

[3] *"Marketing innovations involve the implementation of new marketing methods. These can include changes in product design and packaging, in product promotion and placement, and in methods for pricing goods and services."* (OECD, 2005, p 17)

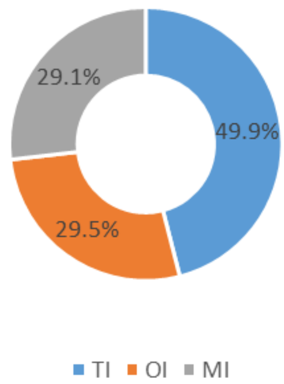

Figure 2 - Distribution of technological, organisational and marketing innovations (Adapted from DGEEC, 2014)

Focusing on technological innovation and organisational innovation in both the industry and services sectors (Figure 3), technological innovation is still more common, with organisational innovation being slightly more prevalent in the services sector than in the industry sector (in terms of percentage). These numbers highlight the common trend of focusing innovation efforts on technological innovation, with only 1170 (27.7%) companies introducing any form of organisational innovation for the industry sector and 917 (32.1%) for the services sector.

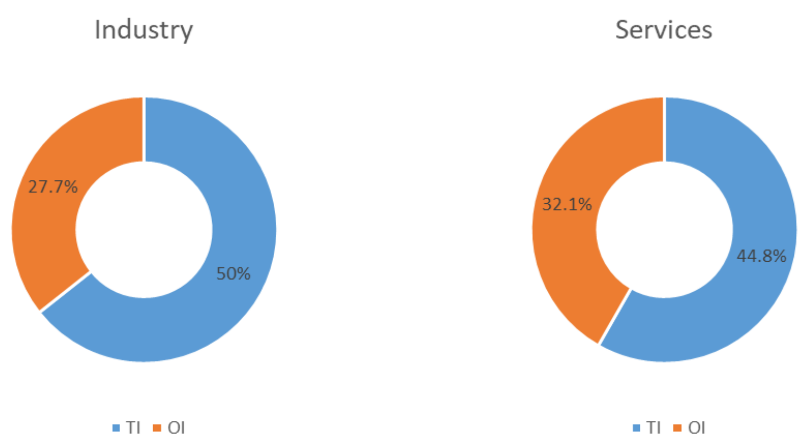

Figure 3 - Technological and organisational innovation prevalence in the industry and services sectors (Adapted from DGEEC, 2014)

Taking a better look at organisational innovation, which is separated in “new business practices”, “new methods of organising work responsibilities and decision making” and “new methods of organising external relations”. The distribution of each class shows that “new methods of organising work responsibilities and decision making” is the preferred organisational innovation focus for companies, with 1539 (21.7%) companies having introduced it (Figure 4). New business practices come in second, with 1302 (18.4%) companies, and new methods of organising external relations was the least introduced form of OI with only 971 (13.7%) companies having introduced it.

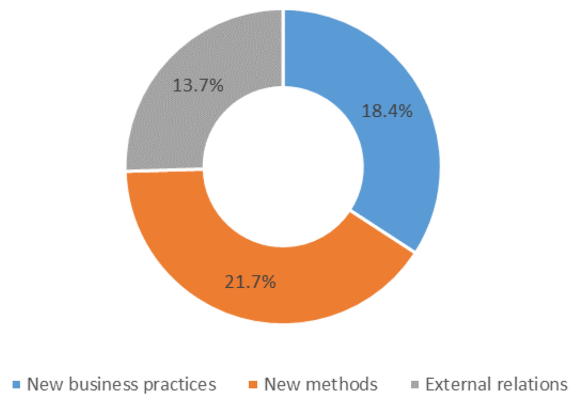

Figure 4 – Distribution of OI's subdivisions (Adapted from DGEEC, 2014)

Company size and location are also discriminated in CIS, with both distributions being showed in Figures 5 and 6, respectively. For company size, using Sample 2, the results seem normal, with innovation implementation being more prevalent as the number of employees increases (Becheikh et al., 2006; Gallego et al., 2013; Marques & Ferreira, 2013; Masso & Vahter, 2008; Mothe et al., 2015; Mothe & Thi, 2010, 2012, 2013).

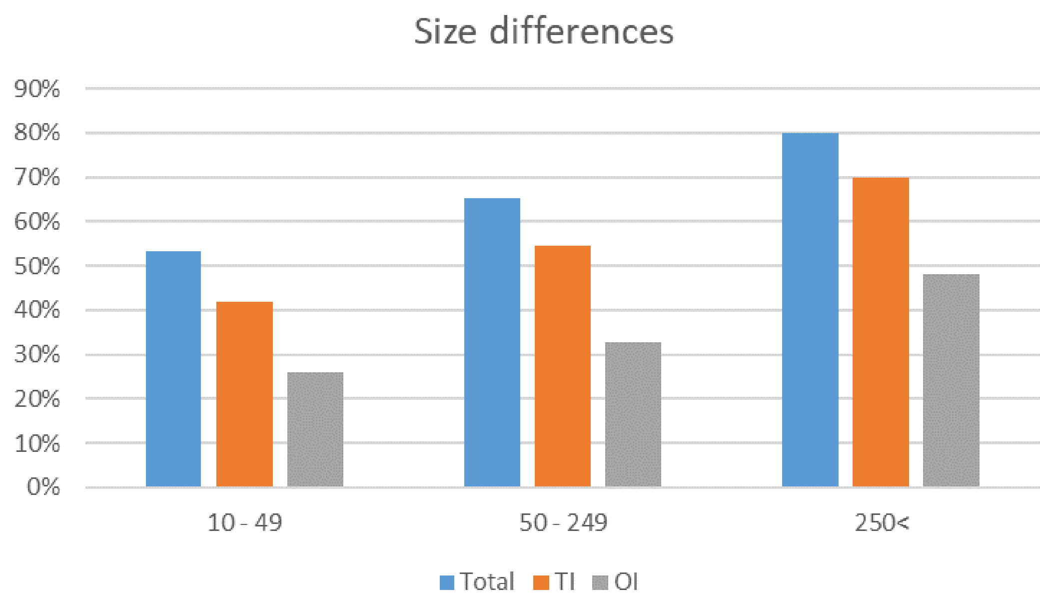

Figure 5 - Distribution of technological innovation and organisational innovation by company size, compared to the total percentage of innovative companies (Adapted from DGEEC, 2014)

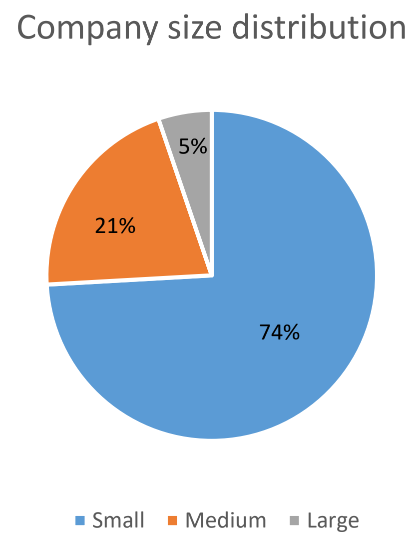

Figure 6 - Distribution of company sizes in Portugal (Adapted from DGEEC, 2014)

For the regional distribution, the Centro region has the highest number of innovative companies in total 4264 (60.2%) and for technological innovation, with 3591 (50.7%). Organisational innovation implementation is the second highest with 2082 (29.4%) companies, just after Lisbon's metro area with 2111 (29.8%) companies. The lowest results come from Algarve, on all types of innovation. It is important to note that location data was not present in the provided dataset, this data comes directly from DGEEC (2014).

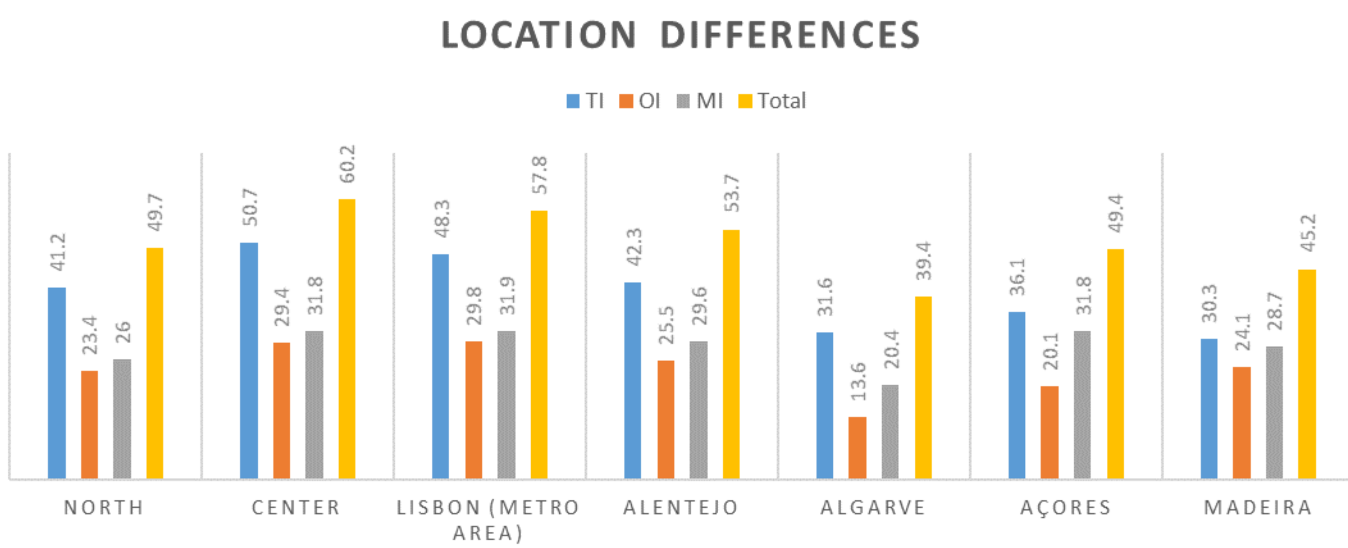

Figure 7 - Distribution of technological innovation, organisational innovation and marketing innovation across the country, compared to the total percentage of innovative companies (Adapted from DGEEC, 2014)

3.2 Variables and model

The following section explains all information regarding variables, why they were chosen and how they are used in the research. The model is also described, along with its construction and how it will be applied to each dependent variable.

3.2.1 Dependent variables

These variables refer to technological innovation, with product innovation being differentiated in both product and service innovations. All three are binary, taking the value of “0” for no innovation of that type being implemented and “1” if that type of innovation was implemented. All dependent variables are presented in Table 3.

Table 3 - List of dependent variables

Designation	Description	Values
PDIp	Implemented product innovation (product)	0-No, 1-Yes
PDIs	Implemented product innovation (service)	0-No, 1-Yes
PCI	Implemented process innovation	0-No, 1-Yes

The variables PDIp and PDIs refer to product innovation in both forms (product and service) while PCI represents process innovations, they were chosen based on the Oslo Manual’s definitions (OECD, 2005). The variables referring to product innovation were divided to account for the fact that some companies may be more focused in providing services, or simply provide services on top of the products they sell. This is expected to add another layer of detail in the analysis, so as to ascertain whether organisational innovations have a more significant impact on product or service innovations, given that there are examples in the literature where the effect is not the same. There is evidence for organisational innovation having a synergistic relationship with only product innovation (Mothe et al., 2015), only with process innovation (Guisado-González et al., 2017), with both product and process innovations (Polder & Leeuwen, 2010), or with neither (Gunday et al., 2011).

3.2.2 Independent variables

These variables represent basic information about a company, and all affect the implementation of technological innovation to some degree. The high number of variables is necessary so that less error is introduced in the equations by clustering or averaging. All independent variables are displayed in Table 4.

Table 4 - List of independent variables

Designation	Description	Values
OI	Implemented organisational innovation	0-No, 1-Yes
OI_1	Implemented new business practices	0-No, 1-Yes
OI_2	Implemented new methods of organising work responsibilities and decision making	0-No, 1-Yes
OI_3	Implemented new methods of organising external relations	0-No, 1-Yes
SEC	Activity sector	0-Industry, 1-Services
GR	Part of a group	0-No, 1-Yes
MAR	Geographic market	0-National, 1-International
COOP	Cooperation with other entities to develop new innovations	0-No, 1-Yes
INABA	Company abandoned innovation activities	0-No, 1-Yes
INONG	Company has ongoing innovation activities	0-No, 1-Yes
RD	Company performs R&D	0-No, 1-Yes
RDi	R&D intensity	Continuous
TS	Total spending on innovation activities	$\log_e$(K€)
REV	Company yearly revenue	$\log_e$(K€)
SMALL	Company size (Small)	0-No, 1-Yes
MEDIUM	Company size (Medium)	0-No, 1-Yes
LARGE	Company size (Large)	0-No, 1-Yes
KS	Company has a preferred knowledge source	0-No, 1-Yes
ACQRD	Acquisition of external R&D for technological innovation	0-No, 1-Yes
ACQEQ	Acquisition of machinery, equipment, software or buildings for technological innovation	0-No, 1-Yes
ACQKN	Acquisition of outside knowledge for technological innovation	0-No, 1-Yes
TRAIN	Staff training for technological innovation	0-No, 1-Yes
INTR	Auxiliary activities to introduce product innovation	0-No, 1-Yes
DES	Design activities to introduce technological innovation	0-No, 1-Yes
MISC	Miscellaneous activities to introduce technological innovation	0-No, 1-Yes
FA	Received financial aid for innovation development	0-No, 1-Yes
CF	Importance of customer feedback	0-Unused, 1-Low,1-Medium, 2-High
PRT	Use of any form of intellectual property protection	0-No, 1-Yes
CEMP	Employees with college education	0- 0%,1- 1%-4%, 2- 5%-9%, 3- 10%-24%, 4- 25%-49%, 5- 50%-74%,6- 75%-100%

The first four variables refer to organisational innovations. These are the focus of the research and are all used to test the hypotheses. The first variable pertaining to organisational innovation (OI) shows whether a company has implemented any form of organisational innovation, having a value of “0” if none was implemented and “1” if at least one was implemented. The following variables (OI_1, OI_2, OI_3) also refer to organisational innovation and have binary values for the implementation of their particular type of organisational innovation. OI_1 shows if a company has implemented new business practices, OI_2 shows if a company has implemented new methods of organising work responsibilities and decision making and OI_3 shows if a company has implemented new methods of organising external relations. These variables were chosen based on the definitions from the Oslo Manual (OECD, 2005) and will be the main focus of the independent variables, since it is the effect of organisational innovation in technological innovation (dependent variables) that is to be examined. Furthermore, organisational innovation has already been linked to technological innovations in other studies (Camisón & Villar-López, 2014; Foss et al., 2011; Gunday et al., 2011).

The binary variable pertaining to the activity sector of a company (SEC) will differentiate what types of innovation are expected. An industrial company is more likely to develop products than a company working on services. However, the innovation types are not exclusive to one another. A company’s activity sector has also been identified in the literature as an innovation determinant (Becheikh et al., 2006).

If a company is part of a larger group (GR), it will (theoretically) have more support and information influx than a single company operating alone. Therefore, companies will be analysed together if they are part of a larger group, or if they operate alone. According to De Faria & Schmidt, (2012), a company belonging to a group is more likely to cooperate in innovation activities.

A company’s geographic market (MAR) refers to whether they operate internationally (equalling “1”) or not (equalling “0”). This variable is commonly used in innovation research and has been identified as an important innovation determinant (Becheikh et al., 2006). One of the reasons being that international companies may need to innovate when trying to expand to new markets in order to remain competitive and to maintain growth.

When it comes to cooperation (COOP), companies who work together are more likely to develop innovations than those who don’t. Furthermore, cooperative interactions are regarded as an innovation determinant (Becheikh et al., 2006).

The variable “INABA” is used to identify whether a company has abandoned any innovation activities. The variable will take the value “1” if the activities were abandoned or “0” if not. The following variable is similar but “INONG” shows if a company still has ongoing innovation activities. If yes then the value will be “1” and if not “0”. The importance of innovation activities is most apparent in the Oslo Manual (OECD, 2005), while their use as a variable makes sense from a logical point of view (companies that perform innovation activities are supposed to be more likely to develop innovations than those who don’t) they can be difficult to implement (Klomp & Van Leeuwen, 2001).

The R&D variables identify if a company has performed R&D (RD) and quantify its intensity (RDi). Both measures can be indicators of innovation for different reasons. According to Carboni & Russu (2018), research efforts have a significant positive impact in the introduction of innovations, while Ballot et al. (2015) say that R&D intensity shapes a company’s ability to benefit from complementarities. More technology-intensive companies will likely rely on R&D often, but less technology-intensive companies may not require continuous R&D to implement innovations (OECD, 2005). The variable RD takes the value of “0” if no R&D is performed and “1” if it is performed. R&D intensity is represented by a company’s R&D expenditures divided by its sales (Gallego et al., 2013; Guisado-González et al., 2017; Mothe et al., 2015).

A company that invests in developing innovations is more likely to perform innovation activities and possibly to implement innovations. Hence the variable total spending (TS), which takes into account all the funds spent specifically in innovation activities and in assets to be used in innovation activities. This variable is present (apart from logical reasons) due to an increase in innovation spending being linked to innovations’ increased financial returns (considered small by managers) being presented by Gunday et al., (2011). Furthermore, it is also recommended by Cohen & Levinthal, (1990) and Hamel, (2006).

The first variable refers to the company’s revenue (REV), which is commonly used in innovation research and has been shown to have a positive effect in innovation development and performance (Klomp & Van Leeuwen, 2001). It is important to note that the relationship is not linear, meaning that an increase in one unit does not equal to an increase or decrease of the same amount in “innovation units”.

The following three variables refer to the size of a company, which is a common control used in innovation research (Ballot et al., 2015; Mothe & Thi, 2012) since its relationship with innovation is not well defined (Carboni & Russu, 2018). All variables are binary, each for a different company size, where small companies have 10 to 49 employees, medium companies have 50 to 249 employees and large companies have more than 250 employees. There are some trade-offs between innovation and company size, since smaller companies have more breathing room when innovating but usually lack the funds to do so, while larger companies have the funds, but innovating may be more restricted for a plethora of reasons (Becheikh et al., 2006; Benavides Espinosa & Merigó Lindahl, 2016).

The next set of variables (ACQRD, ACQEQ, ACQKN, TRAIN, INTR, DES, MISC) represent the specific innovation activities a company has carried out to aid in the implementation of technological innovation during the review period. They are all binary, taking the value “0” for not being carried out and “1” if they were. These were selected to improve the analysis for the same reasons as the variable “INNA”, in particular, since knowledge and technology acquisitions have been identified as innovation determinants (Becheikh et al., 2006), as well as being used to better analyse any possible discrepancies between companies with similar innovation activities.

As for financial aid (FA), besides being considered as an innovation determinant (Becheikh et al., 2006), companies that are given money specifically to develop new innovations have a higher probability of introducing them, or, at the very least, attempt to.

The variable knowledge sources (KS) refers to whether a company uses information preferentially from an external entity. This is a simple binary variable. The positive effect of using different knowledge sources to boost innovation implementation has been defended before by Mol & Birkinshaw, (2009). A company can create one or more linkages with outside entities and receive information that can be used to develop and/or introduce new innovations.

Customer feedback (CF) can be a very helpful in implementing innovations if it used correctly (Foss et al., 2011). The feedback is commonly used to improve existing products or services but can also be used to identify specific demands which can then be used to introduce the desired product/service. This variable uses a Likert-type scale, taking the value “0” when customer feedback is not used, “1” when it is considered as having low importance, “2” when a company considers it to have medium importance and “3” when it is very important.

The variable “PRT” is related to how a company tries to protect its products or services, whether this protection is done by registering patents, trademarking, using trade secrets, or requesting a utility model. If a company uses any of these forms of protection the variable assumes the value “1”, otherwise it is “0”. The choice of this variable is based on both CIS and the Oslo Manual (OECD, 2005), since the risk of imitation can negatively affect the development of innovations, while protecting ideas from being copied can improve the chances of an innovation being successful.

The percentage of employees with college education (CEMP) is relevant in this analysis for it is expected that these people are more likely to either propose new innovations or to help implement them. Kline & Rosenberg, (1986) have also stated that a company lacking in college educated employees are at a significant competitive disadvantage. Meaning that they are less likely to be capable of developing successful innovations. It takes the value of “0” if no employee has college education, “1” if between 1% and 4% do, “2” if between 5% and 9% do, “3” if between 10% and 24% do, “4” if between 25% and 49% do, “5” if between 50% and 74% do and “6” if between 75% and 100% do.

Table 5 - Descriptive statistics for each variable

Variables	Mean	Standard deviation	Minimum	Maximum
Product innovation	.51875	.4997305	0	1
Service innovation	.3717105	.4833411	0	1
Process innovation	.7815789	.4132426	0	1
Organisational innovation	.4769737	.4995517	0	1
Business practices	.3029605	.4596139	0	1
Workplace organisation	.3572368	.4792643	0	1
External relations	.2213816	.4152451	0	1
Sector	.4026316	.4905084	0	1
Group	.3092105	.4622442	0	1
International market	.7552632	.4300018	0	1
Cooperation	.50625	.5000432	0	1
Abandoned innovation activities	.1289474	.3351968	0	1
Ongoing innovation activities	.3565789	.4790677	0	1
R&D	.4131579	.4924817	0	1
R&D intensity	.060507	1.18652	0	44.64222
Spending in innovation activities	308903.2	1481083	0	4.15e+07
Revenue	2.65e+07	1.78e+08	14414	5.10e+09
Small companies	.6776316	.4674601	0	1
Medium companies	.24375	.4294142	0	1
Large companies	.0786184	.2691866	0	1
Acquired external R&D	.2453947	.4303918	0	1
Acquired equipment	.5871711	.4924236	0	1
Acquired outside knowledge	.1407895	.3478615	0	1
Trained staff	.4907895	.4999974	0	1
Performed auxiliary activities	.2934211	.4554046	0	1
Performed design activities	.3786184	.4851226	0	1
Performed miscellaneous activities	.2921053	.4548053	0	1
Financial aid	.2888158	.4532867	0	1
Has a preferred knowledge source	.2273026	.4191586	0	1
Customer feedback	1.851925	1.167838	0	3
Intellectual protection	.2013158	.4010494	0	1
Employees with college education	2.612829	1.735495	0	6
Number of observations	3040			

3.2.3 Model

Having all dependent variables as binary in nature means that both the logit and probit methods can be applied. The logit model was chosen since both models output near identical results and due to its accuracy and ability to handle both discrete and continuous variables (Peng, So, Stage, & St. John, 2002). This form of logistic regression tries to predict the outcome of individual cases with a simplified model, which includes useful predictor variables for estimating the dependent variable (Saha, 2011). In the model, the dependent variables will take binary values (0 and 1), this value will be predicted based on a calculated probability using the control variables according to the following general equation (Cabrera, 1994):

$$\boldsymbol{E}\left[\boldsymbol{Y_i} = \frac{\mathbf{1}}{\boldsymbol{X}} = \boldsymbol{x}\right] = \boldsymbol{P}(\boldsymbol{Y_i} = \mathbf{1}) \tag{1}$$

Here $P(Y_i = 1)$ represents the probability of a positive outcome (innovation implementation) for each *i* (company), depending on the value of *X* (control variable). In this case, P is the overall mean (following a binomial distribution), but the variance (V) will depend on the observed company (*i*):

$$\boldsymbol{V_i} = \boldsymbol{P}(\boldsymbol{Y_i} = \mathbf{1}) \times [\mathbf{1} - (\boldsymbol{P_i} = \mathbf{1})] \tag{2}$$

Where $P(Y_i = 1)$ represents the probability of a positive outcome (innovation implementation) and $[\mathbf{1} - (\boldsymbol{P_i} = \mathbf{1})]$ represents the probability of a negative outcome (no innovation implementation), both being described in the next equation:

$$Y = \begin{cases} PDIp, PDIs, PCI = 1, \text{if any of these types of innovation were implemented} \\ PDIp, PDIs, PCI = 0, \text{if any of these types of innovation were not implemented} \end{cases} \tag{3}$$

The logit model will use several explanatory variables, therefore, the generalized form will be:

$$L = \frac{P(Y)}{1 - P(Y)} = \beta_0 + \sum_{i=1}^{m} (\beta_i x_i) + \varepsilon \tag{4}$$

With L being the logit (natural logarithm of the odds), P(Y) being the probability of Y being successful, β representing the control variables' coefficients, *x* the control variables themselves and ε being the associated error. Finally, the subscript i represents a company.

The probability P(Y) can be obtained by:

$$P(Y) = \frac{e^{\beta_0 + \sum_{i=1}^{m}(\beta_i x_i)}}{1 + e^{\beta_0 + \sum_{i=1}^{m}(\beta_i x_i)}} \tag{5}$$

After being estimated, P(Y) will be a value between 0 and 1, based on the coefficients (β), which can be any value (Cabrera, 1994; Peng et al., 2002; Saha, 2011). The logit model is then applied to transform the value of the probability P(Y) into a continuous variable by using the maximum likelihood method, which tries to assess the effects of the explanatory variables in the probability function (Cabrera, 1994).

The model's equations will use several vectors that encompass different control variables:

- ***λ_1 (Company specifics) – β_2REV + β_3EMP + β_4CEMP + β_5RDp + β_6RDi + β_7KS + β_8MAR + β_9GR + β_{10}SEC + β_{11}COOP + β_{12}FA***

Where REV is the company yearly revenue, EMP is the number of employees, CEMP is the percentage of employees with college education, RDp is the R&D persistence, RDi is the R&D intensity, KS are the most used knowledge sources, MAR is the company's geographic market, GR states whether the company is a part of a group, SEC is the company's operating sector, COOP states whether the company cooperates with other entities when developing innovations and FA denotes whether a company has received financial aid to develop innovations.

- ***λ_2 (Innovation basic information) – β_{12}INNA + β_{13}TS + β_{14}CF + β_{15}PRT***

Where INNA denotes whether the company performed innovation activities, TS is the total spending on innovation activities, CF is the importance of customer feedback and PRT denotes whether the company uses any form of intellectual property protection.

- ***λ_3 (Acquisitions and miscellaneous) – β_{16}ACQRD + β_{17}ACQEQ + β_{18}ACQKN + β_{19}TRAIN + β_{20}INTR + β_{21}DES + β_{22}MISC***

Where ACQRD denotes whether the company has acquired any external R&D, ACQEQ denotes whether the company has acquired machinery, equipment, software or buildings, ACQKN denotes whether the company has acquired any external knowledge, TRAIN denotes whether the company has trained its staff, INTR denotes whether the company has performed any auxiliary activity, DES denotes whether the company has performed any design activities and MISC denotes whether the company has performed any miscellaneous activities, all (if any) of which to introduce technological innovations. As a quick note, the variable INTR is only used for product/service innovations, not for process innovations. Therefore, a new vector must be used for process innovations, this vector (λ_4), is equal to λ_3 except for the removal of INTR.

For the above vectors, $\boldsymbol{\beta_i}$ represents the variable's coefficient and $\boldsymbol{j}$ represents specific variables (IBj), all of which are described in Table 4.

The equations all revolve around identifying whether a company implements any form of technological innovation (product/service or process), hence, using a similar approach as Mothe & Thi (2012):

$$\boldsymbol{PDIp = \beta_1 OI + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \varepsilon} \tag{6}$$

$$\boldsymbol{PDIs = \beta_1 OI + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_4 + \varepsilon} \tag{7}$$

$$\boldsymbol{PCI = \beta_1 OI + \lambda_1 + \lambda_2 + \lambda_3 + \lambda_5 + \varepsilon} \tag{8}$$

Where PDIp represents product innovation, PDIs represents service innovation, PCI represents process innovation, OI represents organisational innovation, $\boldsymbol{\beta_i}$ represents the control variable's coefficient, $\boldsymbol{\lambda_k}$ represents the different vectors explained above and $\boldsymbol{\varepsilon}$ is the associated error.

4 Results

After analysing the dataset, it became apparent that there was a disparity in the number of observations of different variables. While some retain the 6347 usable observations, others have less, as shown in Table 6 below:

Table 6 - Number of observations for each variable

Variables	Number of observations
SEC, GR, MAR, KS, OI, PRT, REV, EMP, CEMP	6346
CF	3629
COOP, INNA, RDp, TS, ACQRD, ACQEQ, ACQKN, TRAIN, INTR, DES, MISC, FA	3041
RDi	3040

The discrepancy between the number of observations is likely due to some companies not knowing or not wishing to disclose certain information, such as how much they spend on innovation activities (TS) or on R&D (RDi). This means that during the estimation of regressions, some models will be restricted by the variable with the least observations. After further analysis, the effects of having less observations were never seen to be significant, since the models had no noteworthy changes when using more or less observations.

Before showing the main models used for testing and their results, there are several aspects that must be explained. First of all, the models are created to show one output, the marginal values from the logit model. When interpreting logit coefficients, which show the relationship between the dependent and independent/control variables as a positive or negative value, only the signal can be interpreted, not the magnitude. The marginal values represent the effect that an independent variable has on the dependent variable, which may or may not be linear. Explained more thoroughly, the marginal effect represents the effect of a change in a variable X on the mean of a variable Y (Cameron & Trivedi, 2009).

The presented statistics also need to be explained. These are the p value, chi-square, pseudo R^2 and the correct prediction percentage. The p value is common in statistics, it shows the significance level, which is usually compared to a chosen limit (1%, 5%, 10%), using values from the chi-square test as a baseline. The pseudo R^2 is, as the name implies, not a “real” R^2 like the one used for ordinary least squares (OLS). The OLS version of R^2 is an indicator of how well a set of independent variables explains the variance observed in the dependent variable (Cabrera, 1994). This cannot be replicated for logistic regression, In this case, the pseudo R^2 can represent the proportion of error variance that an alternative model reduces in relation to the null model (Cabrera, 1994), or put simply, how much variance is reduced by using a particular model. The particular type of pseudo R^2 used here is McFadden’s R^2 (also called ρ^2), where the values for an extremely good fit vary between 0.2 and 0.4 (McFadden, 1977). Finally, the correct prediction percentage, while not being prevalent in the literature, can be very helpful to test if the chosen variables are important to correctly predict the outcome.

There will be two sets of models being used. Set 1 will contain models 1 through 3 and set 2 contains models 4 through 6. The first set is more traditional and contains variables that are used more often in the literature, while the second set contains all the variables from set 1 plus a group of variables that is either seen rarely or not used in the literature. This second set is exploratory, containing variables that are related to a company's innovation activities, financial support, knowledge use, and hiring practices.

Nevertheless, the methodology for using both is the same. First, all variables are used, except for organisational innovation (Model 1), which is added in the second model to highlight the differences between the first two models. Then, OI is replaced by its three components (OI_1, OI_2 and OI_3) to identify which are statistically significant (Model 3). Finally, this last model is reused twice, for industrial companies (model 4) and then for services (model 5) focused companies. The second set is tested identically, with models 1, 2 and 3 being renamed 6, 7 and 8, respectively.

As there is no doubt that adding more variables and reducing the number of observations does not reduce model fit, the results for the dependent variable PDIp (implementing product innovations) using models 1 through 5 are shown in Table 7 below:

Table 7 - Marginal effects for product innovation

Variables	Model 1	Model 2	Model 3	Model 4 Industry	Model 5 Services
Organisational innovation		**0.184****			
		(0.024)			
Business practices			0.0434	0.0150	0.0694
			(0.677)	(0.917)	(0.648)
Workplace organisation			0.134	0.0650	0.191
			(0.183)	(0.642)	(0.194)
External relations			**0.251****	**0.461*****	0.0707
			(0.021)	**(0.003)**	(0.653)
Sector	**-0.811*****	**-0.825*****	**-0.840*****		
	(0.000)	**(0.000)**	**(0.000)**		
Group	-0.00311	-0.00803	-0.0154	-0.0718	-0.0391
	(0.974)	(0.933)	(0.872)	(0.606)	(0.772)
International market	**0.530*****	**0.532*****	**0.528*****	**0.806*****	0.252*
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	(0.053)
Cooperation	**0.550*****	**0.515*****	**0.501*****	**0.530*****	**0.430*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.001)**
Abandoned innovation activities	**0.437*****	**0.427*****	**0.420*****	**0.459*****	0.348*
	(0.000)	**(0.001)**	**(0.001)**	**(0.006)**	(0.078)
Ongoing innovation activities	0.0990	0.0805	0.0711	-0.0276	0.211
	(0.259)	(0.362)	(0.422)	(0.814)	(0.124)
R&D	**0.852*****	**0.842*****	**0.835*****	**1.139*****	**0.434*****
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.001)**
R&D intensity	0.0394	0.0415	0.0407	0.917	0.0486
	(0.472)	(0.460)	(0.478)	(0.583)	(0.432)
Spending on innovation activities	3.09e-08	2.90e-08	2.70e-08	4.74e-08	3.33e-08
	(0.377)	(0.405)	(0.440)	(0.551)	(0.401)
Revenue	2.99e-10	2.83e-10	2.45e-10	-4.77e-10	5.12e-10
	(0.291)	(0.313)	(0.381)	(0.440)	(0.165)
Medium company	-0.152	-0.146	-0.133	-0.121	-0.208
	(0.117)	(0.132)	(0.171)	(0.343)	(0.180)
Large company	-0.177	-0.174	-0.161	0.0224	-0.410
	(0.310)	(0.321)	(0.358)	(0.930)	(0.113)
Constant	-0.675***	-0.727***	-0.732***	-1.061***	-1.166***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3,040	3,040	3,040	1,816	1,224
p value	0.000	0.000	0.000	0.000	0.000
Correct prediction	65.56%	65.66%	66.02%	67.90%	64.13%
chi-square test	420.3	425.4	434.8	285.2	74.80
Pseudo R-squared	0.0998	0.101	0.103	0.117	0.0454

p value in parentheses *** p<0.01, ** p<0.05, * p<0.1

In terms of model fit, all models have a p value of 0, which is a very good indication that the variables are mutually exclusive, and increasing values for the pseudo R^2, which means that the models get closer to the range of 0.2-0.4 of extremely good fit (except for the services sector). The added measure of correctly predicted percentage also shows a small increase, indicating that later models are better at predicting the outcome (except for the services sector).

According to Table 7 above, model 2 shows that organisational innovations are significant (p value of 0.024) and have a positive effect on product innovation (0.184), but model 3 shows that only new methods of organising external relations are positive (0.251) and significant (p value of 0.021), particularly in the industrial sector (model 4 with p value of 0.003). This last finding is likely related to how companies manage their supply chain partners (suppliers, clients, etc.)

The results from model 2 validate H1 (*The introduction of organisational innovation favours the implementation of product innovations*) and those of model 3 validate H6A (*The introduction of new methods of organising external relations favours the implementation of product innovations*) and reject H4A (*The introduction of new business practices favours the implementation of product innovations*) and H5A (*The introduction of new methods of organising work responsibilities and decision-making favours the implementation of product innovations*).

Table 8 - Marginal effects for product innovation using exploratory variables

Variables	Model 6	Model 7	Model 8	Model 9 Industry	Model 10 Services
Organisational innovation		-0.0302			
		(0.732)			
Business practices			-0.0431	-0.120	0.0328
			(0.689)	(0.429)	(0.834)
Workplace organisation			0.0508	-0.0473	0.170
			(0.629)	(0.750)	(0.267)
External relations			0.0828	0.149	-0.0119
			(0.465)	(0.367)	(0.941)
Sector	**-0.836*** **	**-0.835*** **	**-0.842*** **		
	(0.000)	**(0.000)**	**(0.000)**		
Group	0.101	0.102	0.0993	0.0458	0.0463
	(0.318)	(0.316)	(0.327)	(0.762)	(0.743)
International market	**0.447*** **	**0.446*** **	**0.446*** **	**0.644*** **	0.216
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	(0.108)
Cooperation	**0.398*** **	**0.403*** **	**0.395*** **	**0.386*** **	**0.373** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.004)**	**(0.011)**
Abandoned innovation activities	**0.368*** **	**0.370*** **	**0.364*** **	**0.410** **	0.304
	(0.005)	**(0.004)**	**(0.005)**	**(0.020)**	(0.135)
Ongoing innovation activities	-0.0417	-0.0402	-0.0431	-0.116	0.0969
	(0.654)	(0.666)	(0.644)	(0.351)	(0.507)
R&D	**0.718*** **	**0.718*** **	**0.719*** **	**1.003*** **	**0.411*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.005)**
R&D intensity	0.0391	0.0387	0.0395	0.281	0.0462
	(0.489)	(0.492)	(0.488)	(0.848)	(0.458)
Spending on innovation activities	1.63e-08	1.62e-08	1.62e-08	1.70e-08	3.12e-08
	(0.645)	(0.646)	(0.646)	(0.829)	(0.425)
Revenue	1.88e-10	1.90e-10	1.77e-10	-5.40e-10	4.83e-10
	(0.517)	(0.512)	(0.539)	(0.402)	(0.220)
Medium company	-0.154	-0.155	-0.150	-0.137	-0.211
	(0.124)	(0.123)	(0.136)	(0.309)	(0.183)
Large company	-0.281	-0.282	-0.272	0.0343	**-0.549** **
	(0.121)	(0.120)	(0.134)	(0.900)	**(0.041)**
Acquisition of R&D	0.0780	0.0785	0.0783	**0.340** **	-0.135
	(0.467)	(0.464)	(0.465)	**(0.029)**	(0.389)
Acquisition of equipment	-0.0480	-0.0462	-0.0512	0.105	-0.109
	(0.573)	(0.589)	(0.549)	(0.372)	(0.400)
Acquisition of knowledge	0.0782	0.0815	0.0673	0.201	-0.0224
	(0.539)	(0.523)	(0.598)	(0.273)	(0.905)
Training Staff	0.165*	0.169*	0.156*	0.137	0.116
	(0.057)	(0.054)	(0.077)	(0.252)	(0.389)
Auxiliary activities	**0.413*** **	**0.415*** **	**0.408*** **	**0.453*** **	**0.444*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.002)**	**(0.003)**
Design activities	**0.607*** **	**0.608*** **	**0.603*** **	**0.843*** **	**0.323** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.026)**
Miscellaneous activities	0.0455	0.0490	0.0375	0.0692	0.0309
	(0.635)	(0.611)	(0.698)	(0.592)	(0.840)
Financial aid	0.0529	0.0533	0.0574	-0.122	0.138
	(0.603)	(0.600)	(0.573)	(0.371)	(0.399)
Preferred knowledge source	0.00969	0.00844	0.00678	-0.0354	0.0465
	(0.938)	(0.946)	(0.957)	(0.843)	(0.796)
Customer feedback	**0.118*** **	**0.120*** **	**0.115*** **	**0.186*** **	0.0247
	(0.001)	**(0.001)**	**(0.001)**	**(0.000)**	(0.668)
Intellectual protection	**0.383*** **	**0.383*** **	**0.386*** **	**0.391** **	**0.391** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.012)**	**(0.013)**
Employees with college education	**-0.0569** **	**-0.0564** **	**-0.0580** **	0.0190	**-0.0912** **
	(0.046)	**(0.049)**	**(0.043)**	(0.677)	**(0.014)**
Constant	-1.023***	-1.021***	-1.021***	-1.681***	-1.139***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Observations	3,039	3,039	3,039	1,815	1,224
p value	0.000	0.000	0.000	0.000	0.000
Correct prediction	68.64%	68.67%	68.64%	70.91%	66.01%
chi-square test	587.1	587.2	588.1	423.5	116.8
Pseudo R-squared	0.139	0.140	0.140	0.173	0.0709

p value in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 8 shows the results of the effects on product innovation using the exploratory set of variables. First of all, the model fit statistics behave very similarly to those of Table 7, but the values are better, both for the pseudo R^2 and for the correct prediction percentage (the p value is the same at 0).

However, the main results differ quite substantially from those seen on Table 7. The glaring difference is that neither organisational innovation in general nor its subdivisions are statistically significant. Which means that according to the non-significant values (>0.05) of the marginal effects of both organisational innovation in model 7 and of new methods of handling external relations in model 8, H1 and H6A cannot be validated.

Some of the added variables seem to be particularly relevant, since some are statistically significant in most or all models, such as performing auxiliary or design activities to help introduce technological innovations, taking advantage of customer feedback, using intellectual protection and having employees with college education. Although this last variable is close to the chosen 5% limit of statistical significance when it is significant.

Following the previous test's methodology, the effects on service innovations will be tested in Tables 9 and 10 below:

Table 9 - Marginal effects for service innovation

Variables	Model 1	Model 2	Model 3	Model 4 Industry	Model 5 Services
Organisational innovation		**0.724*** (0.000)**			
Business practices			**0.340*** (0.001)**	0.255* (0.073)	**0.485*** (0.002)**
Workplace organisation			**0.456*** (0.000)**	**0.332** (0.017)**	**0.618*** (0.000)**
External relations			**0.406*** (0.000)**	**0.540*** (0.000)**	0.217 (0.188)
Sector	**1.017*** (0.000)**	**0.992*** (0.000)**	**0.985*** (0.000)**		
Group	-0.0388 (0.683)	-0.0600 (0.533)	-0.0654 (0.500)	-0.231 (0.113)	0.160 (0.244)
International market	**-0.304*** (0.001)**	**-0.305*** (0.001)**	**-0.315*** (0.001)**	-0.227 (0.117)	**-0.305** (0.022)**
Cooperation	**0.668*** (0.000)**	**0.543*** (0.000)**	**0.525*** (0.000)**	0.564*** (0.000)	**0.543*** (0.000)**
Abandoned innovation activities	-0.0169 (0.891)	-0.0641 (0.610)	-0.0808 (0.525)	-0.161 (0.332)	0.0609 (0.776)
Ongoing innovation activities	0.158* (0.077)	0.0879 (0.333)	0.0698 (0.446)	0.157 (0.193)	-0.0338 (0.814)
R&D	**0.406*** (0.000)**	**0.376*** (0.000)**	**0.361*** (0.000)**	0.192 (0.128)	**0.662*** (0.000)**
R&D intensity	-0.0804 (0.155)	-0.0726 (0.157)	-0.0780 (0.116)	-0.336 (0.813)	-0.0739 (0.151)
Spending on innovation activities	7.24e-08* (0.068)	6.57e-08* (0.098)	6.11e-08 (0.122)	7.79e-09 (0.919)	9.35e-08 (0.182)
Revenue	-5.65e-11 (0.828)	-1.15e-10 (0.661)	-1.82e-10 (0.493)	-1.25e-09 (0.336)	-3.19e-10 (0.327)
Medium company	**-0.410*** (0.000)**	**-0.403*** (0.000)**	**-0.380*** (0.000)**	**-0.525*** (0.000)**	-0.213 (0.176)
Large company	-0.116 (0.492)	-0.101 (0.557)	-0.107 (0.538)	-0.447* (0.099)	**0.567** (0.044)**
Constant	-1.217*** (0.000)	-1.454*** (0.000)	-1.429*** (0.000)	-1.289*** (0.000)	-0.797*** (0.000)
Observations	3,040	3,040	3,040	1,816	1,224
p value	0.000	0.000	0.000	0.000	0.000
Correct prediction	67.93%	68.72%	69.21%	72.47%	65.77%
chi-square test	333.1	410.1	446.0	124.0	182.1
Pseudo R-squared	0.0830	0.102	0.111	0.0583	0.107

p value in parentheses *** p<0.01, ** p<0.05, * p<0.1

Table 9 shows a similar trend in model fit statistics when compared to the previous results. Here, the R^2 values increase as new models are tested, with the value being higher in the services sector as opposed to the industrial sector (as seen in Tables 7 and 8). The correct prediction also increases but is reversed in the last two models, where it is higher when testing for industrial companies and worse for services.

The main results are positive, with organisational innovation being statistically significant in model 2 (p value of 0.000) and positive (0.724) as well as all three of its subdivisions. Introducing new methods of organising the workplace always has a positive effect on service innovations according to model 3 (marginal effect of 0.340 and p value of 0.001), new business practices are more suited for the services sector (model 5), while new methods of organising external relations is better in the industrial sector, as seen in model 4 (p value of 0.000 and marginal effect of 0.540).

These results clearly validate H2 (The introduction of organisational innovation favours the implementation of service innovations), H4B (The introduction of new business practices favours the implementation of service innovations), H5B (The introduction of new methods of organising work responsibilities and decision-making favours the implementation of service innovations) and H6B (The introduction of new methods of organising external relations favours the implementation of service innovations).

Table 10 - Marginal effects for service innovation using exploratory variables

Variables	Model 6	Model 7	Model 8	Model 9 Industry	Model 10 Services
Organisational innovation		<u>**0.488*****</u> <u>**(0.000)**</u>			
Business practices			<u>**0.309*****</u> <u>**(0.004)**</u>	<u>0.243*</u> <u>(0.097)</u>	<u>**0.465*****</u> <u>**(0.004)**</u>
Workplace organisation			<u>**0.292*****</u> <u>**(0.005)**</u>	<u>0.119</u> <u>(0.412)</u>	<u>**0.513*****</u> <u>**(0.001)**</u>
External relations			<u>**0.286*****</u> <u>**(0.010)**</u>	<u>**0.442*****</u> <u>**(0.003)**</u>	<u>0.0620</u> <u>(0.719)</u>
Sector	**1.019***** **(0.000)**	**1.003***** **(0.000)**	**1.000***** **(0.000)**		
Group	-0.00856 (0.933)	-0.0156 (0.879)	-0.0179 (0.862)	-0.0673 (0.664)	0.0979 (0.498)
International market	**-0.365***** **(0.000)**	**-0.354***** **(0.000)**	**-0.358***** **(0.000)**	-0.255* (0.094)	**-0.309**** **(0.025)**
Cooperation	**0.619***** **(0.000)**	**0.560***** **(0.000)**	**0.557***** **(0.000)**	**0.684***** **(0.000)**	**0.397***** **(0.008)**
Abandoned innovation activities	-0.0525 (0.685)	-0.0724 (0.578)	-0.0796 (0.544)	-0.139 (0.416)	0.0719 (0.747)
Ongoing innovation activities	0.0608 (0.524)	0.0343 (0.721)	0.0278 (0.773)	0.169 (0.183)	-0.218 (0.160)
R&D	**0.324***** **(0.001)**	**0.330***** **(0.001)**	**0.331***** **(0.001)**	**0.283**** **(0.035)**	**0.455***** **(0.003)**
R&D intensity	-0.0723 (0.147)	-0.0685 (0.153)	-0.0720 (0.125)	-0.134 (0.666)	-0.0825 (0.123)
Spending on innovation activities	4.14e-08 (0.255)	4.20e-08 (0.254)	3.90e-08 (0.290)	-3.25e-08 (0.702)	5.75e-08 (0.304)
Revenue	-1.06e-10 (0.690)	-1.44e-10 (0.590)	-1.87e-10 (0.488)	-7.70e-10 (0.493)	-3.89e-10 (0.233)
Medium company	**-0.381***** **(0.000)**	**-0.378***** **(0.000)**	**-0.364***** **(0.001)**	**-0.543***** **(0.000)**	-0.179 (0.271)
Large company	-0.190 (0.284)	-0.170 (0.338)	-0.172 (0.337)	-0.488* (0.076)	0.500* (0.081)
Acquisition of R&D	-0.0885 (0.412)	-0.0973 (0.369)	-0.110 (0.314)	-0.269* (0.086)	0.176 (0.281)
Acquisition of equipment	**0.439***** **(0.000)**	**0.412***** **(0.000)**	**0.410***** **(0.000)**	**0.612***** **(0.000)**	0.200 (0.131)
Acquisition of knowledge	**0.287**** **(0.019)**	0.239* (0.052)	0.224* (0.070)	**0.354**** **(0.027)**	0.0161 (0.937)
Training Staff	**0.317***** **(0.000)**	**0.253***** **(0.005)**	**0.225**** **(0.013)**	0.236* (0.059)	0.245* (0.071)
Auxiliary activities	**0.481***** **(0.000)**	**0.468***** **(0.000)**	**0.456***** **(0.000)**	0.252* (0.072)	**0.721***** **(0.000)**
Design activities	**0.282***** **(0.003)**	**0.269***** **(0.005)**	**0.261***** **(0.007)**	**0.265**** **(0.041)**	0.215 (0.161)
Miscellaneous activities	0.0958 (0.329)	0.0426 (0.667)	0.00525 (0.958)	0.100 (0.443)	-0.0500 (0.760)
Financial aid	-0.152 (0.147)	-0.163 (0.121)	-0.149 (0.158)	-0.136 (0.326)	0.00330 (0.985)
Preferred knowledge source	-0.214* (0.077)	-0.197 (0.106)	-0.219* (0.075)	-0.413** (0.014)	0.127 (0.512)
Customer feedback	**0.168***** **(0.000)**	**0.142***** **(0.000)**	**0.135***** **(0.000)**	**0.141***** **(0.009)**	0.0938 (0.107)
Intellectual protection	**-0.342***** **(0.002)**	**-0.340***** **(0.002)**	**-0.354***** **(0.001)**	**-0.343**** **(0.026)**	**-0.419**** **(0.014)**
Employees with college education	0.0444 (0.118)	0.0359 (0.209)	0.0332 (0.248)	-0.0690 (0.146)	**0.0900**** **(0.017)**
Constant	-2.079*** (0.000)	-2.132*** (0.000)	-2.090*** (0.000)	-1.976*** (0.000)	-1.452*** (0.000)
Observations	3,039	3,039	3,039	1,815	1,224
p value	0.000	0.000	0.000	0.000	0.000
Correct prediction	69.63%	70.78%	70.88%	74.21%	67.48%
chi-square test	518.8	549.4	571.0	211.0	245.3
Pseudo R-squared	0.129	0.137	0.142	0.0992	0.145

p value in parentheses *** p<0.01, ** p<0.05, * p<0.1

Looking at the fit statistics first, the p value remains at 0, the pseudo R^2 retains the growing trend, and the correct prediction behaves identically to the previous example, including the strange reversal when comparing the industrial and services sector. However, all values are higher than the previous ones, meaning that this exploratory model has slightly better fit and is better at predicting the outcome using more variables.

Unlike the results for product innovation, these results are almost identical to those of the traditional model. Organisational innovation in general (model 7) is statistically significant (p value of 0.000) as well as its three subdivisions in model 8 (with p values of 0.004, 0.005 and 0.010), the only difference being in the models that differentiate between sectors. With the industrial sector (model 9) showing that introducing new methods of organising external relations is the only type of organisational innovation that positively affects service innovations (0.442), but in the services sector (model 10) it's the only subdivision that does not.

As for the hypotheses there is no change, H2, H4B, H5B and H6B are all validated in this exploratory set of models.

The only untested dependent variable is PCI (process innovation) which is analysed in Tables 11 and 12 below.

Table 11 - Marginal effects for process innovation

Variables	Model 1	Model 2	Model 3	Model 4 Industry	Model 5 Services
Organisational innovation		**1.209*** (0.000)**			
Business practices			**0.969*** (0.000)**	**1.273*** (0.000)**	**0.731*** (0.000)**
Workplace organisation			**0.706*** (0.000)**	**0.994*** (0.000)**	**0.453*** (0.009)**
External relations			0.203 (0.164)	0.232 (0.288)	0.254 (0.204)
Sector	**-0.387*** (0.000)**	**-0.496*** (0.000)**	**-0.507*** (0.000)**		
Group	**-0.262** (0.015)**	**-0.320*** (0.004)**	**-0.322*** (0.004)**	**-0.442*** (0.009)**	-0.233 (0.123)
International market	0.0533 (0.614)	0.0685 (0.527)	0.0754 (0.487)	-0.0768 (0.643)	0.162 (0.264)
Cooperation	**0.802*** (0.000)**	**0.617*** (0.000)**	**0.611*** (0.000)**	**0.683*** (0.000)**	**0.512*** (0.000)**
Abandoned innovation activities	**-0.400*** (0.003)**	**-0.498*** (0.000)**	**-0.517*** (0.000)**	**-0.763*** (0.000)**	-0.0556 (0.814)
Ongoing innovation activities	-0.185* (0.067)	**-0.311*** (0.003)**	**-0.330*** (0.002)**	**-0.438*** (0.002)**	-0.216 (0.173)
R&D	-0.0886 (0.377)	-0.151 (0.143)	-0.164 (0.114)	-0.205 (0.159)	-0.169 (0.270)
R&D intensity	0.0104 (0.817)	0.0136 (0.780)	0.00642 (0.900)	0.328 (0.810)	-0.00112 (0.982)
Spending on innovation activities	**1.75e-07** (0.036)**	1.48e-07* (0.068)	1.35e-07* (0.092)	2.47e-07 (0.139)	9.17e-08 (0.268)
Revenue	0 (0.961)	-9.28e-11 (0.816)	-1.74e-10 (0.669)	2.76e-09 (0.311)	-3.26e-10 (0.397)
Medium company	0.192* (0.091)	0.226* (0.051)	0.238** (0.041)	0.349** (0.029)	0.0867 (0.617)
Large company	**0.590*** (0.009)**	**0.656*** (0.004)**	**0.627*** (0.007)**	0.627* (0.086)	0.546* (0.095)
Constant	1.150*** (0.000)	0.891*** (0.000)	0.939*** (0.000)	1.006*** (0.000)	0.463*** (0.002)
Observations	3,040	3,040	3,040	1,816	1,224
p value	0.000	0.000	0.000	0.000	0.000
Correct prediction	78.09%	78.26%	78.32%	80.51%	74.59%
chi-square test	125.3	275.6	299.3	224.3	86.82
Pseudo R-squared	0.0393	0.0864	0.0938	0.125	0.0627

p value in parentheses *** p<0.01, ** p<0.05, * p<0.1

The model fit statistics are lower in this case, with the pseudo R^2 being lower than all previous tests, while the p value remains fixed at 0. However, the correct prediction is the highest of all tests and increases with each model except the last (services sector).

This table shows the most consistent results of all tests performed so far, with organisational innovation (model 2, 1.209) and two of its subdivisions in model 3 (new business practices with a marginal effect of 0.969 and new methods of organising work responsibilities and decision-making with a marginal effect of 0.706) being statistically significant and positive in every model that contains them. Introducing new methods of organising external relations is the only one that has no statistically significant effect on process innovations.

The hypotheses being validated are also straightforward, H3 (The introduction of organisational innovation favours the implementation of process innovations), H4C (The introduction of new business practices favours the implementation of process innovations) and H5C (The introduction of new methods of organising work responsibilities and decision-making favours the implementation of process innovations) are all validated by these results.

Table 12 - Marginal effects for process innovation using exploratory variables

Variables	Model 6	Model 7	Model 8	Model 9 Industry	Model 10 Services
Organisational innovation		**1.069*** **			
		(0.000)			
Business practices			**0.949*** **	**1.276*** **	**0.693*** **
			(0.000)	**(0.000)**	**(0.001)**
Workplace organisation			**0.584*** **	**0.829*** **	0.348*
			(0.000)	**(0.000)**	(0.057)
External relations			0.129	0.169	0.203
			(0.396)	(0.464)	(0.330)
Sector	**-0.186***	**-0.259** **	**-0.263** **		
	(0.091)	**(0.021)**	**(0.019)**		
Group	-0.126	-0.163	-0.164	**-0.372** **	-0.0607
	(0.277)	(0.168)	(0.166)	**(0.039)**	(0.706)
International market	0.0298	0.0629	0.0711	-0.0346	0.134
	(0.788)	(0.578)	(0.530)	(0.841)	(0.382)
Cooperation	**0.852*** **	**0.731*** **	**0.736*** **	**0.842*** **	**0.653*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Abandoned innovation activities	**-0.427*** **	**-0.523*** **	**-0.526*** **	**-0.779*** **	-0.0653
	(0.002)	**(0.000)**	**(0.000)**	**(0.000)**	(0.794)
Ongoing innovation activities	**-0.300*** **	**-0.359*** **	**-0.373*** **	**-0.548*** **	-0.183
	(0.006)	**(0.001)**	**(0.001)**	**(0.000)**	(0.287)
R&D	0.0626	0.0818	0.0701	0.0383	0.0822
	(0.577)	(0.477)	(0.542)	(0.811)	(0.638)
R&D intensity	0.0160	0.0281	0.0251	0.937	0.0252
	(0.762)	(0.628)	(0.678)	(0.565)	(0.688)
Spending on innovation activities	5.13e-08	5.89e-08	5.36e-08	3.22e-08	4.47e-08
	(0.416)	(0.385)	(0.421)	(0.791)	(0.542)
Revenue	3.52e-10	2.66e-10	2.24e-10	4.21e-09	-2.17e-10
	(0.466)	(0.568)	(0.631)	(0.180)	(0.652)
Medium company	0.172	0.194	0.194	0.305*	0.0670
	(0.144)	(0.106)	(0.107)	(0.066)	(0.713)
Large company	**0.484** **	**0.518** **	0.471*	0.576	0.345
	(0.043)	**(0.032)**	(0.052)	(0.135)	(0.318)
Acquisition of R&D	-0.0185	-0.0419	-0.0398	-0.244	0.130
	(0.884)	(0.746)	(0.759)	(0.186)	(0.489)
Acquisition of equipment	**0.936*** **	**0.907*** **	**0.906*** **	**0.994*** **	**0.794*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.000)**	**(0.000)**
Acquisition of knowledge	0.179	0.0391	0.0563	-0.283	0.386
	(0.278)	(0.817)	(0.740)	(0.216)	(0.133)
Training Staff	**0.658*** **	**0.546*** **	**0.529*** **	**0.442*** **	**0.627*** **
	(0.000)	**(0.000)**	**(0.000)**	**(0.002)**	**(0.000)**
Design activities	-0.119	-0.170	-0.166	-0.172	-0.135
	(0.259)	(0.115)	(0.125)	(0.248)	(0.408)
Miscellaneous activities	**0.463*** **	**0.363*** **	**0.338*** **	**0.422*** **	0.190
	(0.000)	**(0.002)**	**(0.004)**	**(0.008)**	(0.296)
Financial aid	0.0718	0.0562	0.0645	0.255	-0.228
	(0.561)	(0.657)	(0.612)	(0.142)	(0.244)
Preferred knowledge source	**-0.457*** **	**-0.435*** **	**-0.447*** **	**-0.497** **	**-0.480** **
	(0.004)	**(0.007)**	**(0.006)**	**(0.035)**	**(0.035)**
Customer feedback	0.0938**	0.0405	0.0367	0.0199	0.0703
	(0.022)	(0.336)	(0.384)	(0.729)	(0.269)
Intellectual protection	-0.169	-0.180	-0.194	-0.345*	-0.0242
	(0.173)	(0.155)	(0.127)	(0.050)	(0.898)
Employees with college education	**-0.0990*** **	**-0.121*** **	**-0.123*** **	-0.0345	**-0.182*** **
	(0.002)	**(0.000)**	**(0.000)**	(0.530)	**(0.000)**
Constant	0.392***	0.351**	0.408***	0.357*	0.286
	(0.007)	(0.016)	(0.005)	(0.075)	(0.185)
Observations	3,039	3,039	3,039	1,815	1,224
p value	0.000	0.000	0.000	0.000	0.000
Correct prediction	78.58%	78.81%	78.91%	81.93%	75.00%
chi-square test	333.7	434.8	455.6	314.2	170.5
Pseudo R-squared	0.105	0.136	0.143	0.176	0.123

p value in parentheses *** p<0.01, ** p<0.05, * p<0.1

The models' fit statistics are better than the previous ones (Table 11), being closer to the recommended value range of 0.2 to 0.4. The p value remains locked at 0 and the correct prediction is the highest of all tests, just slightly edging out the results of Table 11.

This exploratory set for process innovations shows almost the same results as the traditional one, with the only difference being that introducing new methods of organising work responsibilities and decision-making is not statistically significant in the services sector (model 10).

Since there are no changes in the general models (excluding the sector specific ones), the same hypotheses are validated (H3, H4C and H5C).

The results for hypothesis testing are summarized in Table 13 below:

Table 13 - Summary of validated and rejected hypotheses

Hypothesis	Result (Traditional)	Result (Exploratory)
H1 - *The introduction of organisational innovation favours the implementation of product innovations*	Validated	Rejected
H2 - *The introduction of organisational innovation favours the implementation of service innovations*	Validated	Validated
H3 - *The introduction of organisational innovation favours the implementation of process innovations*	Validated	Validated
H4A - *The introduction of new business practices favours the implementation of product innovations*	Rejected	Rejected
H4B - *The introduction of new business practices favours the implementation of service innovations*	Validated	Validated
H4C - *The introduction of new business practices favours the implementation of process innovations*	Validated	Validated
H5A - *The introduction of new methods of organising work responsibilities and decision-making favours the implementation of product innovations*	Rejected	Rejected
H5B - *The introduction of new methods of organising work responsibilities and decision-making favours the implementation of service innovations*	Validated	Validated
H5C - *The introduction of new methods of organising work responsibilities and decision-making favours the implementation of process innovations*	Validated	Validated
H6A - *The introduction of new methods of organising external relations favours the implementation of product innovations*	Validated	Rejected
H6B - *The introduction of new methods of organising external relations favours the implementation of service innovations*	Validated	Validated
H6C - *The introduction of new methods of organising external relations favours the implementation of process innovations*	Rejected	Rejected

The models used to test the hypotheses had a null p value every single time, meaning that every variable is mutually exclusive (variables don't depend on each other). This allows for the safe assumption that there is no double counting in the results. The second measure of fit is the pseudo R^2, which was generally between 0.1 and 0.18, with some exceptions going below 0.1 (Table 11). According to McFadden (1977), the values for the R^2 are considered to be very good if they are between 0.2 and 0.4. The obtained results fall short of this range, meaning that the models have good fit at most. The remaining measure is the correct prediction percentage, which is not usually seen in scientific papers, but is included to add a more direct way of interpreting the model accuracy. When analysing each dependent variable with the traditional models the prediction accuracy changes, for product innovations the models correctly predict around 65% of cases, for service innovations the results are closer to 69% and for process innovations are around 78%. When using the exploratory model, the correct prediction increases around 3% for product innovations, 2% for service innovations and only 0.6% for process innovations. This is clearly a case of diminishing returns, where almost doubling the number of variables only increases the correct prediction by a small margin. It is an improvement nonetheless, which is also noted when considering the improvement in the R^2 values, which increase by around 4% for product and service innovations, and by 5% for process innovations.

When considering all the model fit data, the only disparity comes from the analysis of process innovations (Tables 11 and 12), where the exploratory models had slightly weaker fit, but a higher correct prediction percentage. However, both models show the same results for the general analysis (having small differences in the sector differentiation), meaning that the results were consistent.

Furthermore, the lower R^2 values may not be "bad", due to how McFadden's R^2 is calculated. The equation is:

$$R^2 = 1 - \frac{\log(model)}{\log(null)} \tag{9}$$

Both logarithms in this equation refer to the log likelihood of the models, where *log(model)* is the log likelihood of the current model and *log(null)* is the log likelihood of a base model with only one intercept (meaning that every individual has the same chance of success). In a model that only uses binary variables, the outcome is simple to predict, since the averages for calculation are all between 0 and 1. However, this model has three continuous variables that can skew the calculations due to their high values (these variables are related to monetary information like spending). This will increase the variance and the log likelihood of the models decreases (the log likelihood is negative in logistic regression). This brings the value of *log(model)* closer to those of *log(null)* and therefore closer to 1. After subtracting this value from 1, the final result will be closer to 0, but not indicative of weak fit. This is not unexpected since the monetary variables (revenue, spending on innovation activities and R&D intensity) are not found to be significant in models 2, 3, 7, or 8, which are used to test the hypotheses, for any of the dependent variables, therefore being considered bad predictors. Finally, the values for McFadden's R^2 are expected to be lower in this case, since econometric models related to innovation cannot encompass every single driver and are more subject to uncertainty.

When looking at the results for the three dependent variables, the finding suggest that service innovations are always positively affected by the introduction of organisational innovation, both in general and for each subdivision (Tables 9 and 10). Companies in the services sector benefit more from the introduction of new business practices and new methods of organising work responsibilities while new methods of organising external relations are better for industrial companies.

Process innovations are the second in terms of benefits, with the introduction of organisational innovations in general being positive but are not affected by introducing new methods of organising external relations (Tables 11 and 12), unlike service innovations. Companies in the industrial sector can have benefits if new business practices and new methods of organising work responsibilities are introduced, while services companies only benefit from new business practices.

Product innovations don't seem to be affected by introducing organisational innovations or any of its subdivisions, since none of these variables were statistically significant in the (preferred) exploratory models (Table 8).

After testing twelve hypotheses, nine were validated and three were rejected for the traditional set of variables, while 7 were validated and 5 were rejected in the exploratory set. The obtained results are not unexpected, as some researchers have published similar findings. For example, Camisón & Villar-López (2014) found that organisational innovations do not directly affect product innovations, only process innovations. According to their findings organisational innovations can only indirectly affect product innovations if they are mediated by process innovations (this indirect effect was not tested in this research).

This research does differentiate between product and service innovation, which are usually bundled together, and the results show a difference between the two (product innovation is unaffected, but service innovation is positively affected by introducing organisational innovations). Since no other paper is known to have this division, no comparisons can be made, but the results now show that a services oriented company (or a production company that also offers services) is more likely to successfully implement service innovations if organisational innovations are also implemented, at least for Portugal's case.

5 Conclusions

This research was meant to identify how organisational innovations can affect technological (product/service and process) innovations, using data from CIS 2014 for Portugal. Before addressing the conclusions, an important point must be made. The exploratory models have shown a small improvement over the traditional models, meaning that they have noticeable benefits, albeit having diminishing returns (many added variables only improve the model slightly).

The results show that introducing organisational innovations has a positive effect in the introduction of both service and process innovations, using both types of models. The results of the relationship with product innovation are positive in the traditional model, but negative in the exploratory model. This decision is then left to the acceptance of the exploratory models, which, as far was researched, were never used before. Given that the exploratory models have better fit and better correct predictions across every model, the conclusion can be drawn in its favour, meaning that for the purposes of this dissertation, organisational innovations are not seen to have a positive effect in the introduction of product innovations.

Even so, these results are in line with previous literature, with Gunday et al. (2011) and Camisón & Villar-López (2014) having arrived at the same conclusions regarding product innovations, and Camisón & Villar-López (2014), Polder & Leeuwen (2010) and Carboni & Russu (2018) for process innovations. For service innovations, the literature does not contain direct references for this type of innovation separately, since service and product innovation are usually considered as one. This research shows that there is a difference between the two, at least where the effect of organisational innovations is concerned, and both can be studied separately, if the research has more specific goals.

There are also researchers whose findings go against these results, such as Ballot et al. (2015), who uncovered a positive relationship effect between organisational and product innovations in the UK and France. The results also show that the relationships between different types of innovations does change from country to country, these findings were also part of Carboni & Russu's (2018) research, who analysed data from eight countries.

The only research with contradicting information that cannot be explained by country differences is that of Marques & Ferreira, (2013), who also analysed Portuguese companies. One of their findings is that organisational innovations have a positive impact on product innovations, which goes directly against this research’s findings. One possible explanation for this discrepancy is that the models used led to the discrepancy, which also happened in this research, when taking both types of models into account, or that the CIS data that was available for the previous research (CIS 2008) did not include as much information as the one used in the current research (CIS 2014), or that there has been an evolution in Portuguese companies that created a shift in the effect of organisational innovation on product innovation.

The second part of this research tries to identify which parts of organisational innovation are responsible for the effect on technological innovations. The subdivisions are new business practices, new methods of organising work responsibilities and decision making and new methods of organising external relations. The results show that introducing new business practices or new methods of organising work responsibilities and decision making positively affects the introduction of service and process innovations, and that introducing new methods of organising external relations positively affects the introduction of service innovations.

Since papers using these subdivisions are rare, comparisons are difficult to make. The first finding (new business practices positively affect service and process innovations) is contradicted by both Le Bas et al. (2015) and Mothe et al. (2015), who identified a positive relationship between new business practices and product innovations. For the second finding (new methods of organising work responsibilities and decision making positively affect service and process innovations), Le Bas et al. (2015) shows the same results, but Mothe et al. (2015) show the opposite, the positive relationship exists only for product innovations. The final finding (new methods of organising external relations positively affect service innovations) is the only one that cannot be directly compared to any source. The only partial comparison that can be made is to the results obtained by Le Bas et al. (2015) who state that introducing new methods of organising external relations does not positively affect the introduction of process innovations.

As with all research, this one has its limitations. First of all, the data only covers a small amount of time (approximately two years) and none of it can be temporally distinguished, all of it is considered one point in time. To better understand the effects different types of innovation can have on each other, an analysis covering several CIS instances would be more appropriate, for it would add different levels of detail that cannot be seen in a fixed time analysis. Two major benefits from using this extended approach would be the possibility of testing how the introduction of specific types of innovations in the past would affect the decision-making process for innovation implementation in the most recent dataset. The second benefit refers to the study of a country's evolution in terms of how its companies try to implement innovations. This would allow one to better understand the differences between different papers, such as the disparity in findings between this research and that of Marques & Ferreira, (2013) regarding the effects of organisational innovations in product innovations. In this case, a difference of five years can lead to a change of focus in companies, since before, organisational innovations were seen to positively affect product innovations and later that positive affect disappeared. In the future, having research focusing on one country for a longer period of time would likely yield interesting findings, provided that surveys can be standardized to allow for cross referencing the same data.

Another important topic is the separation of product innovations in pure product and pure service innovations. The present results (Table 13) show that the relationship between organisational innovations and either of these subtypes is completely opposite, with product innovation not being affected in any way by organisational innovations and service innovation being positively affected by organisational innovations in general and by all three subtypes. This difference is not properly analysed here since there is no literature to compare results to.

Another important point that could be tested in future research (for Portugal) is that of complementarities between different types of innovation. Where each subdivision of organisational innovation is tested alone and in conjunction with another in different combinations, since there are three subdivisions, six combinations should be created (A, B, C, AB, BC, ABC). This would allow for a better understanding of how organisational innovations can affect technological innovations by further specifying the effects of these subdivisions and comparing them to the effects of introducing them alone. With this analysis, the results can be refined further, which may alter the obtained results, particularly when testing the effects on product innovations. The goal here would be to identify the complementarities between the subdivisions and find which of them create synergies. This type of analysis has been performed by different authors (Ballot et al., 2015; Ennen & Richter, 2010; Mothe et al., 2015) but none was specific for Portugal.

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Appendix

Table A - Relevant literature with research goals, findings, model details and variables

Authors	CIS Round/ Countries	Topics	Model type/ Variables
C. Mothe et al. (2015)	2008 France	Studies effects of combinations of organisational practices on technological innovations; Organisational innovation favours technological innovations; Effects of complementarities depend on type of technological innovations (product or process); Combinations in line with CIS (business practices, workplace organisation, external relations).	**Model**: Heckman's two step selection **Dependent**: PDI performance PDI propensity PCI propensity **Independent**: WO, BP, ER, cost-push, demand-pull, KS **Control**: Company size, group, sector
Haned, Mothe, & Nguyen-Thi (2014)	2004, 2006, 2008 France	Studies the effects of organisational innovation on technological innovation persistence; OI favours TI and its persistence; Effect is more significant when company innovates on both products and services; The more organisational practices being implemented lead to a higher probability of remaining an innovator (except for pure process innovators); OI has more impact on TI on the short term.	**Model**: Dynamic probit random **Dependent**: Product innovator, Process innovator, Complex innovator **Independent**: WO, BP, ER, R&D expenses, **Control**: Company size, market, group, sector technological intensity
Schmidt & Rammer (2007)	2004 Germany	Studies the determinants and effects of NTI and compares them to those of TI; Combining all four types of innovations leads to better sales (with OI and MI being applied simultaneously), but less overall profit (more costs); Higher profit margins are associated with the implementation of only OI and PDI. NTI has less direct impact on profit than TI, but higher impact on TI implementation.	**Model**: Bivariate probit **Dependent**: NTI, TI, NTI with TI, TI with NTI **Control**: Innovation barriers, company size, higher education %, productivity, exports, group, market, number of competitors, innovation intensity, cooperation, R&D spending, innovation activities

Mothe & Thi (2012)	2006 Luxembourg	Studies the effect of NTI on TI; NTI significantly improve the likelihood of innovation, but not of its commercial success; OI are particularly helpful to PDI on the services sector.	**Model:** Logit, probit **Dependent:** Innovation performance (sales), likelihood of innovation **Independent:** NTI, R&D, obstacles to innovation, protection, cost-push, demand-pull **Control:** Size, sector, group, foreign ownership, obstacles to innovation
Sapprasert & Clausen (2012)	2000, 2004 Norway	Studies the attempts at OI and its effects; OI positively impacts company performance; Smaller companies benefit more from OI; OI persistence improves the benefits and complement TI.	**Model**: Heckman's two step selection **Dependent**: OI, OI effects **Independent**: Size, age, sector, past attempts at OI, past performance, innovation barriers, effect of OI+TI
Gallego, Rubalcaba, & Hipp (2013)	2004 18 countries	Studies effects of OI on TI; OI is particularly effective on small companies' performance and TI implementation; Combining OI and TI leads to increased company performance;	**Model**: Tobit **Dependent**: TI **Independent**: Internal R&D intensity, external knowledge intensity, OI **Control**: International competition, size, sector
Polder & Leeuwen (2010)	2002, 2004, 2006 Netherlands	Studies drivers, complementarity and productivity effects of PDI, PCI and OI; OI is complementary to PCI and has considerable productivity effects when combined with PDI and PCI.	**Model**: GHMP, RM, tobit, probit **Dependent**: R&D, ICT, PDI, PCI, OI **Independent**: R&D expenses, ICT investment, sector, size, group dependence on foreign markets, cooperation, financial support
Hervas-Oliver, Sempere-Ripoll, Boronat-Moll, & Rojas (2015)	2006 Spain	Studies effect of NTI on TI in R&D non-performing companies; Joint implementation of NTI with TI improves innovation performance and capabilities; NTI is used to compensate the lack of R&D in some Spanish companies.	**Model**: Heckman's two step selection, FIML **Dependent**: Innovative performance, production performance, market performance **Independent**: OI, MI **Control**: Knowledge acquisition, machinery acquisition, internal information sources, external information sources, size, sector

Le Bas, Mothe, & Nguyen-Thi (2015)	2006, 2008 Luxembourg	Studies the major determinants of TI and the role of OI; OI positively influences TI persistence; Business practices have a positive effect on PDI persistence; Workplace organisation has a positive effect on PCI persistence.	**Model**: Multinomial probit **Dependent**: PDI, innovation persistence **Independent**: BP, WO, ER, OI, R&D intensity, protection, competition intensity, **Control**: KS, size, group, sector
Ballot, Fakhfakh, Galia, & Salter (2015)	2004 UK, France	Studies the relationships and complementarities in performance between PDI, PCI and OI; OI and PDI are complementary (complementarities vary depending on country);	**Model**: Supermodularity **Dependent**: Company performance **Control**: Size, R&D intensity, staff training, cooperation, number of external KS, innovation barriers, protection, internationalisation, group, sector
Marques & Ferreira (2013)	2008 Portugal	Studies the impact of NTI on TI; NTI increases the probability of a company implementing other innovations; OI has a greater effect on industrial sector companies than on services sector companies; The probability to innovate increases as company size increases.	**Model**: Probit **Dependent**: Likelihood to innovate, extent of innovation **Independent**: MI, OI, size, group, R&D intensity
Mothe & Thi (2010)	2006 Luxembourg	Studies the role of NTI in the innovation process; NTI positively impacts innovation capabilities, but not performance (sales); The effects of NTI depend on the phase of the innovation process.	**Model**: Tobit **Dependent**: Innovative performance, innovation probability **Independent**: BP, WO, ER, OI, MI, internal R&D intensity, external R&D intensity, external KS, cooperation, innovation barriers, protection **Control**: Size, sector, foreign ownership

Guisado-González et al. (2017)	**-** **Spain**	Studies the relationship between different types of innovation using the distinctive view, integrative view and product-process matrix (PPM) framework; The relationships depend on which innovation types interact, vary between countries and can change over time; According to the distinctive view, there are no complementarities; According to the integrative view, all innovation types are complementary to some degree; According to the PPM view, PDI and PCI are complementary; The combination of OI and PDI creates no positive or negative synergies; OI and PCI are substitutive when no PDI is performed (in Spain, these are not implemented at the same time). OI can be a catalyst for complementarity only if PDI and PCI are implemented simultaneously.	**Model:** Complementarity approach **Dependent:** Labour productivity **Independent:** PDI, PCI, OI, R&D intensity, Legal protection, Internal sources, Industrial external sources, Scientific external sources, Cost obstacles, Financial obstacles, Knowledge obstacles, Market obstacles, Group, Cooperation, Export intensity, Size
Carboni & Russu (2018)	- 8 countries	Studies the roles of heterogeneity and simultaneity in a company's decision to engage in innovations (PDI, PCI and OI); All three innovation types are interdependent, their simultaneous implementation is likely to create synergies; Public support facilitates the introduction of these innovation types. The effects of introducing PCI and OI are particularly high; Company size has a positive impact in the choice of strategy (except for PDI); Exporting and credit rationed companies are more likely to innovate; Internal financing has no impact on innovation choice; There are substantial cross-country and cross-industry differences.	**Model**: Multivariate probit **Dependent**: PDI, PCI, OI **Independent**: Size, Capital intensity, R&D subsidy, R&D expenditure, Exports **Control:** Financial constraints, Debt, Sector

Ali-Yrkkö & Martikainen. O (2008)	- Finland	Studies relationship between innovations and company growth (software industry); Combination of non-technological and technological innovations helps company growth more than either by itself.	**Model:** Evans **Dependent:** Growth of net sales **Independent:** Size, age, TI, NTI, R&D intensity, sum of NTI dimensions
Camisón & Villar-López (2014)	- Spain	Studies relationship between organisational and technological innovation capabilities; Organisational innovation favours the development of technological innovations and company performance; OI directly affects implementation of process innovations, and indirectly affects the implementation of product innovations (mediated by process innovations).	**Model**: PLS, SEM **Dependent**: PDI, PCI, company performance **Independent**: OI **Control**: Size, age, environmental uncertainty, previous year's performance
Foss, Laursen, & Pedersen (2011)	- Denmark	Studies the effect of organisational innovation (organisational practices) and customer feedback on company performance; Link between customer feedback and innovation is mediated by organisational innovation. responsibility, the more communication will take place inside it.	**Model:** LISREL **Dependent:** Innovative performance **Independent:** Customer feedback, customer collaboration, strategy of close collaboration with customers, team autonomy, employee influence, salary associated with ability and willingness to share knowledge, internal communication, innovation capabilities relative to competitors, profitability relative to competitors **Control:** Higher education %, employee proportions for R&D, foreign ownership, product diversification, R&D intensity, sector

Gunday, Ulusoy, Kilic, & Alpkan (2011)	- Turkey	Studies the effect of different types of innovation on company performance; Relationship between OI and PDI not significant; OI has a fundamental role in innovative capabilities and performance; OI can facilitate the implementation of other types of innovation.	**Model:** SEM **Dependent:** Company performance **Independent:** PDI, PCI, OI, MI, innovative performance, production performance, market performance **Control:** Size, age, ownership status, foreign investment
Ryu & Lee (2015)	- Korea	Studies the relationship between technological and non-technological innovations; Non-technological innovations have a moderating effect in innovation success; Technological innovations only have a strong impact on innovation success when assisted by non-technological innovations.	**Model**: PLS structural **Dependent**: Company performance **Independent**: OI, PDI, PCI, MI
Acronyms		Technological innovation – TI Non-technological innovation – NTI Organisational innovation – OI Product innovation – PDI Process innovation – PCI Marketing innovation – MI	Workplace organisation – WO Business practices – BI External relations – ER Knowledge sources – KS

Table B - Descriptive statistics for both samples

Variable	Values	Sample 1	Sample 2
Product innovation	PDIp=1	26.5%	24.8%
Service innovation	PDIs=1	18.5%	17.8%
Process innovation	PCI=1	39.3%	37.5%
Organisational innovation	OI=1	29.5%	28.7%
	OI_1=1	18.4%	17.2%
	OI_2=1	21.7%	21.2%
	OI_3=1	13.7%	13.3%
Sector	Industrial	59.7%	58%
	Services	40.3%	42%
Group	GR=1	28.3%	25.7%
Market	National	30.9%	32.4%
	International	69.1%	67.6%
Cooperation	COOP=1	26.4%	24.3%
Innovation activities	Abandoned	6.9%	2.1%
	Ongoing	19%	17.1%
R&D	Performed	72%	71.9%
Size	Small	-	74.1%
	Medium	-	20.7%
	Large	-	5.2%
Acquisition of R&D	ACQRD=1	13%	11.8%
Acquisition of equipment	ACQEQ =1	29.8%	28.2%
Acquisition of knowledge	ACQKN =1	7.1%	6.7%
Staff training	TRAIN=1	25%	23.5%
Auxiliary Activities	INTR=1	15.2%	14.1%
Design Activities	DES=1	19%	18.1%
Miscellaneous Activities	MISC=1	15.4%	14%
Financial aid	FA=1	15.8%	13.8%
Has preferred knowledge sources	Yes	12.7%	10.9%
Customer feedback	Not important	13.2%	13.4%
	Low importance	4.7%	4.6%
	Medium importance	18.1%	17.6%
	High importance	22.8%	21.5%
Intellectual property protection	PRT=1	14.1%	12.7%
Employees with college education	0	15.6%	17.1%
	1-4	25.8%	26.8%
	5-9	13.1%	12.6%
	10-24	20.5%	19.1%
	25-49	10.9%	10.4%
	50-74	7%	6.7%
	75-100	7.1%	7.2%

Table C - Correlation matrix for all variables

Variables	PDIp	PDIs	PCI	OI	OI_1	OI_2	OI_3	SEC	GR	MAR	COOP	INABA	INONG	RD	RDi
PDIp	1														
PDIs	0.1226	1													
PCI	-0.1151	0.0421	1												
OI	0.0871	0.2165	0.2271	1											
OI_1	0.0951	0.1964	0.2096	**0.6903**	1										
OI_2	0.0808	0.2162	0.1927	**0.7806**	0.5227	1									
OI_3	0.0951	0.1898	0.1244	0.5583	0.388	0.4357	1								
SEC	-0.193	0.2497	-0.0698	0.0886	0.0512	0.096	0.0791	1							
GR	0.0186	0.0646	-0.002	0.0983	0.106	0.066	0.0841	0.1522	1						
MAR	0.1759	-0.0813	0.0309	0.0076	0.0174	-0.0002	0.0254	-0.1925	-0.0565	1					
COOP	0.1632	0.1781	0.1494	0.2368	0.2285	0.1758	0.1636	0.07	0.2015	0.0486	1				
INABA	0.1212	0.0167	-0.0439	0.0844	0.0837	0.0818	0.0596	-0.0398	0.055	0.0593	0.0638	1			
INONG	0.1304	0.0696	-0.0125	0.1579	0.1607	0.1256	0.1124	-0.0274	0.0923	0.1029	0.1759	0.2463	1		
RD	0.255	0.1051	0.0162	0.1374	0.1546	0.0978	0.1156	-0.0298	0.1517	0.1608	0.2245	0.1814	0.3055	1	
RDi	0.0307	-0.0108	0.0071	0.0151	0.0283	0.0238	0.0363	0.0332	-0.0023	0.0244	0.0432	0.0336	0.0331	0.0595	1
TS	0.0555	0.0688	0.0507	0.0778	0.0938	0.0642	0.0868	0.0488	0.1561	0.0264	0.1105	0.0755	0.1174	0.1221	0.032
REV	0.026	0.0411	0.0244	0.0608	0.0801	0.0552	0.0821	0.076	0.155	-0.0219	0.0684	0.0519	0.0353	0.0556	-0.0069
SMALL	-0.0512	0.0263	-0.0641	-0.0506	-0.0786	-0.0134	-0.0207	0.0248	-0.3406	-0.0732	-0.1679	-0.0939	-0.1144	-0.1979	0.0297
MEDIUM	0.0226	-0.0595	0.0309	0.013	0.0191	-0.0221	-0.0076	-0.0382	0.1709	0.0578	0.0962	0.0215	0.0635	0.107	-0.0248
LARGE	0.0529	0.0494	0.062	0.0673	0.1063	0.0587	0.0481	0.0178	0.3193	0.0349	0.1383	0.129	0.0974	0.1732	-0.012
ACQRD	0.1257	0.0911	0.0514	0.1593	0.1762	0.1171	0.1359	0.0476	0.201	0.0296	0.3291	0.1341	0.2249	0.2914	0.0358
ACQEQ	0.0566	0.0944	0.2208	0.1128	0.0917	0.1076	0.0655	-0.1117	-0.0528	0.0746	0.095	0.0015	0.0813	0.0072	0.0286
ACQKN	0.1023	0.1328	0.0833	0.1947	0.1509	0.1718	0.1919	0.0108	0.0978	0.0083	0.184	0.0474	0.1191	0.1059	0.0523
TRAIN	0.1209	0.182	0.1678	0.2525	0.2064	0.2379	0.2121	0.057	0.0688	-0.0046	0.1671	0.0602	0.1184	0.1254	0.0123
DES	0.2385	0.1494	0.0409	0.1702	0.1483	0.1558	0.1705	-0.0099	-0.0299	0.1003	0.1352	0.1086	0.1385	0.1594	0.0051
MISC	0.1391	0.0826	0.0938	0.2011	0.1956	0.1858	0.184	-0.0756	0.0813	0.071	0.1517	0.1092	0.1747	0.1623	0.0326
FA	0.1579	0.0113	0.059	0.1193	0.1436	0.0549	0.0709	-0.1208	0.0954	0.184	0.2271	0.0926	0.271	0.3363	0.07
KS	0.1534	0.0894	0.049	0.1655	0.1787	0.1213	0.1682	0.0059	0.2217	0.0496	0.5356	0.1379	0.2696	0.3307	0.0785
CF	0.1672	0.1308	0.0702	0.2171	0.1873	0.1863	0.1538	-0.0269	0.0635	0.0949	0.1448	0.0631	0.145	0.222	0.0244
PRT	0.1537	0.0126	-0.0069	0.0788	0.1116	0.0348	0.0958	0.031	-0.0019	0.1313	0.138	0.0809	0.1434	0.1651	0.0795
CEMP	-0.0037	0.1856	-0.0608	0.1715	0.1494	0.1436	0.1499	0.4347	0.2774	-0.0179	0.1897	0.0416	0.1517	0.2567	0.088

Table C - Correlation matrix for all variables (continued)

Variables	TS	REV	SMALL	MEDIUM	LARGE	ACQRD	ACQEQ	ACQKN	TRAIN	DES	MISC	FA	KS	CF	PRT	CEMP
TS	1															
REV	0.4464	1														
SMALL	-0.1861	-0.1695	1													
MEDIUM	0.0193	0.0036	**-0.8237**	1												
LARGE	0.2928	0.289	-0.4228	-0.1655	1											
ACQRD	0.1405	0.0998	-0.1925	0.0999	0.1752	1										
ACQEQ	0.1051	0.0105	-0.0486	0.0074	0.0727	0.096	1									
ACQKN	0.1086	0.0508	-0.0529	0.0168	0.0651	0.2087	0.1357	1								
TRAIN	0.0922	0.0317	-0.0601	0.0084	0.0912	0.1438	0.1661	0.2214	1							
DES	0.0712	0.0477	-0.0458	0.0041	0.0731	0.1162	0.0889	0.1795	0.225	1						
MISC	0.0901	0.0571	-0.0825	0.0248	0.1038	0.1518	0.0294	0.1895	0.1604	0.2557	1					
FA	0.1295	0.0228	-0.1882	0.13	0.1195	0.2302	0.1553	0.0946	0.0744	0.0969	0.1625	1				
KS	0.169	0.1127	-0.1888	0.0814	0.1984	0.3455	0.0863	0.1708	0.1429	0.1028	0.1905	0.2968	1			
CF	0.0436	0.0396	-0.0603	0.032	0.0537	0.1188	0.0454	0.1048	0.1763	0.1687	0.1378	0.1573	0.169	1		
PRT	0.0705	0.0305	-0.0524	0.034	0.0369	0.1216	0.0526	0.0915	0.0324	0.2122	0.0999	0.1995	0.1543	0.1255	1	
CEMP	0.103	0.0663	-0.042	-0.0029	0.0777	0.1742	-0.0446	0.0957	0.0897	0.073	0.0876	0.1558	0.2064	0.1361	0.1568	1