Universidade de Aveiro Departamento de Ciências Sociais, Políticas e do Território
2016

Joana Maria Costa Martins das Dores

Três Ensaios em Economia da Inovação

Three Essays on Economics of Innovation

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Three Essays on Economics of Innovation

Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Doutor em Políticas Públicas, realizada sob Exclusiva Responsabilidade

We must now do what the world will tomorrow.

Jean Cocteau

o júri

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Prof. Doutor Domingos Fernando da Cunha Santos
Professor adjunto do Instituto Politécnico de Castelo Branco

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palavras-chave Inovação, Persistência, Barreiras à innovação, Universidades, Especialização Inteligente

resumo

O presente trabalho pretende contribuir para a literatura na economia e política de inovação no que se refere a comportamentos inovadores em contextos de ambientes macroeconómicos instáveis, práticas de abandono ou continuidade de atividades inovadoras, bem como recurso a importantes fontes de inovação.
O trabalho encontra-se organizado em quatro capítulos. O primeiro capítulo procede a uma apresentação detalhada da base de dados – Community Innovation Survey (CIS) Portugal – utilizada nos capítulos subsequentes. A relevância de fazer desta o primeiro capítulo do presente trabalho prende-se com o facto de constituir este primeiro esforço em compilar e analisar temporalmente sob a forma de painel as diversas sessões do CIS realizados em Portugal. Este capítulo serve ainda para fornecer ao leitor uma visão da evolução temporal das atividades de inovação em Portugal nas últimas quase duas décadas, bem como da evolução dos seus fatores determinantes tal como identificados na literatura. Finalmente, são também apresentados e discutidos ao longo deste primeiro capítulo alguns importantes conceitos desenvolvidos na literatura da economia e política de inovação usados nos capítulos subsequentes.
No segundo capítulo são utilizadas três sessões do CIS-Portugal, com estrutura em painel, para o teste e análise de importantes questões relacionadas com a persistência de atividades de inovação que têm sido colocadas na mais recente literatura que procura analisar o efeito de envolventes instáveis, como as decorrentes da crise internacional de 2008, nessas atividades. Os resultados obtidos permitem-nos rejeitar a hipótese tradicional de persistência, indicando-nos que a persistência nas atividades de inovação em contextos instáveis e de incerteza não podem ser desligados do perfil de comportamento inovador nem do tipo/vetor de inovação.
No terceiro capítulo são utilizadas, também com estrutura em painel, as duas sessões do CIS-Portugal que incluem questões sobre barreiras à inovação para atualizar as determinantes do abandono destas atividades por parte das empresas portuguesas.
A análise realizada neste capítulo permite-nos compreender melhor o perfil de persistência investigado no segundo capítulo. Entre outros, os resultados obtidos permitem-nos concluir que a dimensão das empresas bem como o acesso a fundos governamentais não têm papel relevante nesse abandono, mas que o nível de educação/qualificação da força de trabalho e as restrições financeiras (de tesouraria) exercem um papel significativo nas decisões de abandono das atividades de inovação das empresas portuguesas.
De destacar que, e de forma contrária ao esperado e habitualmente reportado na literatura, os resultados aqui obtidos indicam-nos também que maior incerteza quanto às condições de procura no mercado reduz a probabilidade de abandono de atividades de inovação por parte das empresas. Ainda que inesperado, este resultado está em consonância com o perfil das empresas persistentes na inovação identificado no segundo capítulo desta dissertação, correspondendo este ao de empresas que encetam atividades de inovação em contextos instáveis, na decorrência de choques e adaptadas a novas condições envolventes.
No quarto capítulo são utilizadas as três sessões do CIS-Portugal, usadas também no segundo capítulo, para analisar a importância das universidades como fontes de atividades de inovação pelas empresas portuguesas. Tendo verificado no capítulo anterior que as restrições financeiras são importantes determinantes do abandono das atividades de inovação, coloca-se a questão de saber se as empresas portuguesas recorrem ou percecionam as universidades como relevantes fontes de inovação uma vez que estas se constituem como importantes fontes relativamente pouco dispendiosas, e qual o perfil das empresas que o fazem.
De entre os resultados obtidos, e controlando por outros fatores, destaca-se o facto de as empresas portuguesas que se percecionam a si próprias como inovadoras persistentes não atribuírem um papel relevante às universidades enquanto fonte de inovação. De certa forma, este resultado também se encontra em consonância com o perfil de persistência identificado no segundo capítulo, em que se verificam que a persistência nas atividades de inovação em Portugal é, em presentes contextos de incerteza, negativamente afetada por sucesso em atividade de inovação passadas. Assim, não vendo as universidades como relevantes, estas empresas limitam as suas próprias alternativas para fazer face a novos desafios e exigências dos mercados, quebrando o ciclo virtuoso de aprendizagem/acumulação conducente a mais atividade inovadora de sucesso. No seu conjunto, estes resultados constituem evidência empírica sólida justificativa da necessidade de se proceder a uma política efetiva de promoção de uma maior e estreita ligação entre o tecido

empresarial e as Universidades Portuguesas como fator determinante do sucesso económico do país nos presentes contextos de incertezas económicas, sociais e políticas em que opera indeterminadamente.

keywords Innovation, Persistence, Innovation barriers, Universities, Smart specialisation

abstract

The present work aims to contribute to the literature in economics and innovation policy in what concerns innovative behavior under unstable macroeconomic contexts, innovation abandon and continuity in innovation activities as well as the relevance of the innovation sources.
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The present work is organized in four chapters. The first chapter presents a detailed analysis of the database – Community Innovation Survey (CIS) Portugal – used in the following chapters. The relevance of this analysis relies in the fact that it is the first effort to compile and analyse by means of a time series, using a panel the different CIS waves implemented in Portugal. This chapter will allow us to grasp a comprehensive view about the evolution of the innovative activities in Portugal during the last two decades, as well as the determinants identified in the literature. Finally, we present and discuss the major concepts presented in the literature and used in the following chapters.
In the second chapter we will use three sessions of the CIS – Portugal, by constructing a panel, to test and analyse the relevant questions connected to innovation persistence recently posed in the literature which aims to analyse the effect of the international crisis of 2008 over these variables. The results allow us to reject the traditional hypothesis of the persistence, indicating that persistence in innovative activities under unstable contexts and uncertainty cannot be disconnected from the innovative profile, innovative behavior as well as innovation vector/innovation type.
In the third chapter we will use, again by means of a panel, comprising two CIS waves (CIS – Portugal) questions concerning innovation abandon and the barriers to innovation. We aim at understanding the determinants of the abandon of the Portuguese firms. The analysis performed in this chapter allows us a better understanding in the persistence profile used in the second chapter. The results allow us to conclude that the dimension as well as the access to funds are not relevant to the abandon, although, education intensity and financial constraints are significant in the abandon decisions of the firms. Importantly and contrarily to what is expected and reported in the literature, the obtained results; higher uncertainty about demand conditions reduce the abandon probability. Despite being unexpected, this result goes along with innovation persistence found in the second chapter corresponding to firms that do perform innovation given the existence of exogenous shocks.
In the fourth chapter we will use the three CIS waves from the CIS – Portugal, also used in the second chapter, to analyse the relevance of the universities as sources of innovation activities for the Portuguese firms. Having considered, in the former chapter that financial constraints are abandon determinants, one should ask the question if the Portuguese firms do rely on Universities or find them as being relevant for innovation given that they are determinant and not expensive, as well as the profile of the firms that use them. Among the obtained results we should underline the fat that Portuguese firms which consider themselves as being persistently innovative do not consider the Universities as a relevant source of innovation. To a certain extent, this result goes along with the persistence profile identified in the former chapter, and it is proved that persistence is negatively influenced by former innovation when considering unstable environments.
Therefore, given that the firms do not consider the Universities as being a relevant source of innovation, these firms restrict their own choices to face the challenges of the markets, disrupting virtuous cycles of accumulation and feedback leading to more innovation in the future.
As a whole, the results provide solid empirical evidence justifying the need to develop an effective policy to promote a larger and closer connection between firms and Universities as a determinant factors of the country economic success under the context of economic, social and political uncertainty in which it operates internationally.

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OVERALL PERSPECTIVES

Ever since becoming a member the European Union in the later 80's Portugal was enrolled to a combination of economic policies to boost economic efficiency, sustainable growth, regional cohesion and development.

Noticeable changes were implemented in the design and conduction of the policy actions, which reinforced the efficiency in the use of resources improving the performance of the economy as registered in the EIS and IUS reports. However, the crisis of 2008 brought important drawbacks in terms of the macroeconomic performance as well as the innovation indicators; moreover the existing policy framework presented in the Lisbon strategy was underperforming, requiring major policy re-design.

The present work starts with an exhaustive portrait of the Portuguese Innovative activities, providing a detailed analysis of its evolution since the beginning of data collection about innovation figures – the CIS 2, up to the latest edition, the CIS 12, this provides a time span from 1995 to 2012. This chapter delivers a diachronic view of all the CIS waves implemented in Portugal and details time evolution of its major indicators.

There was a general improvement in terms of the innovative performance as an increasing number of firms performed efforts to achieve innovation, more resources devoted to R&D, a higher percentage of firms hiring skilled personnel, drawing upon sources of knowledge, using public support and belonging to technological intensive sectors. Even though the crisis of 2008 made these results go back to the levels of past years, representing a step back in the performance of the country.

The analysis of the innovative performance provided using the CIS was complemented with those of the Innobarometer. The composite indicator that evidences the yearly performance of the European countries was analysed since the 2001 edition up to 2015.

In the same vein as the results from the CIS, this composite indicator evidenced an improved performance of the different indicators, approaching the European average, but, since 2008, the results worsened. Portugal is, at present considered as a moderate innovator, which is not far away from its position years ago.

As the statistical evidence illustrated a retreat of the Portuguese performance in terms of Innovation, it seemed of major importance to understand the underlying factors of this downturn.

A major question to be answered was why were the Portuguese firms stopping their innovative activities rather than continuing their upward trend supported by the literature.

The existing literature sustain that there is persistence of the innovative activities, which means that past innovative behaviours will enhance the probability to continue innovation at present. As a result there was no straightforward answer to support the behaviour of the Portuguese firms. Even though, most of the empirical evidence arrived from innovation leaders or followers, which posed the hypothesis that moderate innovators did not approach persistence in the same manner than top innovators.

Empirical evidence addressing the CIS 6, 8 and 10 (2004-2010) permitted the understanding of persistence before and after the financial crisis highlighting eventual changes in terms of firm strategy. Thus, the results do not confirm the role of the crisis but some other arguments of major importance – Portuguese firms have an intermittent strategy towards innovative activities. These results completely changed the preconceived beliefs that considered the crisis the response for every drawback in terms of innovation.

When analysing the innovation types separately, different patterns emerge, so innovation policies are somehow myopic when treating all types of innovation in the same manner. The difference in the patterns best fitted the case of a moderate innovators, as they are less prone to perform product or service innovation and more prone to perform process, marketing and organisational innovations.

The hypothesis of pure persistence in the Portuguese case does not hold, meaning that Portuguese firms, independent of the reason, do not perform innovation in a continuous base. Moreover, firms considered as sporadic innovators will present a discontinuous strategy in innovation. Firms that are new to innovation will continue their innovative path.

Traditional structural traits such as size, economic group, economic sector and technological intensity punctually appear as statistically significant. Notwithstanding, the strategy in terms of the use of alternative sources of innovation (proxied by openness) appear as determinant to explain the innovation performance.

These results supported the belief that, for some reason, the Portuguese firms opted to start and stop their innovative efforts according to their convenience rather than embedding virtuous cycles of continuous innovation. As a consequence it was important to grasp some understanding about the hampering factors faced by the Portuguese firms to perform their innovative activities. This motivation made us move towards the second major question, determining the hindering factors of innovation in the Portuguese firms.

Again, the preconceived idea relies on the lack of finance, either arising from internal or external sources. This fact will be even more noticeable undergoing an economic crisis. Much attention is devoted to innovation success and its reasons, however getting an understanding about the failure may help policy makers in the creation of instruments to avoid this situations.

The abandon of the innovative activities in the Portuguese case is somehow due to the lack of finance but other barriers to innovation complement finance. Our firms point the absence of qualified personnel as a hampering factor to innovation. The incapability of benefitting from external sources of knowledge also hampers innovation.

Evidence also showed that the availability of funds does not influence the propensity to abandon, which somehow proves that public funding is not a substitute for the internal or external finance. This result proves, to some extent that the policy instruments are not provided to firms in an efficient manner.

Abandoning the innovative activities will also depend on the type of innovation being performed by the firms. When pursuing process innovation, firms are less prone to abandon their innovative activities, this evidences that this innovation is central to the firms and cannot be paused or postponed. Other innovation types such as organisational or marketing are perceived as secondary as they will have a higher probability of abandon.

In sum, the evidence shows that some innovation is abandoned due to insufficiencies in finance, but, core innovative actions will be continued. The results in terms of innovative strategies depict the probability to abandon in the same vein than the persistence patterns drawn in the previous model; former occasional and persistent innovators will have increased probabilities to abandon innovation. The absence of information and knowledge arising from inside the productive chain as well as the insignificance of the use of innovation sources such as the University, along with openness, reinforces the need for a full comprehension of the role of these institution in

innovation. Moreover, these results point to a complementarity in knowledge production of firms and academia. As firms will continuously face to some extent financial constraints, the academia should eventually replace them in the production of certain types of innovation that become unfeasible for firms and diffuse it in the innovation system. This idea creates the need for understanding the role of Universities in creating relevant knowledge for innovation.

In the Portuguese case, firms tend to neglect the role of Universities as knowledge producers and diffusers. However the efficient use of public support and the cohesive development of the regions, with special emphasis in the less favoured, requires shared roles in the innovative activities.

Relying on the academia to produce relevant knowledge is prone in innovative firms, of large size with top educated workers, which adopt an open innovative strategy. Persistent innovators also find the University as being important to their innovative activities then others. Firms that use the public support for their innovative activities tend to find the University as being a relevant source of knowledge than others.

The type of innovation in analysis also influences relying upon Universities; when performing product innovation, firms have a reduced probability to rely upon the Universities. This finding illustrates that firms fear involuntary change of relevant information, and industrial secrecy.

Policy guidelines contained in the RIS3 strategy reinforce the role of the Universities in the National Systems of innovation as developers of the innovative strategy at the regional level as well as its integration in the national dimension; therefore Universities will play a multi-level role, identifying the differentiating domains, creation of the conditions for their implementation, produce knowledge and qualified workers accordingly. Our evidence shows that much has to be done in this field as the University seems to be undervalued by the firms, which use them for simple discontinuous problem solving.

Rapid action must be taken as public money which can be devoted to the innovation policy is scant, even more in adverse economic contexts. Moreover, less favoured regions must compete with strong regions which argue more efficiency in the use of public funds. The RIS3 argues that sustainable development and the cohesion among European regions

relies on the implementation of strong linkages among Universities and firms serving the purposes of the differentiating domains reinforced by policy instruments and support.

Our general evidence proves that the poor innovative performance that is hampering the Portuguese convergence with Europe tends to be justified with the financial crisis and inexistence finance, even though our result consistently prove that this is not the case as moderate innovators do not face innovation in the same vein as innovation leaders; availability of finance is a necessary but insufficient condition due to the voluntary intermittence in terms of innovation strategy of firms.

Giving Universities a central role, properly defined in the RIS3 is the key solution for an entrepreneurial sector which is believed to be underperforming but which is, by nature different from the innovation leaders and to whom the "one size fits all" policy framework does not serve.

GENERAL OVERVIEW OF THE PORTUGUESE INNOVATIVE ACTIVITIES

Part of this chapter is forthcoming in the book "Corporate Sustainability: the new pillar of the circular economy" ed. Nova Publisher

1. Introduction

1.1. Initial considerations

The quantitative analysis of the innovative performance of the Portuguese firms invariably relies on the Community Innovation Survey (CIS). This survey is the most comprehensive to describe the innovative actions over the last decades. In Portugal, data collection has started with the CIS 2, analysing data from the 1995-1997, and the most recent wave was the CIS 12, with evidence from 2010-2012.

This chapter will provide a comprehensive analysis of the different waves of CIS survey in what concerns the most relevant variables mentioned in the literature as determinants of the firms' innovative performance.

The rest of the chapter is organised as follows: section 1.2 details the database construction and methodological changes over time; section 2 provides a descriptive analysis of each variable and its evolution over time; section 3 provides a diachronic description of the Portuguese innovative performance in macroeconomic terms by means of the European Innovation Scoreboard (EIS) depicting the Portuguese positioning compared to the rest of Europe.

1.2. Database

The empirical part of the essays will rely on the statistical data provided by the CIS (Community Innovation Survey) for Portugal. This survey is run by the national statistical agencies of the EU member states, based on the *Oslo Manual* (OECD and Eurostat, 2005) and following the methodological recommendations of the Eurostat.

To our knowledge, the CIS is the most comprehensive database in terms of firms' innovative activities and it respects reliable data collection methodologies in terms of sampling design and data treatment.

The CIS database consists of a stratified cross-section sample. It encompasses a wide variety of economic sectors and its scope was enlarged by different implementations following the recommendations of the European Commission. Presently, the survey includes firms from the primary, the secondary and tertiary sectors with no exception.

The survey is biennial, and is done simultaneously by all participant Countries throughout Europe. It fully covers the Portuguese territory despite it not being targeted towards regional analysis. This comprehensive survey covers all the economic activities and regions, respects mainstream conceptual terms as well as the question design (allowing for intuitive statistical treatment and econometric analysis, regardless of the sample structure).

Portugal started participating in this European survey in its second round (CIS 2) which took place in the second half of 1998 requesting firms data regarding the period of 1995-1997. This survey was extended to the Euro-15, Norway and Iceland.

The inquiry is sent to firms across the economic sectors according to their SIC codes (Standard Industrial Classification), and follows strict procedures.

In the case of the CIS 2, participant countries were asked to send the respondents two alternative questionnaires: one for the industrial sector and another, slightly different, for the services. In this wave, the *construction* sector firms were not included, whereas in the following waves, all sectors of activity were covered.

The inquiry has an unaltered list of questions to provide information about firms' structural characteristics and their innovative activities during the two-year period covered in the survey. The subsequent editions of the survey were the CIS3, CIS4, CIS6, CIS8, CIS10 and the CIS 12.

The questionnaire had suffered small adjustments over time. Some issues were included others removed to match the economic context and the relevance the different topics. Consequently, some groups of questions will be present in all CIS waves and others, such as barriers to innovative activities, are analysed only each four years, which means that in this particular case, the information available will be collected for the CIS 6 and put along with the CIS 10.

The use of the different waves of the CIS to build a panel requires a complex and careful effort as several methodological and conceptual constraints must be taken into account, namely: the sample design, the reformulations occurred in the survey, the

introduction of new or redesigned concepts, the approach to the European codifications of the economic activities (SIC codes).

When building a panel comprising several periods, due to the sampling method used, firms may not be observed across all waves. The explanation can either be a simple non-response or not being included on the sample on that wave. Therefore, the number of firms presented in a multi-wave panel is naturally expected to fall. Due to sample design, not all firms are requested to provide information in every survey. This is a hindering factor when building a panel as many observations fail to be present in all waves.

The rise in the number of the respondent firms in the latest editions of the CIS, enhances the robustness of the statistical analysis and the econometric estimations improving model building, interpretation, hypothesis testing and guarantees the reliability of the results.

Table 1 - Respondent firms per survey

Survey	Period of Analysis	Number of respondents
CIS2*	1995-1997	819 (Industry) 1016 (Services)
CIS 3	1998-2000	1875
CIS 4	2002-2004	4815
CIS 6	2004-2006	4721
CIS 8	2006-2008	6593
CIS 10	2008-2010	6160
CIS 12	2010-2012	6840

* The industry and the service sectors answered to separate questionnaires in CIS2

Source: Author's own computation and notation based on CIS surveys

In 1998, Portugal started collecting innovation data under this methodology, and the survey included 819 firms in the industrial sector and 1016 in the services. As seen in table 1, there are two major modifications in terms of the number of respondents caused by the methodological redesign of the sample. Indeed, there is an important increase in the number of observations and also in the range and organisation of economic activities.

The CIS 2 and the CIS 3 were ground-breaking in both the European and the Portuguese case. Even though, the Eurostat's recommendation require70% response rate to ensure representativeness, in Portugal the response rate in these waves was respectively 53.8% and 45.8%.

The number of respondents in the next two waves, the CIS 4 and the CIS 6, more than doubled, with a total number of respondents of 4815 and 4721. These figures provide statistical robustness to the regional representation. The next three waves, CIS 8, CIS 10 and CIS 12 contained the second important change, which rose again the number of respondents. It was caused by the mandatory modification concerning the SIC codes' representativeness, forcing the questionnaire to grasp three-digit detail in some specific cases rather than the two-digit requests of the previous sessions.

To allow for transnational comparisons and to approach the European concepts and methodologies, the Portuguese statistical institute was asked to implement changes in the codifications so as to adapt questions to standardise outcomes.

In what concerns the sectoral classification (SIC – standard industrial classification), between 1995 and 2012, changes were made aiming at approaching European codification, the data collection criteria, and the inclusion of new activities formerly inexistent. Due to the changes implemented in the last two decades, presently the Portuguese classifications are harmonized with the European, allowing comparisons with other EU members.

During the time span comprised by the CIS 2 up to the CIS 12 the codification of the economic activities was based in three different versions: the Rev. 2, the Rev. 2.1 and the Rev. 3 (in use at present).

The CAE Rev. 2 was the framework considered for data from the period between 1/1/1994 and 31/12/2002 (equivalent to the NACE Rev. 1). There was a minor update for the CAE Rev. 2.1 (NACE Rev. 1.1) occurring in the period between 1/1/2003 up to 31/12/2007. A second revision was implemented producing effects from 1/1/2008 until the present date CAE Rev. 3 (NACE Rev. 2).

The CIS 2, CIS 3, CIS 4, CIS 6 used the CAE Rev. 2 and the CAE Rev. 2.1, at the two-digit level, which means that the codification the update did not produce major effects. The CIS 8, CIS 10 and CIS 12 used the CAE Rev. 3. The changes in the SIC codes applied require careful conversions to avoid structural breaks. The implemented correspondence procedure, if needed for time series analysis, will strictly follow the Eurostat/INE (Statistics Portugal) recommendations.

The data presented in the next sections considers these changes and, when needed it includes the methodological transformations.

2. Data Description

Throughout the CIS waves, firms were inquired about structural characteristics such as: SIC code, size, turnover, workforce structure, innovative behaviour and performance (in areas such as product and/or service innovation, process innovation, organisational and marketing innovation), R&D activities in different fields, innovation sources, innovation partners and innovation barriers, as well as about the success of their projects. Sporadically, questions were included in some sessions, regarding strategic behaviour, environmental behaviour and its connection to the innovative process.

The dataset comprises discrete, continuous, binary and qualitative variables depending on the topic which is analysed. The nature of the variables and the information included is preserved when performing primary analysis; when required, transformations are operated maintaining the original arrangement.

2.1. Size

The innovative behaviour of the firms is influenced by several aspects; one of the most important is the *size* of the firm. Despite being controversial, in what concerns its impact, the size of the firm was never indifferent to its innovative performance. The work of Galbraith (1957) pointed to the importance of large monopolists in the innovative processes; conversely Shumaker (1973) believed that small firms are more efficient in the innovative process. Schumpeter (1942) underlined the importance of small firms as exogenous inventors, raising the availability of new products, then, it was stated that innovation emerged from the R&D labs of the large companies, as an endogenous action.

The variety of positions suggests that these firms play complementary roles in innovation and technological change. Amongst others, the endowments of human resources will allow for different approaches in terms of innovation, adoption or imitation.

As is the CIS, and following the European procedure, the size of the firm will be proxied by the number of employees. Firms were categorised as small, medium or large (European Commission, 2009).

Accordingly to the taxonomy adopted, small firms have less than 50 employees (this category also includes the micro-firms), medium sized firms have from 50 to 249 employees and large firms have 250 or more. Firms with less than 10 employees were

excluded from the sample and the large firms were included in the sample by censitory method.

In order to ensure statistical secrecy, due to the shortage of respondents, in some sectors of activity, the variable *size* is presented with two categories (the actual CAE code of the firm and the sequential following code); to accurately compile the data, only the first one is considered. For all other cases, firms are presented at the interval that corresponds to their number of employees.

Table 2 - Distribution of firms per size

Survey		Firm size (number of employees)		
		20 to 49	**50 to 249**	**250 or more**
CIS 2	**n**	1017	523	295
	%	55.4	28.5	16.1
CIS 3	**n**	977	656	242
	%	52.1	35	12.9
CIS 4	**n**	3171	1164	480
	%	65.9	24.1	10
CIS 6	**n**	3043	1165	513
	%	64.4	24.7	10.9
CIS 8	**n**	4353	1799	441
	%	66	27.3	6.7
CIS 10	**n**	4035	1743	382
	%	65.5	28.3	6.2
CIS 12	**n**	4607	1850	383
	%	67.4	27	5.6

Source: Author's own computation based on CIS surveys

In table 2 we can observe that the Portuguese entrepreneurial environment is mostly composed by small firms. Not surprisingly, the database includes a significant proportion of small firms (less than 50 employees), thus illustrating the real economic environment. Small firms have natural characteristics that influence managerial and economic decisions on a daily base; expectably, their organisational structure is exiguous hampering some possibilities to allocate human capital exclusively to innovative activities as well as their ability to grasp financial support.

Large firms represent a smaller proportion of the grand total. Consequently the number of large firms included in the survey will be reduced; to guarantee the availability of a significant number of respondents in this category, the percentage of inquiries sent to

large firms is artificially high by construction. The information that these observations bring to the panel is of extreme relevance as large firms are organisationally more complex and expectably have a higher aptitude to embrace innovation projects.

When analysing the relative weight of large firms over time we observe a negative trend while medium firms remain with a similar relative weight over time. Small firms are the most relevant firm structure in the Portuguese case.

2.2. Economic group

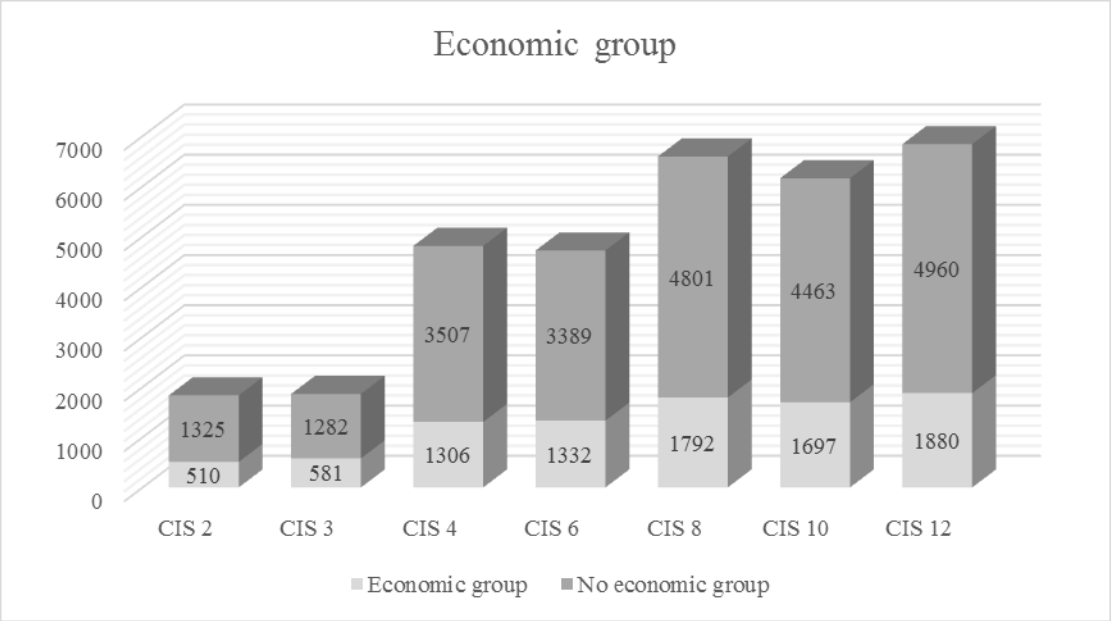
Economic groups search economic advantages for their members; there is an advantage in embeddedness. When firms are formally linked, regardless of belonging to similar or different activities, operating in the same or different headquarters, they will benefit from enlarged networks of stakeholders thus generating synergies (Granovetter, 1994).

Being a member of an economic group, among others, will enhance the availability of financial resources, hereby raising the probability of supporting innovative activities with equity capital.

The existence of simplified communication channels, an enlarged knowledge pool, and diversity of skills raises firm's innovative potential. Moreover, linking individual and collective expertise of the employees will boost innovative activities.

Economic groups benefit from scale effects on their innovative actions, therefore it is expected that they are more proactive in this field than firms with a smaller dimension.

Graphic 1 - Firms reporting belonging to an economic group



Source: Author's own computation based on CIS surveys

Graphic 1 reflects that during the different CIS waves the proportion of firms integrating an economic group remained almost unchanged, being slightly more than one quarter of the total sample (in concrete 27%). The CIS 3 was the wave in which more respondents integrated economic groups, with its proportion being nearly one third of the total respondents (31.2%).

The proportion of firms belonging to an economic group presents a pattern which is similar to most of the countries; particularly those in which an important proportion of the firms are small and medium sized. So, an important of the respondent firms will exclusively use their own human and financial resources to perform innovative activities.

2.3. Economic Sector

Innovation has different features across the economic sectors. The type of innovation will depend on the nature of the technological progress, product and industry lifecycles. Furthermore, the degree of novelty as well as the pace of technological change will determine the need and the pace of R&D activities.

Understanding the nature of the economic activities performed by the firms in the respondent sample will allow us to recognize the technological regimes, and the efforts

devoted to innovation. This framework is designed for understanding a specific knowledge base and the competitive technology dynamics of the different sectors targeting at interpreting the variety of innovative processes (Nelson and Winter, 1977 and 1982; Winter, 1984; Pavitt, 1984). In doing so, we will connect the various aspects of the innovation process and systematize inter-industry distinctions into a few invariant categories.

The economic activity will determine the firm's behaviour in general and particularly in what concerns innovation. Firms in different sectors will present different propensities to innovate as their motivation is completely different.

In section 2.5, technological intensity will be analysed in detail, however, it is worth understanding the array of activities in the sample to grasp awareness about the Portuguese reality.

Economic sectors will be broken up by their Standard industrial classification (SIC – code), the Portuguese CIS uses the two-digit CAE code (classification of the economic activity), corresponding to the international SIC code. Due to methodological and theoretical recommendations the codes have changed over time, the analysis strictly follows the official procedure and nomenclature proposed by the INE (Statistics Portugal).

Tables 3 and 4 present the number of firms per sector and their sample weight in each of the different CIS waves. Information is divided in order to respect the official changes in the codes, thus the first table includes the surveys which use CAE Rev. 2 / Rev. 2.1 (CIS 2, CIS 3, CIS 4 and CIS 6) and the second the CAE Rev. 3 (CIS 8, CIS 10 and the CIS 12).

As formerly mentioned the CIS 2 and the CIS 3 did not collect evidence for the *Construction* sector; besides, no data is presented concerning the *agricultural and farming* sector. *Extractive industry* is quite insignificant in terms of its relative importance.

The *Manufacturing industry* is the most important amongst the sample in the different waves representing nearly half of the respondents (41.4% in CIS 2; 68% in CIS 3 and 49.5% in CIS 10 as examples); analysing the sector in detail we can observe that in the CIS 2 wave, *textiles and wearing apparel* are the most important sectors weighting respectively 6.2 and 8.3%. In the tertiary sector, the most important sectors are wholesale, weighing 20% and land transport 15.6%.

In the CIS 3 *food products* is the economic activity among the manufacturing sector which weighs the most, achieving 8.3%, *wholesale* weighed much less than in the former wave, achieving only 8.9%. The CIS 4 wave presented similar results to the former inquiry; the most important sectors are the same as the previous biennium.

The results in the CIS 6 presented as the most important sectors *wearing apparel* 6.2%, *wholesale* 13.4% *other business* 13.8%.

When performing a global analysis, the *manufacturing sector*, is the most important; weighing 43.7% in the CIS 2, 67.8% in the CIS 3, 49.2% in the CIS 4 and 47.1% in the CIS 6. Concerning the *primary sector*, the relative importance is invariably low. For the tertiary, no remarkable changes are presented during the waves.

The respondent sample is quite illustrative of the Portuguese reality as traditional sectors such as the textile and wearing apparel come out with a remarkable importance, regardless of the CIS wave. *Wholesale* and *other tertiary activities* are also of remarkable importance despite being more unstable during the several biennia.

In the CIS 8, the CIS 10 and the CIS 12 (table 4) the Construction sector was included, despite its importance being almost neglectable, only 45 firms in the CIS 8, 47 in the CIS 10 and 36 in the CIS 12. The former result is the sum of SIC 42 and 43; to compare with former editions, due to the change in the nomenclature, would require combining these sectors with another one in the tertiary sector named Architectural engineering and related technical activities.

The Manufacturing Sector[1], non-surprisingly, is the most important among all 55.8%, 52.5% and 52.6% respectively in the CIS 8, the CIS 10 and the CIS 12. Wholesale trade, as previously, is the most important two-digit SIC code weighing 13.2%, 14.1% and 15.7% in the CIS 8 the CIS 10 and the CIS 12, respectively.

[1] according to INE – Statistics Portugal, the Manufacturing sector comprises firms from SIC 10 to 33

Table 3 - Distribution of firms per sector CAE Rev. 2.1 (appendix 2 and 3)

	Portuguese Classification of Economic Activities (CAE) REVISION 2.1 - NACE Rev. 1.1 (1/1/2003 until 31/12/2007)	CIS 2		CIS 3		CIS 4		CIS 6	
		n	%	n	%	n	%	n	%
PRIMARY	10 - Mining of coal and lignite; extraction of peat	n.a.		n.a.		n.a.		n.a.	
	11 - Extraction of crude petroleum and natural gas (…)	n.a.		n.a.					
	12 - Mining of uranium and thorium ores	n.a.		n.a.		95*	0.04	104*	2.20
	13 - Mining and preparation of metal ores	n.a.		22	1.17				
	14 - Other mining and quarrying	n.a.		23	1.23				
SECONDARY	***15 - Manufacture of food products and beverages***	94	5.12	156	8.32	269	5.59	239	5.06
	16 - Manufacture of tobacco products								
	17 - Manufacture of textiles	113	6.16	106	5.65	198	4.11	181	3.83
	18 - Manufacture of wearing apparel; dressing and dyeing of fur	152	8.28	104	5.55	335	6.96	293	6.21
	19 – Tanning, dressing of leather lugg, hb sad.. harness, footwear	53	2.89	54	2.88	163	3.39	79	1.67
	20 - Manufacture of wood, prod. of wood and cork. except furniture	25	1.36	67	3.57	161	3.34	114	2.41
	21 - Manufacture of pulp. paper and paper products	14	0.76	49	2.61	67	1.39	52	1.10
	22 – Publishing. printing and reproduction of recorded media	20*	1.09	59	3.15	92	1.91	104	2.20
	23 - Manufacture of coke. refined petroleum products and nuclear fuel				n.a.	119	2.47	140	2.97
	24 - Manufacture of chemicals and chemical products	28	1.53	60	3.20				
	25 - Manufacture of rubber and plastic products	17	0.93	60	3.20	105	2.18	106	2.25
	26 - Manufacture of other non-metallic mineral products	59	3.22	84	4.48	131	2.72	153	3.24
	27 - Manufacture of basic metals	20	1.09	43	2.29	57	1.18	59	1.25
	28 - Manufacture of fabricated metal prod. except mach. and equip.	44	2.40	80	4.27	119	2.47	147	3.11
	29 - Manufacture of machinery and equipment n.e.c	36	1.96	61	3.25	86	1.79	102	2.16
	30 - Manufacture of office machinery and computers	20*	1.09	4	0.21	74*	1.54	79*	1.67
	31 - Manufacture of electrical machinery and apparatus n.e.c.			49	2.61				
	32 - Manufacture of radio tv and communication equip and apparatus	17	0.93	25	1.33	54	1.12	46	0.97
	33 - Manufacture of medical precision and opt inst.. watches and clocks	16	0.87	30	1.60	79	1.64	37	0.78
	34 - Manufacture of motor vehicles. trailers and semi-trailers	22	1.20	70	3.73	65	1.35	85	1.80
	35 - Manufacture of other transport equipment	13	0.71	36	1.92	61	1.27	62	1.31
	36 - Manufacture of furniture; other manufacturing activities. n.e.c.	31	1.69	64	3.41	99	2.06	109	2.31
	37 – Recycling	6	0.33	14	0.75	32	0.66	38	0.80
	40 – Prod. and dist. of electricity, gas, steam and hot water supply	19*	1.04	8	0.43	28	0.58	30	0.64
	41 - Water collection. treatment and distribution			13	0.69	53	1.10	73	1.55
	45 – Construction	n.a.		n.a.		172	3.57	191	4.05
TERTIARY	51 - Wholesale trade and commission trade. except of motor vehicles and motorcycles	367	20.00	167	8.91	700	14.54	632	13.39
	52 - Retail trade.exp motor vehicles motos; repair pers.household goods	n.a.		n.a.		95	1.97	101	2.14
	55 - Hotels and restaurants	n.a.		n.a.		28	0.58	28	0.59
	60 - Land transport; transport via pipelines	287	15.64	78	4.16	133	2.76	173	3.66
	61 - Water transport	17*	0.93	13*	0.07	17	0.35	23	0.49
	62 - Air transport					15	0.31	13	0.28
	63 - Supporting and auxiliary transport activities; (…)	n.a.		55	2.93	133	2.76	146	3.09
	64 - Post and telecommunications	14	0.76	17	0.91	46	0.96	45	0.95
	65 - Financial intermediation. except insurance and pension funding	121	6.59	53	2.83	6	0.12	63	1.33
	66 - Insurance. Pension funding; complementary act. of soc. security	34	1.85	27	1.44	41	0.85	56	1.19
	67 - Activities auxiliary to financial intermediation	25	1.36	24	1.28	58	1.20	54	1.14
	70 - Real estate activities	n.a.		n.a.		n.a.		n.a.	
	71 – Rent. of mach and equip w/out operator; pers and household goods	n.a.		n.a.		n.a.		n.a.	
	72 - Computer and related activities	58	3.16						
	73 - Research and development	n.a.		38*	2.03	140*	2.91	114*	2.41
	74 - Other business activities	93	5.07	62	3.31	689	14.31	650	13.77

* Due to statistical secrecy in some cases the SIC is presented with two codes

Source: Author's own computation based on CIS survey

Table 4 - Distribution of firms per sector CAE Rev. 3 (appendix 4)

		Portuguese Classification of Economic Activities (CAE) REVISION 3 - NACE Rev. 3 (1/1/2008- ….)	CIS 8		CIS 10		CIS 12	
			n	%	n	%		
PRIMARY	7	Mining and preparation of metal ores						
	8	Other mining and quarrying	130*	1.97	111*	1.80	73	1.07
	9	Mining and quarrying related service activities			n.a.			
SECONDARY	***10***	***Manufacture of food products***	160	2.43	144	2.34	195	2.85
	11	***Manufacture of beverages***	86*	1.30	73*	1.19	128*	1.87
	12	***Manufacture of tobacco products***						
	13	***Manufacture of textiles***	193	2.93	134	2.18	132	1.93
	14	***Manufacture of wearing apparel***	225	3.41	82	1.33	114	1.67
	15	***Manufacture of leather and related products***	213	3.23	133	2.16	188	2.75
	16	***Manufacture of wood and of products of wood and cork. (…)***	191	2.90	220	3.57	203	2.97
	17	***Manufacture of paper and paper products***	110	1.67	95	1.54	89	1.30
	18	***Printing and reproduction of recorded media***	159	2.41	127	2.06	163	2.38
	19	***Manufacture of coke. refined petroleum products and fuels briquettes***	130*	1.97	111*	1.80	116	1.70
	20	***Manufacture of chemicals. chemical products and man-made fibers. (…)***						
	21	***Manufacture of basic pharmaceutical products and pharmaceutical preparations***	39	0.59	47	0.76	46	0.67
	22	***Manufacture of rubber and plastic products***	220	3.34	184	2.99	221	3.23
	23	***Manufacture of other non-metallic mineral products***	285	4.32	264	4.29	333	4.87
	24	***Manufacture of basic metals***	70	1.06	68	1.10	66	0.96
	25	***Manufacture of fabricated metal products. except machinery and equipment***	723	10.97	584	9.48	654	9.56
	26	***Manufacture of computer. communication equipment. electronic and optical products***	51	0.77	49	0.80	53	0.77
	27	***Manufacture of electrical equipment***	82	1.24	99	1.61	91	1.33
	28	***Manufacture of machinery and equipment n.e.c.***	162	2.46	232	3.77	203	2.97
	29	***Manufacture of motor vehicles. trailers. semi-trailers and parts (…)***	131	1.99	90	1.46	107	1.56
	30	***Manufacture of other transport equipment***	34	0.52	46	0.75	50	0.73
	31	***Manufacture of furniture***	172	2.61	154	2.50	154	2.25
	32	***Other manufacturing activities***	143	2.17	151	2.45	137	2.00
	33	***Repair. maintenance and installation of machinery and equipment***	102	1.55	147	2.39	157	2.30
	35	Electricity. gas. steam. cold and hot water and cold air	33	0.50	38	0.62	42	0.61
	36	Water collection. treatment and distribution	70	1.06	70	1.14	66	0.96
	37	Collection. drainage and treatment of sewage	21	0.32	17	0.28	18	0.26
	38	Waste collection. treatment and disposal activities; materials recovery	134*	2.03	143*	2.32	158	2.31
	39	Remediation and similar activities						
	42	Civil engineering	30	0.46	30	0.49	25	0.37
	43	Specialised construction activities	15	0.23	17	0.28	11	0.16
TERTIARY	46	Wholesale trade (include commission trade). except of motor vehicles (…)	873	13.24	866	14.06	1072	15.67
	47	Retail trade. except of motor vehicles and motorcycles	19	0.29	16	0.26	15	0.22
	49	Land transport and transport via pipelines	265	4.02	266	4.32	313	4.58
	50	Water transport	27	0.41	23	0.37	25	0.37
	51	Air transport	23	0.35	21	0.34	27	0.39
	52	Warehousing and support activities for transportation (include cargo handling)	151	2.29	113	1.83	175	2.56
	53	Postal and courier activities	11	0.17	15	0.24	15	0.22
	58	Publishing activities	111	1.68			107	1.56
	59	Motion picture. video and television program production. (…)			104*	1.69	31	0.45
	60	Radio and television activities	49*	0.74			15	0.22
	61	Telecommunications			37	0.60	32	0.47
	62	Computer programming. consultancy and related activities	165	2.50	146	2.37	161	2.35
	63	Information service activities	23	0.35	30	0.49	30	0.44
	64	Financial service activities. except insurance and pension funding	162	2.46	129	2.09	146	2.13
	65	Insurance. reinsurance and pension funding. except compulsory social security	53	0.80	54	0.88	55	0.80
	66	Activities auxiliary to financial services and insurance activities	77	1.17	74	1.20	78	1.14
	69	Legal and accounting activities	126	1.91	157	2.55	112	1.64
	71	Architectural engineering and related technical activities; (…)	136*	2.06	171	2.78	141	2.06
	72	Scientific research and development			14	0.23	30	0.44
	73	Advertising. market research and public opinion polling	94	1.43	91	1.48	96	1.40
	74	Other consultancy. scientific and technical activities	23	0.35	71	1.15	57	0.83
	75	Veterinary activities	10	0.15	10	0.16	20	0.29
	86	Human health activities	81	1.23	92	1.49	94	1.37

* Due to statistical secrecy in some cases the SIC is presented with two codes

Source: Author's own computation based on CIS survey

2.4. Innovative Activities

Firms belonging to the industrial sector and the service sector are expected to perform different kinds of innovative activities. The first are expected to perform product innovation more intensively and, the second service innovation, although they are not expected to perform high levels of formal R&D.

There is an ongoing debate in the definition of "innovation-intensive sectors". There is a common belief that R&D intensive sectors will be innovation intensive, despite the empirical evidence showing that the association is very often false. Presenting a top performance in terms of formal R&D does not mean that the sector will become a top innovator (OECD, 2011).

The OECD definition of innovative intensive sectors comprises several vectors of analysis: product and process innovations, organization and market innovation, intellectual property rights and innovation-related expenditures. In this section we will exploit a narrow version of innovation using just one innovation vector – product innovation. So, we will consider firms that had performed product innovation (table 5 and 6).

Product innovation, according to the CIS definition, based on the *Oslo Manual* (OECD and Eurostat, 2005), is the creation of a good or service which is new or significantly improved to the market.

The CIS questionnaire strictly follows the OECD methodology and explores all dimensions of the innovative process. With the exception of the CIS 2, all firms, regardless of their SIC code were asked about the different dimensions of the innovative activities. The CIS 2 questionnaire included segmentation in which, the *Manufacturing Sector* firms were asked about product and process innovation whereas the *Service Sector* was asked about service innovation. The information treated in the following tables includes data from de CIS 6 up to the CIS 12.

Table 5 - Firms reporting product innovation in the period according to CIS 2, CIS 3, CIS 4 and CIS 6 (CAE Rev. 2.1)

Portuguese Classification of Economic Activities (CAE) REVISION 2.1 - NACE Rev. 1.1 (1/1/2003 until 31/12/2007)	CIS 2		CIS 3		CIS 4		CIS 6	
11 - Extraction of crude petroleum and natural gas (…)	n.a.		n.a.					
13 - Mining and preparation of metal ores	n.a.		3	13.64	16	16.84	18	17.31
14 - Other mining and quarrying	n.a.							
15 - Manufacture of food products and beverages	15	15.96	41	26.28	78	29.00	74	30.96
17 - Manufacture of textiles	31	27.43	38	35.85	45	22.73	36	19.89
18 - Manufacture of wearing apparel; dressing and dyeing of fur	6	3.95	13	12.50	34	10.15	25	8.53
19 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	5	9.43	7	12.96	20	12.27	8	10.13
20 - Manufacture of wood and of products of wood and cork, except furniture; (...)	4	16.00	12	17.91	37	22.98	30	26.32
21 - Manufacture of pulp, paper and paper products	10	71.43	9	18.37	15	22.39	17	32.69
22 - Publishing, printing and reproduction of recorded media	4	20.00	9	15.25	22	23.91	24	23.08
23 - Manufacture of coke, refined petroleum products and nuclear fuel			n.a.					
24 - Manufacture of chemicals and chemical products	14	50.00	37	61.67	66	55.46	67	47.86
25 - Manufacture of rubber and plastic products	10	58.82	32	53.33	46	43.81	34	32.08
26 - Manufacture of other non-metallic mineral products	12	20.34	24	28.57	36	27.48	44	28.76
27 - Manufacture of basic metals	5	25.00	8	18.60	19	33.33	13	22.03
28 - Manufacture of fabricated metal products, except machinery and equipment	11	25.00	27	33.75	23	19.33	43	29.25
29 - Manufacture of machinery and equipment n.e.c	17	47.22	17	27.87	25	29.07	31	30.39
30 - Manufacture of office machinery and computers	13	65.00	3	75.00	31	41.89	35	44.3
31 - Manufacture of electrical machinery and apparatus n.e.c.			16	32.65				
32 - Manufacture of radio, television and communication equipment and apparatus	9	52.94	14	56.00	30	55.56	24	52.17
33 - Manufacture of medical, precision and optical instruments, watches and clocks	9	56.25	10	33.33	25	31.65	14	37.84
34 - Manufacture of motor vehicles, trailers and semi-trailers	6	27.27	28	40.00	31	47.69	39	45.88
35 - Manufacture of other transport equipment	2	15.38	9	25.00	11	18.03	17	27.42
36 - Manufacture of furniture; others manufacturing activities, n.e.c.	5	16.13	27	42.19	28	28.28	29	26.61
37 - Recycling	2	33.33	3	21.43	8	25.00	6	15.79
40 - Production and distribution of electricity, of gas, of steam and of hot water supply	3	15.79	2	25.00	4	14.29	2	6.67
41 - Water collection, treatment and distribution			6	46.15	5	9.43	6	8.22
45 - Construction	n.a.		n.a.		20	11.63	20	10.47
51 - Wholesale trade and commission trade, except of motor vehicles and motorcycles	43	11.72	39	23.35	105	15.00	107	16.93
52 - Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	n.a.		n.a.		11	11.58	11	10.89
55 - Hotels and restaurants	n.a.		n.a.		1	3.57	3	10.71
60 - Land transport; transport via pipelines	62	21.60	12	15.38	8	6.02	18	10.4
61 - Water transport	3	17.65	5	38.46	3	17.65	0	0.00
62 - Air transport					2	13.33	0	0.00
63 - Supporting and auxiliary transport activities; (…)	n.a.		10	18.18	11	8.27	19	13.01
64 - Post and telecommunications	8	57.14	14	82.35	14	30.43	12	26.67
65 - Financial intermediation, except insurance and pension funding	41	33.88	24	45.28	0	0.00	19	30.15
66 - Insurance, pension funding and others complementary activities of social security	16	47.06	14	51.85	11	26.83	20	35.71
67 - Activities auxiliary to financial intermediation	12	48.00	8	33.33	6	10.34	9	16.67
72 - Computer and related activities	37	63.79	18	47.37	56	40.00	53	46.49
74 - Other business activities	23	24.73	20	32.26	75	10.89	63	9.69
TOTAL	**438**	**23.87**	**559**	**29.81**	**978**	**20.31**	**990**	**20.97**

* percentages calculated compared to the number of respondents CIS2 1835; CIS 3 1875; CIS 4 4815; CIS 6 4721

Source: Author's own computation based on CIS 6

Table 6 - Firms reporting product innovation in the period according to CIS 8, CIS 10 and CIS 12 (CAE Rev. 3) (appendix 3 and 5)

		Portuguese Classification of Economic Activities (CAE) REVISION 3 - NACE Rev. 3 (1/1/2008- ….)	CIS 8		CIS 10		CIS 12	
			n	%	n	%	n	%
	7	Mining and preparation of metal ores	26	20	13	11.71	8	10.96
SECONDARY	***10***	***Manufacture of food products***	61	38.13	42	29.17	59	30.26
	11	***Manufacture of beverages***	43	50	31	42.47	45	35.16
	12	***Manufacture of tobacco products***	n.a.	n.a.	n.a.	n.a.		
	13	***Manufacture of textiles***	69	35.75	30	22.39	43	32.58
	14	***Manufacture of wearing apparel***	23	10.22	12	14.63	14	12.28
	15	***Manufacture of leather and related products***	57	26.76	33	24.81	35	18.62
	16	***Manufacture of wood and of products of wood and cork. (…)***	59	30.89	73	33.18	50	24.63
	17	***Manufacture of paper and paper products***	41	37.27	36	37.89	26	29.21
	18	***Printing and reproduction of recorded media***	40	25.16	29	22.83	31	19.02
	19	***Manufacture of coke. refined petroleum products and fuels briquettes***	81	62.31	70	63.06	61	52.59
	20	***Manufacture of chemicals. chemical products and man-made fibres. (…)***	n.a.	n.a.	n.a.	n.a.		
	21	***Manufacture of basic pharmaceutical products and pharmaceutical preparations***	21	53.85	26	55.32	24	52.17
	22	***Manufacture of rubber and plastic products***	115	52.27	96	52.17	99	44.80
	23	***Manufacture of other non-metallic mineral products***	93	32.63	85	32.2	97	29.13
	24	***Manufacture of basic metals***	27	38.57	28	41.18	18	27.27
	25	***Manufacture of fabricated metal products. except machinery and equipment***	229	31.67	191	32.71	155	23.70
	26	***Manufacture of computer. communication equipment. electronic and optical products***	38	74.51	33	67.35	39	73.58
	27	***Manufacture of electrical equipment***	51	62.2	60	60.61	47	51.65
	28	***Manufacture of machinery and equipment n.e.c.***	77	47.53	107	46.12	91	44.83
	29	***Manufacture of motor vehicles. trailers. semi-trailers and parts (…)***	56	42.75	42	46.67	48	44.86
	30	***Manufacture of other transport equipment***	10	29.41	18	39.13	17	34.00
	31	***Manufacture of furniture***	77	44.77	75	48.7	53	34.42
	32	***Other manufacturing activities***	63	44.06	62	41.06	52	37.96
	33	***Repair. maintenance and installation of machinery and equipment***	31	30.39	35	23.81	25	15.92
	35	*Electricity. gas. steam. cold and hot water and cold air*	4	12.12	3	7.89	5	11.90
	36	Water collection. treatment and distribution	7	10	5	7.14	8	12.12
	37	Collection. drainage and treatment of sewage	3	14.29	1	5.88	0	0.00
	38	Waste collection. treatment and disposal activities; materials recovery	28	20.9	24	16.78	30	18.99
	39	Remediation and similar activities			n.a.	n.a.		
	42	Civil engineering	2	6.67	7	23.33	5	20.00
TERTIARY	43	Specialised construction activities	4	26.67	5	29.41	2	18.18
	46	Wholesale trade (include commission trade). except of motor vehicles (…)	246	28.18	208	24.02	209	19.50
	47	Retail trade. except of motor vehicles and motorcycles	8	42.11	7	43.75	6	40.00
	49	Land transport and transport via pipelines	59	22.26	50	18.8	30	9.58
	50	Water transport	6	22.22	5	21.74	1	4.00
	51	Air transport	6	26.09	2	9.52	4	14.81
	52	Warehousing and support activities for transportation (include cargo handling)	16	10.6	12	10.62	19	10.86
	53	Postal and courier activities	4	36.36	1	6.67	1	6.67
	58	Publishing activities	39	35.14	43	41.35	40	37.38
	59	Motion picture. video and television programme production. (…)	14	28.57	n.a.	n.a.	5	16.13
	60	Radio and television activities	n.a.	n.a.	n.a.	n.a.	3	20.00
	61	Telecommunications	n.a.	n.a.	11	29.73	8	25.00
	62	Computer programming. consultancy and related activities	88	53.33	75	51.37	68	42.24
	63	Information service activities	8	34.78	10	33.33	6	20.00
	64	Financial service activities. except insurance and pension funding	45	27.78	10	7.75	17	11.64
	65	Insurance. reinsurance and pension funding. except compulsory social security	25	47.17	12	22.22	17	30.91
	66	Activities auxiliary to financial services and insurance activities	13	16.88	6	8.11	3	3.85
	69	Legal and accounting activities	11	8.73	10	6.37	2	1.79
	71	Architectural. engineering and related technical activities; (…)	39	28.68	24	14.04	21	14.89
	72	Scientific research and development	n.a.	n.a.	2	14.29	11	36.67
	73	Advertising. market research and public opinion polling	19	20.21	21	23.08	8	8.33
	74	Other consultancy. scientific and technical activities	2	8.7	14	19.72	6	10.53
	75	Veterinary activities	4	40	1	10	5	25.00
	86	Human health activities	23	28.4	22	23.91	17	18.09

Source: Author's own computation based on CIS survey

When performing an aggregate analysis, the CIS 2 includes mostly firms in the secondary sector. Industrial firms are expected to develop innovative activities as part of their daily actions. In the CIS 2, 71% of the firms from the *manufacture of pulp, paper and paper products* reported having performed product innovation, which is the highest score among all sectors. The second highest proportion was achieved by the firms in the computer *and related activities* (SIC 72) also responded affirmatively in 64% of the cases.

The next wave, the CIS 3, the highest percentage of firms agreeably responding to the implementation of innovative products was the *post and telecommunications* (SIC 64) with 82% immediately followed by the *manufacture of office machinery and computers* (SIC 30) with 75%.

The responses presented in the CIS 4 and CIS 6, point to the *manufacture of radio, television and communication equipment and apparatus* (SIC 32) as being the highest percentage of product innovators with 56% and 52%, respectively. The different CIS waves pointed to different performances along sectors which suggest that firms will opt for different innovative strategies according to the period.

In the next three waves, the CIS 8, the CIS 10 and the CIS 12 there were important changes in terms of the structure of the sample, rising, as mentioned, the number of respondents. The manufacturing sector and the others have a distinct behavior, higher levels of product innovation per sector are found in this sector. The Manufacture of computer, communication equipment, electronic and optical products (SIC 26) presented product innovation scores of 75%, 67% and 74%, respectively; immediately followed by the SIC 27 (Manufacture of electrical equipment), with 62, 61 and 52% in each wave.

2.5. Technological Intensity

Firms operating in different economic sectors design their optimal combinations of resources in a specific way, and thus they will choose the technological level embedded in their products.

Most commonly, firms are classified as high-tech by analysing their direct R&D intensities. Alternatives such as skill intensity or indirect R&D intensity are also used.

The classification of technological intensity is flexible. Each economic sector may need or use different R&D intensities; moreover, the same industry may produce a scope of products embedding different technological intensities.

Research comprises the general and systematic work aiming at finding new knowledge. Development systematically uses the findings from research, hereby bringing about innovations.

High-tech is associated to modernity, rapid change, electronic devices, gadgets mobiles and computers, complicated frameworks with automatisation, massive industries and high-value added.

The concept has two major streams: input or output-based. The first relies on the use of physical or human capital in the productive process, while the second, consists of the firms' value added.

Amongst the input-based definitions, the work of Kelly (1977) is very popular. It ranks products by their R&D intensity, segments the sectors by their technology type being the upper quartile the high tech and so forth. To the U.S. Congress (Committee on Science and Technology, 1982; 1985) high-tech was proxied with R&D intensity. The Committee on Science and Technology (1985) classified the high-tech industries as having at least twice the average proportion of employment in scientific and technical occupations additionally to twice the average proportion of net sales devoted to R&D from manufacturing. Markusen, Hall and Glasmeiers (1986) classified high-tech sectors as those in which the human capital component is determinant due to the know-how embedded in their jobs (three indicators were presented: technical sophistication, employment growth, R&D to sales ratio).

According to the Frascatti Manual, OECD (2002), the most accurate classification for the concept will rely on R&D intensity. The analysis provided using the CIS rely on this assumption and we will strictly follow this interpretation, adopting the same procedure.

Table 7 distributes the firms according to the technological intensity following Pavitt's taxonomy (Pavitt, 1984).

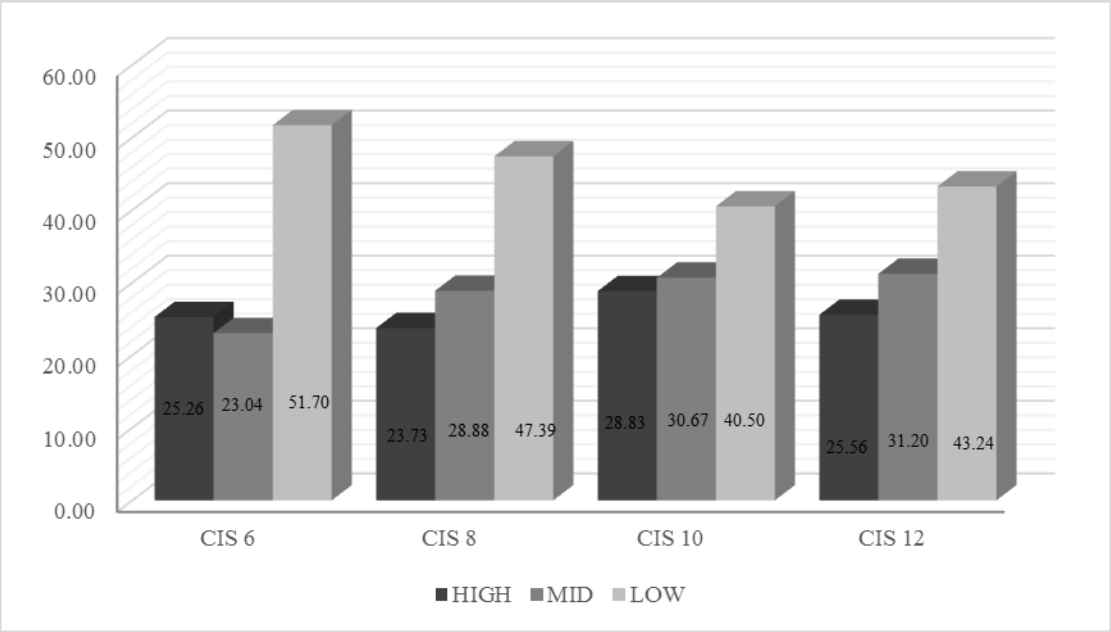
Table 7 - Technological intensity per SIC Codes (CAE Rev .3)

Technological Intensity	SIC Code	Description
High and mid-tech sectors	*20*	*Manufacture of chemicals, chemical products and man-made fibers, except pharmaceutical products*
	26	*Manufacture of computer, communication equipment, electronic and optical products*
	27	*Manufacture of electrical equipment*
	28	*Manufacture of machinery and equipment n.e.c.*
	29	*Manufacture of motor vehicles, trailers, semi-trailers and parts and accessories for motor vehicles*
	30	*Manufacture of other transport equipment*
Mid-low technology sectors	22	*Manufacture of rubber and plastic products*
	23	*Manufacture of other non-metallic mineral products*
	24	*Manufacture of basic metals*
	32	*Other manufacturing activities*
Low-tech sectors	10	*Manufacture of food products*
	11	*Manufacture of beverages*
	12	*Manufacture of tobacco products*
	13	*Manufacture of textiles*
	14	*Manufacture of wearing apparel*
	15	*Manufacture of leather and related products*
	16	*Manufacture of wood and of products of wood and cork, except furniture; (...)*
	17	*Manufacture of paper and paper products*

Source: Author's own computation based on OECD (2011)

Graphic 2 will illustrate the distribution of the technological intensity manufacturing firms tend to carry out more innovation than the service sector. In fact, the usual taxonomies tend to typify only these sectors, though, the tertiary activities cannot be considered as low-tech. According to OECD (2010), sectors such as the *Telecommunication Services, Finance, Computer and R&D Services*, have similar intensities of in-house R&D and innovation rates close to the high-tech manufacturing levels being called knowledge-intensive business services (KIBS).

Graphic 2 - Distribution of firms per technological intensity



Source: Author's own computation based on CIS

High and mid-high sectors reach a volatile proportion of respondent sample in the four CIS waves (CIS 6, CIS 8, CIS 10 and CIS 12), weighing respectively 25, 24, 29 and 26%; this sector presents a volatile importance across three waves with a small recovery in the CIS 12.

During the fourth biennia, the low tech firms represent almost a half of the respondent sample, despite illustrating a decreasing trend over the period.

Mid and low-tech sectors, are the category grasping an increasing percentage of respondents. In the CIS 8 and the CIS 10, the relative importance of the sector moved from 23% in the first biennia to 31% in the last. In the CIS 12 it was 43%.

2.6. Resources devoted to R&D

Very often, R&D projects fail to become innovations. Given the intrinsic risk of innovative activities, the development of simultaneous projects will increase the odds of success. This strategic option is called "parallel-path strategy" (Nelson, 1961).

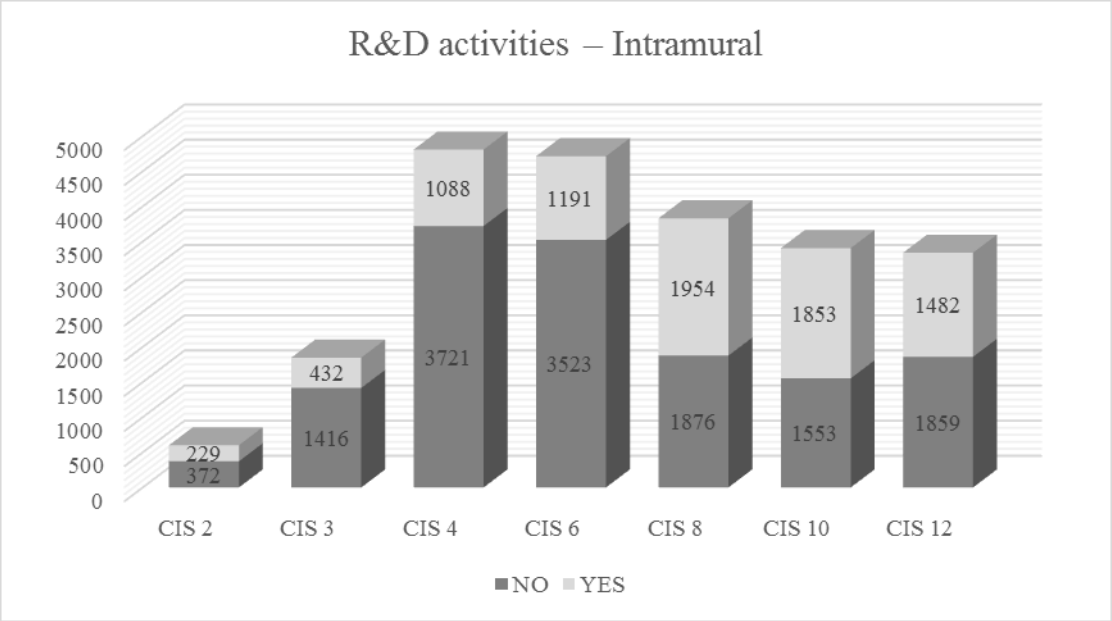
These activities must be performed on a strategical basis where firms target their efforts towards their priorities. The efforts may be concentrated in internal activities, if the firm decides to develop its actions drawing upon the internal resources and relying on their

human capital or external activities meaning cooperation with external partners or complete outsourcing due to the lack of internal skills.

Moreover, the R&D activities can be directed to the acquisition of machinery, software, training of the labour force, marketing and product development. All these actions are an integrating part of the entire R&D tactic aiming at the achievement of innovations.

The following graphics depict the distribution of firms performing R&D in the different CIS waves, divided by the innovation types (graphic 3 - intramural, graphic 4 – extramural, graphic 5 – machinery, graphic 6 – external knowledge, graphic 7 – training, graphic 8 – new products, graphic 9 – others, graphic 10 - persistence).

Graphic 3 - Firms reporting different types of R&D along CIS waves – Intramural



Source: Author's own computation based on CIS

Intramural R&D activities include the expenditures in R&D performed within the firm. Following the international guidelines, they will comprise the expenditures inside the firms aiming at discovering new knowledge to be applied in new or significantly improved goods and services.

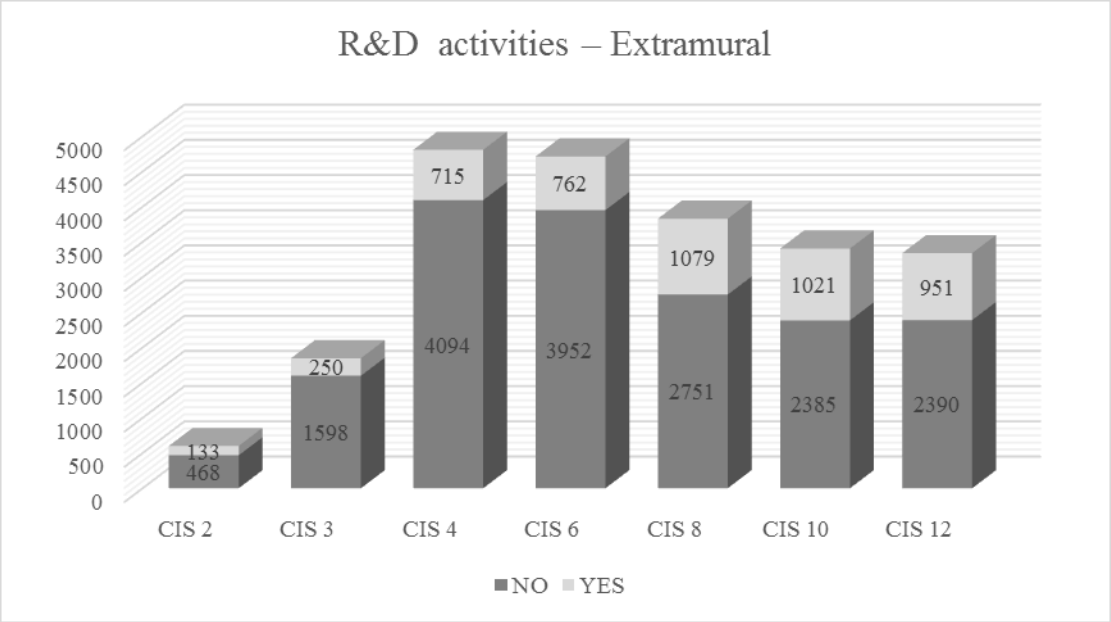
These activities encompass the development of basic research (empirical or theoretical research to acquire knowledge with no particular purpose), applied research

(undertaken to solve a particular problem) or experimental development (building upon exiting knowledge to generate new solutions).

Along the CIS waves, the proportion of firms performing intramural R&D significantly changed. During the CIS 3, CIS 4 and CIS 6 there were scarce affirmative responses (e.g. 25.3% in the CIS 6), whereas in the CIS 8, the CIS 10 and the CIS 12 there was a significant improve, in which positive responses achieved 51% and 54.4% and 44.4%.

Sometimes firms perform their R&D activities relying on external rather than internal sources due to the insufficiency of resources or even to their inadequacy. Extramural R&D activities comprise the same actions as the intramural just being performed outside the firm, by other firms in the same group, public or private labs.

Graphic 4 - Firms reporting different types of R&D along CIS waves - Extramural



Source: Author's own computation based on CIS

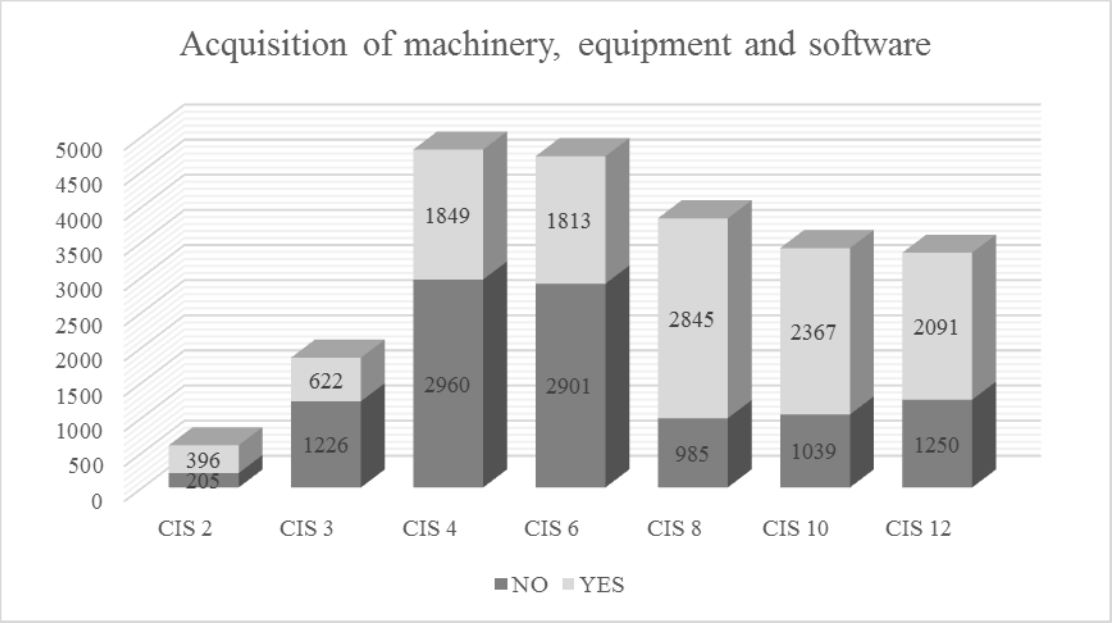
Along the different CIS waves, the proportion of firms reporting not relying on extramural R&D activities exceeds those who opt for these types of actions.

The use of outsourcing in R&D activities may avoid embeddedness; although it is seen as expensive and not fast, requiring important firm adjustments. The scarce use of external sources suggests that firms wave difficulties in connecting to other units, for

several reasons such as financial constraints, absence of knowledge proximity and differences in the pace of response.

This component of R&D expenditures encompasses the acquisition of capital goods, regardless of being machines, computers or any tangible assets devoted to the productive activity, thus expected to increase the overall productive efficiency. Moreover, it includes the acquisition of intangible assets, such as software, software licences, or any other virtual applications to improve products or processes. The result for the CIS 12 points to 28.5% of affirmative responses.

Graphic 5 - Firms reporting different types of R&D along CIS waves – Machinery

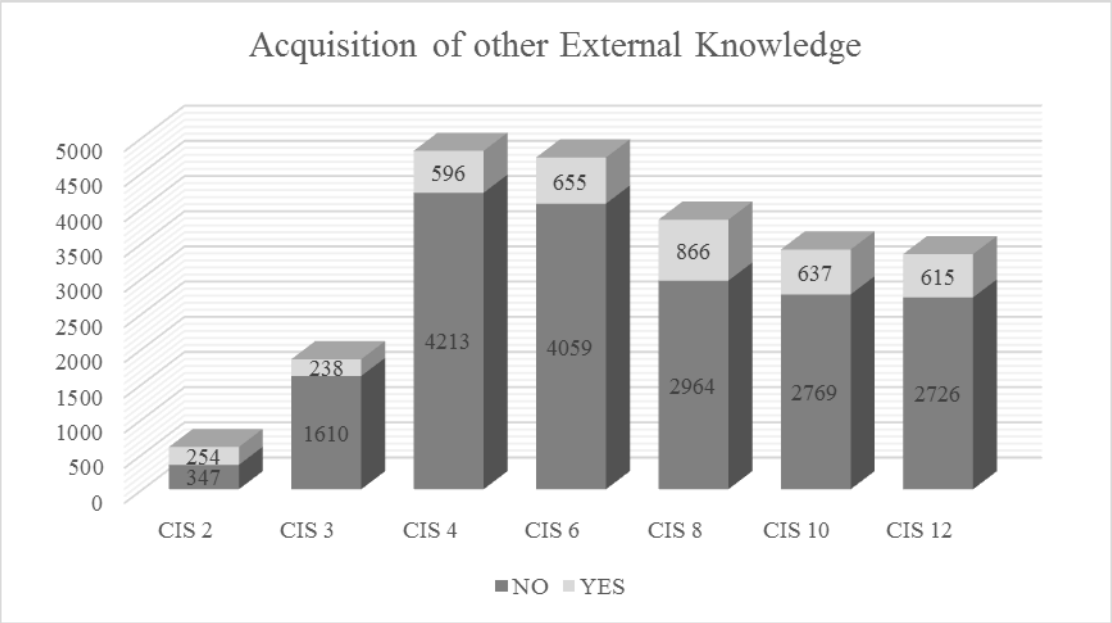


Source: Author's own computation based on CIS

The first CIS waves presented very poor results in terms of this R&D component, most of the respondent firms in the CIS 2, CIS 3, CIS 4 and CIS 6 reported not counting on this factor. Conversely, in the CIS 8 and the CIS 10, most of the firms affirmatively answered the question, meaning that there was a positive impulse in the acquisition of this equipment (74.3% and 69.5% respectively).

The acquisition of industrial licenses, copyrights, patents, not patented inventions, specific know-how, industrial secrets, recipes, formulas and other types of knowledge can come from external units. The external knowledge vector includes all these dimensions.

Graphic 6 - Firms reporting different types of R&D along CIS waves – External Knowledge



Source: Author's own computation based on CIS

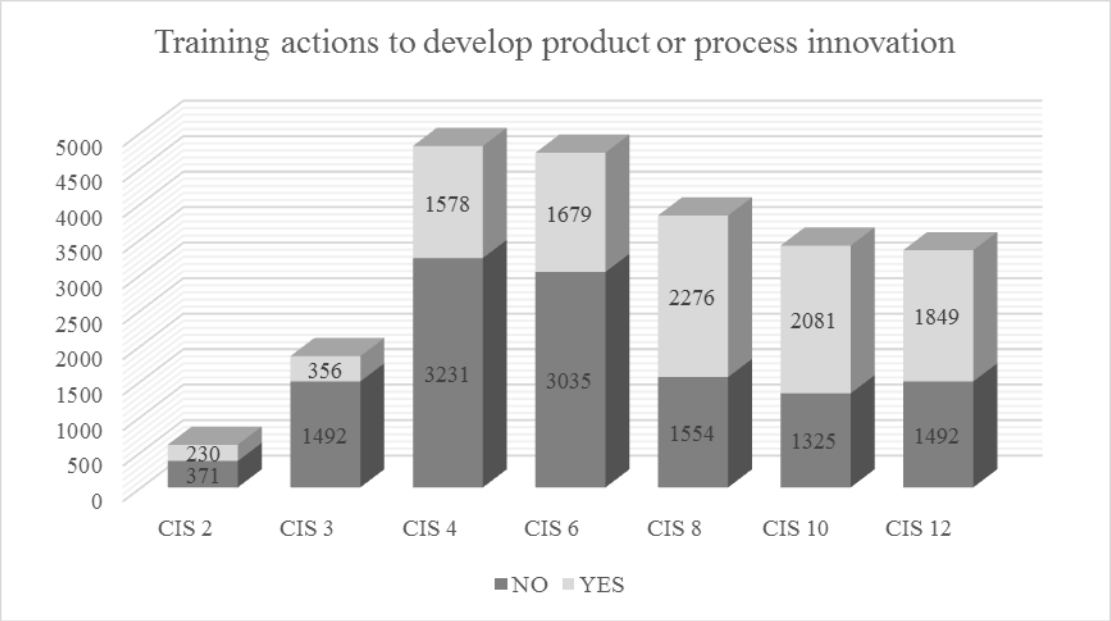
Invariably, most of the respondent firms declined relying on this type of R&D activity. Even though, in the CIS 2, 42.4% of the firms reported this type of R&D activity, in the next session this proportion radically fell to 12.9%, henceforth the results remained at a very low level. In the CIS 4 only a few (12.4%) of the firms affirmatively answered this question affirmatively, in the next wave it moved to 13. 9%; in the CIS 8, 22.6% and finally, it went back to 18.7%. Concerning the CIS 12, the result is 18.4%

Providing the labour force with accurate training will improve the productive efficiency of this factor of production. Moreover, formal education or on the job training will enhance the ability to acquire and diffuse explicit and tacit knowledge, which is a crucial part of scientific knowledge (Polanyi, 1966).

Equipping the labour force with these skills will boost the individual potential, allowing the development of individual competences and personal elements.

This vector of R&D includes the development of training activities in an in-house or outsourced base for the personnel, with the aim of introducing and developing new or significantly improved products or processes.

Graphic 7 - Firms reporting different types of R&D along CIS waves – Training



Source: Author's own computation based on CIS

The CIS 2 and the CIS 3 presented meager results in this component. Most of the firms declined having developed training activities do develop new products or processes. In the CIS 4, and henceforward, there has been a significant growth in the number of firms reporting these activities. The percentage of firms training their labour force in these areas moved from 32.8% to 61%. In the last three waves, the proportion of firms mentioned training decreased; in the last wave it was 55.3%.

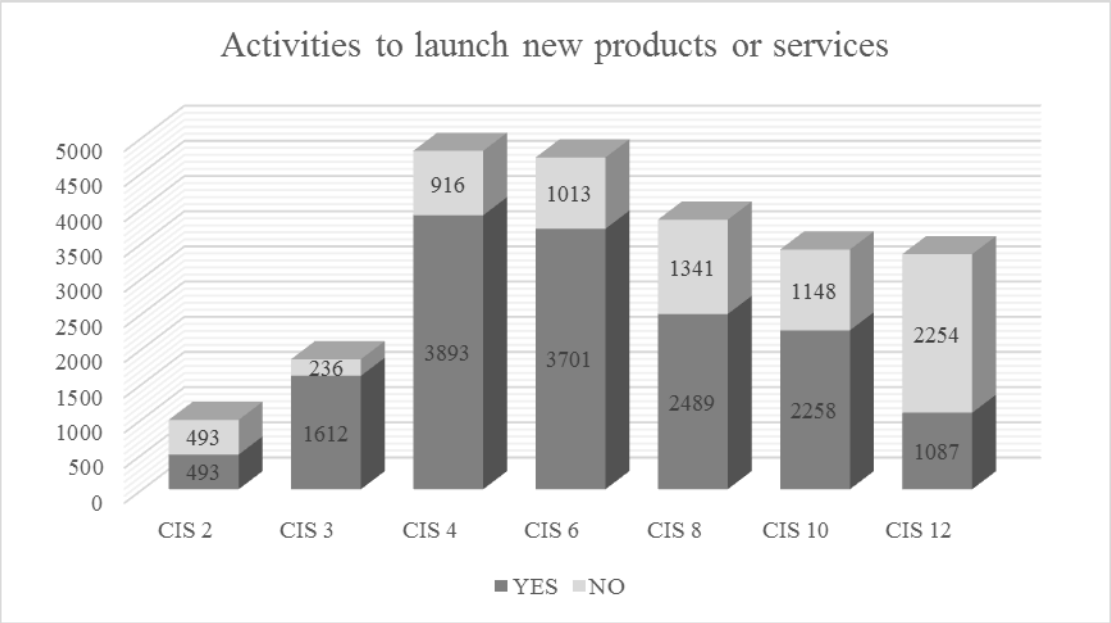
In the particular case of Portugal this achievement is possibly due to the European support in terms of Funds to improve the skills and competences of the workers.

The fact is that in recent years the average level of education of the Portuguese labour force rose significantly; on the one hand due to the increase in the number of years of compulsory schooling, the introduction of, the compulsory teaching of foreign languages, the use of computers and other technological skills and on the other hand due to the emergence of informal schooling opportunities for seniors by means of life-long learning programmes. This combined action of the Government and the Educational System targeted at making the performance in the workplace more efficient.

This vector of R&D activities includes in-house or outsourced activities devoted to the introduction of new or significantly improved products in the market including the

development of market research and launch advertisement. In doing so, firms will support their new projects with collateral activities, aiming at reducing uncertainty.

Graphic 8 - Firms reporting different types of R&D along CIS waves – New products

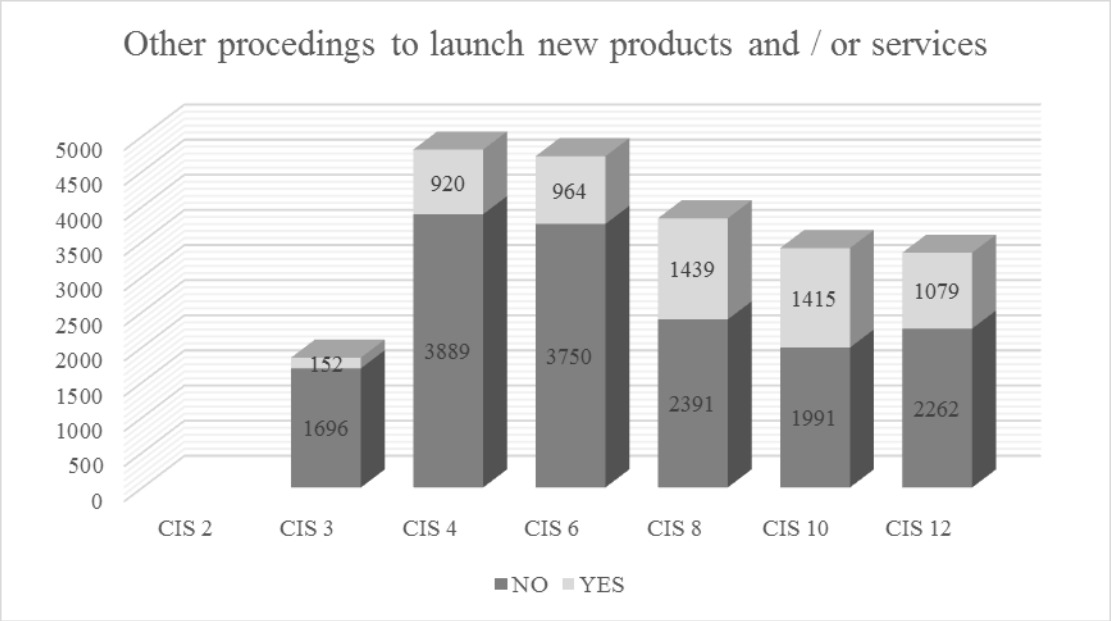


Source: Author's own computation based on CIS

There were downturns and upturns in the relative importance of firms reporting the development of collateral activities to launch their new products or services along the CIS waves. The weight of firms answering this item affirmatively was 50% in the CIS 2, then 12.7% in the CIS 3, 19% in the CIS 4, 21.5% in the CIS 6, 35% in the CIS 8 and 33% in the CIS 10. No clear trend can be defined, despite the overall progress in its importance. The results presented for the CIS 12 is much higher 67.5%.

This vector refers to other in-house or outsourced activities meant to implement new or significantly improved products and processes such as feasibility studies, testing, routine software development, tooling up and industrial engineering. This item was excluded in the CIS 2 as only from the CIS 3 time onwards were firms asked about performing this type of activity.

Graphic 9 - Firms reporting different types of R&D along CIS waves – Others



Source: Author's own computation based on CIS

Predominantly, the respondents declined this type of action, but, there was an increase in the number of positive answers. In the latest two biennia the proportion of firms reporting this type of R&D presented an upturn; in the CIS 8 was 37.6% and 41.5% in the CIS 10; in the CIS 12, the result was 32.3%.

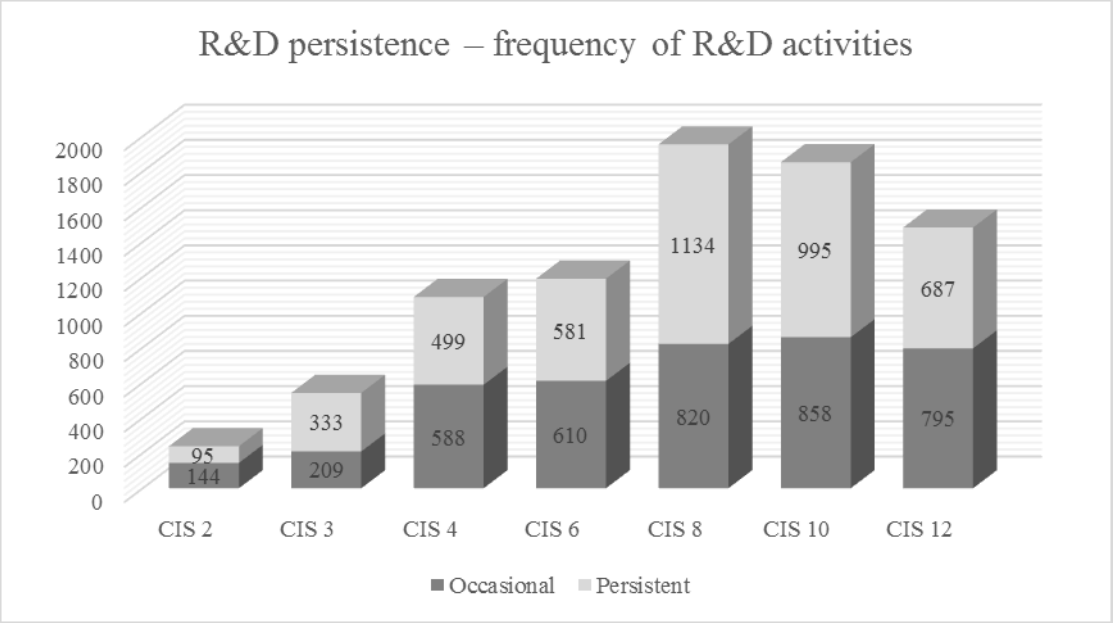
The frequency the R&D activities are performed will determine the pace of the innovation success. Being a continuous performer of R&D activities, it will enhance the probability of reaching more often and faster the implementation of new products, processes, services, organisational or marketing practices more often and faster.

Nevertheless, neither all sectors nor all firms opt for this strategy due to a different understanding of the need or priority of innovative activities. When analysing the regularity of R&D actions, the survey presents two alternatives, occasional innovation or persistent.

Persistence in R&D activities is not a synonym of persistence in innovation. There is randomness in the success of the R&D activities; firms who consistently perform R&D will probably become persistent innovators, while, occasional R&D will never lead to persistent innovation.

There is extensive literature in terms of innovation persistence (e.g. Malerba et al. (1997), Cefis and Orsenigo (2001), Duflos (2006), Peters (2009), Antonelli et al. (2010), Colombelli and Tunzelmann (2011), among others); which illustrates the importance of this aspect. The basis of persistence in terms of innovative activities will rely on the systematic development of R&D.

Graphic 10 - Firms reporting different types of R&D along CIS waves – Persistence



Source: Author's own computation based on CIS

In the respondent sample, the proportion of firms reporting continuous or occasional R&D activities is very close. The proportion of firms reporting continuous R&D activities is slightly higher than the occasional ones, but these results change with an undefined trend in the different CIS waves. It is worth underlying the similar figures for occasional and persistent innovators, across the waves each category grasp a half of the respondents.

2.7. Innovation sources

Very often, innovation is the result of a combined effort of agents and not a solitary activity. It requires drawing upon new sources of theoretical and empirical knowledge, and applying it to the products, processes and organizational structures (Roelandt and den

Hertog, 1999). Innovation consists in combining the existing knowledge with new, based on learning, transferring and accumulating tacit knowledge (Howells, 1995).

The formulation of public policies must vary from sector to sector as the economic activities have different specificities. Firms have different organisational structures, operate in different institutional environments and regulations, and are subject to different learning processes and establish different linkages (Malerba, 2005).

Consequently, firms in diverse activities will establish dissimilar patterns of connection with the distinct sources of information for innovative activities. Interactive learning and cooperative actions of firms will determine their success in the innovative process (Lundvall, 1995). There are several possibilities in terms of the establishment of linkages between firms and the possible innovation sources. The choice will depend on the objective of the contact, the duration, the cost, the availability of substitutes, the expected returns, among others, meaning that firms will choose their sources based on what they expect as a return (von Hippel, 1998).

The success of the innovative activities relies on two major vectors: the internal, mostly fed by the skills of the labour force and the R&D activities (Caloghirou et al, 2004, and Galende and de la Fuente, 2003) and the external depending on their ability to appropriate the knowledge arriving from the distinct sources, in sum their absorptive capacity (Cohen and Levinthal, 1990).

Firms accessing a large variety of sources of information for their innovative activities have an advantage to develop innovative projects; internal capabilities and openness towards knowledge sharing and upgrade the innovative performance (Laursen and Salter, 2004).

Drawing upon internal or external sources, as well as upon agents belonging to the same productive chain or Government institutions will depend on the gaps the firms have to fulfil. The openness to knowledge will speed up the pace of the innovation process.

Radical innovations require a variety of sources for innovative activities, internal sources seem insufficient. Concerning incremental innovations, external sources of information for innovation seem redundant as internal resources suffice (Maillat, 1991).

Following Pavitt's taxonomy (Pavitt, 1984) firms have different approaches to the innovation sources, which will shape their innovation sources. Supplier-dominated firms make minor contribution to their own innovations, therefore suggesting little internal

endowments of resources for innovative activities. They seek for their sources of information for innovation in their chain of production, relying on clients, suppliers and competitors.

On the other hand, scale-intensive firms present a medium level of appropriability, consequently they will combine the use of both internal and external sources of information for innovative activities; they tend to be large firms and operating in mass markets with mass production.

Other relevant segmentation presented was the specialised suppliers. These firms operate in niche markets supplying very particular needs of their clients with very few competition. They have a high proportion of embeddedness, as they extensively use tacit knowledge Tacit knowledge coexists with a high level of appropriability (patents, trademarks, copyrights and industrial secrets). To develop their daily activities, they will rely on internal sources and knowledge based institutions, as they demand for very specific aspects of knowledge and their activities target very specific aims.

Science–based firms are by definition high-tech. The complexity of the products they offer it will request complex knowledge transfer. The natural sources of knowledge to rely in Universities, R&D laboratories and other external sources connected to the explicit and tacit knowledge production. Absorptive capacity is determinant when relying on sources of knowledge such as the Universities (Cohen and Levinthal, 1990), moreover, size and R&D intensity will also boost the use of this source (Laursen and Salter, 2004).

The following tables will summarise the use of the different sources of innovation for the firms according to the SIC codes. Table 8 reports the CIS 6 results, table 9 the CIS 8 and finally table 10 the CIS 10.

Table 8 - Firms reporting the use of different sources of information for innovative activities CIS 6 (CAE Rev. 2.1)

SIC CODE	Inside the firm		Suppliers		Clients		Competitors		Cons & Priv. Labs.		Universities		Gov Labs		Conferences		Scientific journals		Firm Associations	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
11 - Mining and quarrying	30	81.08	31	83.78	196	72.97	353	59.46	16	43.24	10	27.03	80	27	134	59.46	25	67.57	22	59.46
15 - Manufacture of food, beverages and tobacco	105	88.98	108	91.53	289	85.59	466	73.73	59	50.00	44	37.29	131	36	205	77.12	87	73.73	82	69.49
17 - Manufacture of textiles	55	85.94	60	93.75	240	89.06	423	81.25	27	42.19	28	43.75	114	38	195	79.69	49	76.56	43	67.19
18 - Manufacture of wearing apparel; dressing dyeing of fur	59	86.76	54	79.41	220	82.35	382	60.29	22	32.35	15	22.06	69	25	116	66.18	42	61.76	40	58.82
19 - Tanning and dressing of leather;	19	79.17	20	83.33	183	70.83	337	62.50	10	41.67	6	25.00	73	25	123	62.50	13	54.17	15	62.50
20 - Manufacture of wood and of products	52	83.87	53	85.48	222	85.48	393	66.13	27	43.55	22	35.48	101	37	174	77.42	48	77.42	39	62.90
21 - Manufacture of pulp, paper and paper products	26	96.30	24	88.89	209	96.30	394	88.89	10	37.04	7	25.93	70	22	118	77.78	19	70.37	17	62.96
22 - Publishing, printing reproduction of recorded media	51	85.00	56	93.33	234	76.67	404	56.67	28	46.67	10	16.67	73	17	107	80.00	42	70.00	36	60.00
23 - Manufacture of coke and chemical products	84	92.31	84	92.31	269	84.62	446	79.12	44	48.35	43	47.25	139	40	225	85.71	82	90.11	69	75.82
25 - Manufacture of rubber and plastic products	51	92.73	46	83.64	222	90.91	397	67.27	20	36.36	21	38.18	96	29	163	81.82	45	81.82	35	63.64
26 - Manufacture of other non-metallic mineral products	69	88.46	69	88.46	246	80.77	415	75.64	33	42.31	31	39.74	113	41	194	78.21	59	75.64	54	69.23
27 - Manufacture of basic metals	27	93.10	23	79.31	195	68.97	344	55.17	12	41.38	13	44.83	99	31	175	68.97	18	62.07	15	51.72
28 - Manufacture of fabricated metal products	68	93.15	63	86.30	242	89.04	418	69.86	37	50.68	27	36.99	115	34	186	79.45	56	76.71	51	69.86
29 - Manufacture of machinery and equipment n.e.c	46	90.20	47	92.16	229	86.27	408	66.67	21	41.18	22	43.14	106	35	185	76.47	34	66.67	29	56.86
30 - Manufacture of mach and comp. electrical machinery	43	95.56	43	95.56	234	88.89	419	71.11	23	51.11	22	48.89	122	40	211	84.44	40	88.89	36	80.00
32 - Manufacture of radio, television	31	96.88	30	93.75	221	96.88	411	78.13	17	53.13	15	46.88	115	31	193	84.38	26	81.25	17	53.13
33 - Manufacture of medical and optical instruments	18	100.00	17	94.44	211	100.00	406	83.33	11	61.11	11	61.11	133	50	244	94.44	17	94.44	13	72.22
34 - Manufacture of motor vehicles, trailers semi-trailers	55	94.83	53	91.38	239	86.21	417	65.52	30	51.72	30	51.72	133	36	221	72.41	44	75.86	30	51.72
35 - Manufacture of other transport equipment	25	86.21	27	93.10	206	82.76	382	65.52	12	41.38	9	31.03	81	34	147	68.97	20	68.97	17	58.62
36 - Manufacture of furniture; man activities, n.e.c.	44	93.62	38	80.85	212	87.23	381	82.98	19	40.43	13	27.66	81	19	128	87.23	36	76.60	35	74.47
37 - Recycling	18	90.00	14	70.00	174	85.00	329	65.00	10	50.00	10	50.00	110	35	195	100.00	17	85.00	14	70.00
40 - Production and distribution of electricity	14	100.00	14	100.00	214	85.71	400	92.86	10	71.43	9	64.29	145	57	266	85.71	13	92.86	11	78.57
41 - Water collection, treatment and distribution	39	88.64	40	90.91	220	68.18	379	63.64	28	63.64	26	59.09	149	48	256	77.27	36	81.82	23	52.27
45 - Construction	69	92.00	70	93.33	255	78.67	427	81.33	43	57.33	31	41.33	130	41	212	81.33	61	81.33	57	76.00
51 - Wholesale trade and commission trade	235	88.68	236	89.06	414	83.40	586	71.32	124	46.79	75	28.30	150	24	202	76.60	188	70.94	174	65.66
52 - Retail trade	36	94.74	30	78.95	204	86.84	369	84.21	27	71.05	10	26.32	107	18	152	63.16	25	65.79	21	55.26
55 - Hotels and restaurants	10	83.33	9	75.00	167	75.00	317	66.67	7	58.33	4	33.33	96	33	162	75.00	8	66.67	8	66.67
60 - Land transport; transport via pipelines	66	84.62	69	88.46	242	74.36	405	66.67	32	41.03	20	25.64	87	18	130	52.56	45	57.69	50	64.10
61 - Water transport	9	100.00	9	100.00	209	100.00	409	88.89	7	77.78	3	33.33	114	33	181	66.67	7	77.78	6	66.67
62 - Air transport	8	100.00	7	87.50	195	100.00	382	100.00	3	37.50	2	25.00	65	25	115	100.00	6	75.00	6	75.00
63 - Supporting and auxiliary transport activities	72	92.31	67	85.90	245	73.08	404	67.95	36	46.15	27	34.62	108	23	165	64.10	57	73.08	52	66.67
64 - Post and telecommunications	30	100.00	27	90.00	217	86.67	394	70.00	19	63.33	13	43.33	120	43	206	80.00	22	73.33	20	66.67
65 - Financial interm., except insurance pension funding	47	97.92	44	91.67	234	83.33	409	83.33	31	64.58	15	31.25	111	21	163	62.50	28	58.33	23	47.92
66 - Insurance, pension funding	41	97.62	36	85.71	219	88.10	393	92.86	33	78.57	16	38.10	133	14	185	73.81	31	73.81	33	78.57
67 - Activities auxiliary to financial intermediation	24	88.89	24	88.89	202	74.07	365	66.67	13	48.15	8	29.63	86	26	141	66.67	19	70.37	23	85.19
72 - Computer and related activities and R&D	82	100.00	76	92.68	269	89.02	450	78.05	50	60.98	49	59.76	170	39	269	85.37	76	92.68	51	62.20
74 - Other business activities	225	90.00	223	89.20	402	81.60	573	68.80	123	49.20	103	41.20	193	32	266	70.40	191	76.40	175	70.00
TOTAL	1983	90.71	1941	88.79	2121	83.21	2293	71.91	1074	49.13	820	37.51	907	31	975	75.21	1632	74.66	1442	65.97

Source: Author's own computation based on CIS 6

Table 9 - Firms reporting the use of different sources of information for innovative activities CIS 8 (CAE Rev. 3)

SIC CODE		Inside the firm		Suppliers		Clients		Competitors		Cons & Priv. Labs.		Universities		Gov Labs		Conferences		Scientific journals		Firm Associations	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
7	Mining and quarrying	46	83.64	49	89.09	43	78.18	38	69.09	36	65.45	23	41.82	27	49.09	36	65.45	35	63.64	39	70.91
10	*Manufacture of food products*	79	89.77	79	89.77	79	89.77	68	77.27	55	62.50	38	43.18	29	32.95	66	75.00	61	69.32	63	71.59
11	*Manufacture of beverages and tobacco*	51	82.26	52	83.87	50	80.65	45	72.58	38	61.29	29	46.77	27	43.55	49	79.03	48	77.42	46	74.19
13	*Manufacture of textiles*	84	83.17	84	83.17	92	91.09	70	69.31	63	62.38	38	37.62	37	36.63	78	77.23	70	69.31	58	57.43
14	*Manufacture of wearing apparel*	42	66.67	51	80.95	46	73.02	42	66.67	23	36.51	17	26.98	13	20.63	34	53.97	37	58.73	31	49.21
15	*Manufacture of leather and related products*	77	83.70	83	90.22	79	85.87	68	73.91	42	45.65	21	22.83	22	23.91	74	80.43	65	70.65	68	73.91
16	*Manufacture of wood and of products of wood cork*	79	78.22	89	88.12	84	83.17	70	69.31	54	53.47	27	26.73	27	26.73	77	76.24	67	66.34	64	63.37
17	*Manufacture of paper and paper products*	55	82.09	62	92.54	61	91.04	51	76.12	32	47.76	28	41.79	20	29.85	52	77.61	47	70.15	39	58.21
18	*Printing and reproduction of recorded media*	63	75.00	75	89.29	69	82.14	61	72.62	36	42.86	11	13.10	5	5.95	63	75.00	71	84.52	59	70.24
19	*Manufacture of coke and chemical products*	94	94.00	91	91.00	92	92.00	88	88.00	66	66.00	48	48.00	35	35.00	84	84.00	89	89.00	74	74.00
21	*Manufacture of basic pharmaceutical products*	27	96.43	26	92.86	27	96.43	23	82.14	22	78.57	23	82.14	23	82.14	22	78.57	26	92.86	27	96.43
22	*Manufacture of rubber and plastic products*	127	86.99	125	85.62	133	91.10	109	74.66	81	55.48	64	43.84	53	36.30	112	76.71	110	75.34	89	60.96
23	*Manufacture of other non-metallic mineral products*	130	80.25	137	84.57	126	77.78	112	69.14	86	53.09	62	38.27	53	32.72	124	76.54	105	64.81	100	61.73
24	*Manufacture of basic metals*	39	95.12	37	90.24	35	85.37	29	70.73	21	51.22	18	43.90	19	46.34	31	75.61	30	73.17	26	63.41
25	*Manufacture of fabricated metal products,*	343	83.45	363	88.32	351	85.40	295	71.78	202	49.15	128	31.14	106	25.79	314	76.40	297	72.26	255	62.04
26	*Manufacture of computer*	44	100.00	42	95.45	40	90.91	35	79.55	29	65.91	29	65.91	21	47.73	39	88.64	39	88.64	23	52.27
27	*Manufacture of electrical equipment*	59	95.16	58	93.55	56	90.32	52	83.87	40	64.52	27	43.55	26	41.94	53	85.48	56	90.32	42	67.74
28	*Manufacture of machinery*	97	91.51	95	89.62	96	90.57	82	77.36	51	48.11	32	30.19	28	26.42	84	79.25	76	71.70	64	60.38
29	*Manufacture of motor vehicles*	81	94.19	81	94.19	77	89.53	63	73.26	60	69.77	46	53.49	36	41.86	69	80.23	68	79.07	58	67.44
30	*Manufacture of other transport equipment*	12	75.00	11	68.75	13	81.25	11	68.75	8	50.00	5	31.25	5	31.25	12	75.00	12	75.00	12	75.00
31	*Manufacture of furniture*	79	82.29	82	85.42	88	91.67	73	76.04	47	48.96	28	29.17	23	23.96	81	84.38	72	75.00	64	66.67
32	*Other manufacturing activities*	68	80.95	73	86.90	68	80.95	54	64.29	39	46.43	29	34.52	22	26.19	65	77.38	60	71.43	48	57.14
33	*Repair, maintenance and installation*	41	82.00	45	90.00	45	90.00	36	72.00	29	58.00	23	46.00	20	40.00	37	74.00	38	76.00	36	72.00
35	Electricity, gas, steam, cold and hot water, cold air	17	89.47	17	89.47	14	73.68	10	52.63	15	78.95	12	63.16	8	42.11	15	78.95	12	63.16	12	63.16
36	Water collection, treatment and distribution	41	91.11	40	88.89	35	77.78	31	68.89	32	71.11	30	66.67	29	64.44	36	80.00	37	82.22	29	64.44
37	Collection, drainage and treatment of sewage	14	100.00	13	92.86	10	71.43	9	64.29	12	85.71	10	71.43	9	64.29	12	85.71	12	85.71	10	71.43
38	Waste collection and Remediation	80	89.89	79	88.76	74	83.15	70	78.65	54	60.67	40	44.94	35	39.33	70	78.65	70	78.65	58	65.17
42	Civil engineering	19	100.00	18	94.74	15	78.95	14	73.68	14	73.68	10	52.63	11	57.89	14	73.68	14	73.68	12	63.16
43	Specialised construction activities	9	90.00	10	100.00	10	100.00	8	80.00	6	60.00	5	50.00	4	40.00	7	70.00	8	80.00	6	60.00
46	Wholesale trade	379	82.39	399	86.74	373	81.09	325	70.65	231	50.22	143	31.09	116	25.22	357	77.61	328	71.30	282	61.30
47	Retail trade, except motor vehicles and motorcycles	17	100.00	16	94.12	16	94.12	15	88.24	13	76.47	11	64.71	6	35.29	16	94.12	16	94.12	15	88.24
49	Land transport and transport via pipelines	121	82.88	127	86.99	114	78.08	95	65.07	63	43.15	44	30.14	36	24.66	88	60.27	96	65.75	99	67.81
50	Water transport	11	73.33	11	73.33	12	80.00	9	60.00	9	60.00	8	53.33	7	46.67	13	86.67	13	86.67	11	73.33
51	Air transport	13	81.25	11	68.75	11	68.75	9	56.25	9	56.25	3	18.75	1	6.25	11	68.75	13	81.25	11	68.75
52	Warehousing and support activities	76	86.36	74	84.09	69	78.41	61	69.32	36	40.91	26	29.55	26	29.55	55	62.50	53	60.23	61	69.32
53	Postal and courier activities	7	87.50	7	87.50	6	75.00	5	62.50	7	87.50	3	37.50	2	25.00	6	75.00	7	87.50	7	87.50
58	Publishing activities, Motion picture and Radio	63	92.65	61	89.71	61	89.71	53	77.94	39	57.35	31	45.59	16	23.53	51	75.00	50	73.53	43	63.24
59	Motion picture and Radio and Telecommunications	32	96.97	32	96.97	28	84.85	25	75.76	23	69.70	19	57.58	13	39.39	30	90.91	27	81.82	24	72.73
62	Computer programming, consultancy related act	132	97.06	114	83.82	127	93.38	109	80.15	89	65.44	85	62.50	64	47.06	115	84.56	117	86.03	91	66.91
63	Information service activities	20	95.24	20	95.24	21	100.00	18	85.71	13	61.90	13	61.90	7	33.33	19	90.48	17	80.95	14	66.67
64	Financial service activities	105	97.22	100	92.59	96	88.89	97	89.81	78	72.22	39	36.11	32	29.63	69	63.89	77	71.30	64	59.26
65	Insurance, reinsurance and pension funding,	45	100.00	38	84.44	42	93.33	36	80.00	33	73.33	19	42.22	13	28.89	31	68.89	36	80.00	34	75.56
66	Activities auxiliary to financial services	41	93.18	37	84.09	34	77.27	33	75.00	18	40.91	8	18.18	8	18.18	22	50.00	31	70.45	28	63.64
69	Legal and accounting activities	41	83.67	38	77.55	31	63.27	23	46.94	23	46.94	16	32.65	7	14.29	30	61.22	36	73.47	32	65.31
71	Architectural activitiesand R&D	89	93.68	87	91.58	82	86.32	75	78.95	66	69.47	64	67.37	56	58.95	82	86.32	86	90.53	80	84.21
73	Advertising, market research and public op. polling	60	95.24	55	87.30	55	87.30	46	73.02	32	50.79	20	31.75	13	20.63	52	82.54	49	77.78	35	55.56
74	Other consultancy, scientific and technical activities	12	100.00	11	91.67	12	100.00	12	100.00	9	75.00	10	83.33	7	58.33	11	91.67	12	100.00	9	75.00
75	Veterinary activities	5	100.00	5	100.00	4	80.00	3	60.00	3	60.00	5	100.00	2	40.00	4	80.00	5	100.00	2	40.00
86	Human health activities	57	95.00	55	91.67	45	75.00	50	83.33	47	78.33	40	66.67	35	58.33	51	85.00	52	86.67	42	70.00
	TOTAL	3323	86.76	3365	87.86	3247	84.78	2816	73.52	2134	55.72	1508	39.37	1240	32.38	2923	76.32	2853	74.49	2496	65.17

Source: Author's own computation based on CIS 8

Table 10 - Firms reporting the use of different sources of information for innovative activities CIS 10 (CAE Rev. 3)

SIC CODE		Inside the firm		Suppliers		Clients		Competitors		Cons & Priv. Labs.		Universities		Gov Labs		Conferences		Scientific journals		Firm Associations	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
7	Mining and quarrying	27	75.00	30	83.33	30	83.33	24	66.67	21	58.33	13	36.11	16	44	22	61.11	25	69.44	25	69.44
10	*Manufacture of food products*	68	89.47	65	85.53	66	86.84	56	73.68	47	61.84	24	31.58	24	32	54	71.05	46	60.53	41	53.95
11	*Manufacture of beverages and tobacco*	46	92.00	45	90.00	47	94.00	36	72.00	34	68.00	28	56.00	27	54	41	82.00	38	76.00	39	78.00
13	*Manufacture of textiles*	54	81.82	57	86.36	61	92.42	56	84.85	44	66.67	33	50.00	26	39	54	81.82	47	71.21	42	63.64
14	*Manufacture of wearing apparel*	20	83.33	18	75.00	17	70.83	15	62.50	11	45.83	8	33.33	6	25	15	62.50	15	62.50	12	50.00
15	*Manufacture of leather and related products*	42	77.78	46	85.19	47	87.04	39	72.22	27	50.00	20	37.04	19	35	37	68.52	34	62.96	30	55.56
16	*Manufacture of wood and of prod of wood and cork*	91	84.26	101	93.52	91	84.26	79	73.15	60	55.56	43	39.81	37	34	82	75.93	60	55.56	73	67.59
17	*Manufacture of paper and paper products*	50	87.72	54	94.74	48	84.21	48	84.21	31	54.39	24	42.11	20	35	43	75.44	42	73.68	37	64.91
18	*Printing and reproduction of recorded media*	53	84.13	56	88.89	54	85.71	45	71.43	26	41.27	14	22.22	10	16	48	76.19	43	68.25	40	63.49
19	*Manufacture of coke and chemical products*	86	97.73	77	87.50	78	88.64	71	80.68	61	69.32	43	48.86	36	41	71	80.68	71	80.68	59	67.05
21	*Manufacture of basic pharmaceutical products*	35	100.00	29	82.86	33	94.29	29	82.86	29	82.86	28	80.00	21	60	27	77.14	28	80.00	29	82.86
22	*Manufacture of rubber and plastic products*	106	91.38	104	89.66	104	89.66	88	75.86	63	54.31	54	46.55	40	34	95	81.90	86	74.14	69	59.48
23	*Manufacture of other non-metallic mineral products*	105	85.37	102	82.93	100	81.30	90	73.17	77	62.60	64	52.03	57	46	94	76.42	87	70.73	77	62.60
24	*Manufacture of basic metals*	40	93.02	40	93.02	39	90.70	32	74.42	32	74.42	21	48.84	20	47	32	74.42	29	67.44	23	53.49
25	*Manufacture of fabricated metal products,*	278	86.07	279	86.38	284	87.93	241	74.61	174	53.87	120	37.15	111	34	247	76.47	223	69.04	217	67.18
26	*Manufacture of computer*	38	97.44	34	87.18	36	92.31	30	76.92	26	66.67	23	58.97	21	54	34	87.18	30	76.92	22	56.41
27	*Manufacture of electrical equipment*	71	95.95	68	91.89	66	89.19	58	78.38	48	64.86	39	52.70	35	47	63	85.14	60	81.08	47	63.51
28	*Manufacture of machinery*	133	93.01	134	93.71	138	96.50	121	84.62	83	58.04	64	44.76	50	35	125	87.41	116	81.12	87	60.84
29	*Manufacture of motor vehicles*	55	93.22	51	86.44	54	91.53	43	72.88	36	61.02	30	50.85	20	34	40	67.80	36	61.02	28	47.46
30	*Manufacture of other transport equipment*	24	92.31	24	92.31	25	96.15	25	96.15	19	73.08	13	50.00	11	42	21	80.77	20	76.92	19	73.08
31	*Manufacture of furniture*	82	83.67	79	80.61	81	82.65	70	71.43	49	50.00	24	24.49	23	23	72	73.47	66	67.35	64	65.31
32	*Other manufacturing activities*	71	87.65	72	88.89	72	88.89	61	75.31	51	62.96	36	44.44	27	33	68	83.95	57	70.37	53	65.43
33	*Repair, maintenance and installation*	63	95.45	60	90.91	65	98.48	56	84.85	36	54.55	26	39.39	25	38	54	81.82	52	78.79	40	60.61
35	Electricity, gas, steam, cold and hot water and cold air	19	95.00	20	100.00	16	80.00	13	65.00	15	75.00	16	80.00	12	60	16	80.00	15	75.00	15	75.00
36	Water collection, treatment and distribution	34	94.44	33	91.67	33	91.67	30	83.33	30	83.33	28	77.78	22	61	32	88.89	32	88.89	26	72.22
37	Collection, drainage and treatment of sewage	9	100.00	9	100.00	8	88.89	8	88.89	8	88.89	8	88.89	6	67	9	100.00	9	100.00	6	66.67
38	Waste collection and Remediation	64	83.12	65	84.42	60	77.92	52	67.53	46	59.74	37	48.05	26	34	58	75.32	55	71.43	45	58.44
42	Civil engineering	22	95.65	21	91.30	19	82.61	17	73.91	15	65.22	15	65.22	13	57	18	78.26	19	82.61	15	65.22
43	Specialised construction activities	12	100.00	12	100.00	11	91.67	11	91.67	11	91.67	10	83.33	9	75	12	100.00	10	83.33	9	75.00
46	Wholesale trade	360	82.95	362	83.41	345	79.49	309	71.20	228	52.53	137	31.57	124	29	299	68.89	272	62.67	258	59.45
47	Retail trade, except of motor vehicles and motorcycles	13	100.00	13	100.00	13	100.00	12	92.31	13	100.00	6	46.15	6	46	12	92.31	11	84.62	12	92.31
49	Land transport and transport via pipelines	108	81.82	117	88.64	103	78.03	90	68.18	61	46.21	38	28.79	32	24	76	57.58	88	66.67	95	71.97
50	Water transport	7	77.78	7	77.78	7	77.78	6	66.67	4	44.44	4	44.44	3	33	5	55.56	5	55.56	5	55.56
51	Air transport	8	88.89	6	66.67	7	77.78	6	66.67	6	66.67	5	55.56	6	67	5	55.56	6	66.67	5	55.56
52	Warehousing and support activities	58	93.55	53	85.48	48	77.42	50	80.65	40	64.52	27	43.55	22	35	40	64.52	40	64.52	43	69.35
53	Postal and courier activities	8	100.00	7	87.50	7	87.50	7	87.50	5	62.50	6	75.00	4	50	4	50.00	5	62.50	5	62.50
58	Publishing activities, Motion picture and Radio	68	98.55	59	85.51	67	97.10	59	85.51	39	56.52	35	50.72	25	36	50	72.46	54	78.26	41	59.42
61	Telecommunications	21	100.00	21	100.00	20	95.24	19	90.48	16	76.19	12	57.14	11	52	19	90.48	18	85.71	15	71.43
62	Computer programming, consultancy related act	124	100.00	107	86.29	117	94.35	111	89.52	89	71.77	88	70.97	63	51	107	86.29	104	83.87	84	67.74
63	Information service activities	24	100.00	18	75.00	21	87.50	21	87.50	14	58.33	13	54.17	11	46	18	75.00	18	75.00	15	62.50
64	Financial service activities	62	91.18	61	89.71	59	86.76	54	79.41	43	63.24	34	50.00	23	34	49	72.06	48	70.59	45	66.18
65	Insurance, reinsurance and pension funding,	43	97.73	39	88.64	41	93.18	41	93.18	34	77.27	21	47.73	9	20	33	75.00	38	86.36	35	79.55
66	Activities auxiliary to financial services	29	85.29	26	76.47	27	79.41	23	67.65	17	50.00	13	38.24	11	32	21	61.76	19	55.88	20	58.82
69	Legal and accounting activities	42	76.36	42	76.36	42	76.36	35	63.64	32	58.18	26	47.27	20	36	37	67.27	40	72.73	39	70.91
71	Architectural, engineering related technical activities	83	89.25	85	91.40	77	82.80	65	69.89	59	63.44	54	58.06	50	54	72	77.42	74	79.57	61	65.59
72	Scientific research and development	13	100.00	12	92.31	10	76.92	9	69.23	9	69.23	10	76.92	8	62	10	76.92	9	69.23	7	53.85
73	Advertising, market research public opinion polling	44	89.80	44	89.80	43	87.76	35	71.43	24	48.98	16	32.65	16	33	39	79.59	38	77.55	23	46.94
74	Other consultancy, scientific and technical activities	41	87.23	36	76.60	38	80.85	33	70.21	25	53.19	21	44.68	13	28	33	70.21	31	65.96	24	51.06
75	Veterinary activities	3	100.00	3	100.00	2	66.67	2	66.67	2	66.67	2	66.67	2	67	3	100.00	3	100.00	2	66.67
86	Human health activities	64	91.43	67	95.71	56	80.00	59	84.29	54	77.14	43	61.43	41	59	54	77.14	55	78.57	46	65.71
	TOTAL	**3021**	**88.70**	**2970**	**87.20**	**2933**	**86.11**	**2590**	**76.04**	**2024**	**59.42**	**1517**	**44.54**	**1270**	**37**	**2570**	**75.46**	**2427**	**71.26**	**2169**	**63.68**

Source: Author's own computation based on CIS 10

Table 11 - Firms reporting the use of different sources of information for innovative activities CIS 12 (CAE Rev. 3)

SIC CODE		Inside the Firm		Suppliers		Private Clients		Public Clients		Competitors		Cons. Priv. Labs		Universities		Gov Labs		Conferences		Scientific Journals		Firm Associations	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
7	Mining and quarrying	18	94.74	16	84.21	15	78.95	9	47.37	14	73.68	12	63.16	9	47.37	10	52.63	13	68.42	13	68.42	9	47.37
10	*Manufacture of food products*	88	88.89	88	88.89	78	78.79	60	60.61	68	68.69	57	57.58	38	38.38	30	30.30	60	60.61	60	60.61	61	61.62
11	*Manufacture of beverages and tobacco*	62	86.11	61	84.72	59	81.94	45	62.50	59	81.94	52	72.22	39	54.17	35	48.61	58	80.56	54	75.00	53	73.61
13	*Manufacture of textiles*	68	94.44	68	94.44	64	88.89	34	47.22	53	73.61	52	72.22	41	56.94	32	44.44	60	83.33	52	72.22	50	69.44
14	*Manufacture of wearing apparel*	22	66.67	23	69.70	22	66.67	10	30.30	18	54.55	11	33.33	10	30.30	9	27.27	15	45.45	16	48.48	14	42.42
15	*Manufacture of leather and related products*	62	89.86	58	84.06	54	78.26	27	39.13	38	55.07	42	60.87	25	36.23	27	39.13	40	57.97	37	53.62	42	60.87
16	*Manufacture of wood and of products of wood and cork*	75	88.24	75	88.24	72	84.71	50	58.82	62	72.94	50	58.82	44	51.76	36	42.35	55	64.71	49	57.65	59	69.41
17	*Manufacture of paper and paper products*	43	91.49	44	93.62	39	82.98	26	55.32	41	87.23	29	61.70	22	46.81	18	38.30	35	74.47	35	74.47	34	72.34
18	*Printing and reproduction of recorded media*	54	77.14	63	90.00	55	78.57	37	52.86	45	64.29	34	48.57	26	37.14	24	34.29	46	65.71	47	67.14	45	64.29
19	*Manufacture of coke and chemical products*	77	97.47	71	89.87	72	91.14	48	60.76	58	73.42	51	64.56	46	58.23	37	46.84	59	74.68	60	75.95	51	64.56
21	*Manufacture of basic pharmaceutical products*	30	93.75	31	96.88	29	90.63	24	75.00	29	90.63	26	81.25	26	81.25	28	87.50	30	93.75	28	87.50	28	87.50
22	*Manufacture of rubber and plastic products*	131	92.25	125	88.03	121	85.21	64	45.07	98	69.01	70	49.30	59	41.55	54	38.03	102	71.83	98	69.01	85	59.86
23	*Manufacture of other non-metallic mineral products*	135	87.66	129	83.77	122	79.22	87	56.49	101	65.58	83	53.90	78	50.65	69	44.81	116	75.32	97	62.99	94	61.04
24	*Manufacture of basic metals*	33	94.29	30	85.71	30	85.71	17	48.57	26	74.29	21	60.00	20	57.14	18	51.43	25	71.43	25	71.43	27	77.14
25	*Manufacture of fabricated metal products,*	255	86.73	259	88.10	245	83.33	142	48.30	198	67.35	148	50.34	117	39.80	106	36.05	198	67.35	181	61.56	189	64.29
26	*Manufacture of computer*	43	100.00	43	100.00	43	100.00	28	65.12	38	88.37	33	76.74	33	76.74	24	55.81	40	93.02	39	90.70	34	79.07
27	*Manufacture of electrical equipment*	58	93.55	56	90.32	51	82.26	41	66.13	48	77.42	37	59.68	30	48.39	28	45.16	47	75.81	50	80.65	43	69.35
28	*Manufacture of machinery*	108	93.10	106	91.38	107	92.24	63	54.31	89	76.72	55	47.41	58	50.00	43	37.07	94	81.03	85	73.28	77	66.38
29	*Manufacture of motor vehicles*	69	93.24	68	91.89	67	90.54	36	48.65	49	66.22	42	56.76	44	59.46	35	47.30	55	74.32	55	74.32	53	71.62
30	*Manufacture of other transport equipment*	28	96.55	27	93.10	25	86.21	14	48.28	23	79.31	12	41.38	16	55.17	11	37.93	25	86.21	22	75.86	18	62.07
31	*Manufacture of furniture*	68	90.67	71	94.67	68	90.67	47	62.67	62	82.67	45	60.00	35	46.67	35	46.67	62	82.67	55	73.33	56	74.67
32	*Other manufacturing activities*	62	92.54	60	89.55	59	88.06	36	53.73	45	67.16	33	49.25	27	40.30	24	35.82	56	83.58	45	67.16	40	59.70
33	*Repair, maintenance and installation*	58	89.23	56	86.15	52	80.00	32	49.23	44	67.69	30	46.15	27	41.54	27	41.54	46	70.77	47	72.31	39	60.00
35	Electricity, gas, steam, cold and hot water and cold air	21	95.45	19	86.36	14	63.64	12	54.55	16	72.73	15	68.18	16	72.73	13	59.09	17	77.27	17	77.27	15	68.18
36	Water collection, treatment and distribution	34	97.14	34	97.14	24	68.57	24	68.57	27	77.14	25	71.43	30	85.71	28	80.00	33	94.29	31	88.57	24	68.57
37	Collection, drainage and treatment of sewage	8	88.89	8	88.89	7	77.78	7	77.78	7	77.78	6	66.67	7	77.78	7	77.78	7	77.78	8	88.89	6	66.67
38	Waste collection and Remediation	75	90.36	76	91.57	66	79.52	51	61.45	64	77.11	45	54.22	41	49.40	36	43.37	63	75.90	69	83.13	55	66.27
42	Civil engineering	15	100.00	15	100.00	12	80.00	12	80.00	12	80.00	12	80.00	11	73.33	10	66.67	13	86.67	14	93.33	13	86.67
43	Specialised construction activities	4	100.00	4	100.00	4	100.00	4	100.00	4	100.00	3	75.00	4	100.00	3	75.00	3	75.00	3	75.00	2	50.00
46	Wholesale trade	380	85.97	381	86.20	359	81.22	262	59.28	305	69.00	229	51.81	166	37.56	166	37.56	311	70.36	286	64.71	286	64.71
47	Retail trade, except of motor vehicles and motorcycles	11	100.00	10	90.91	10	90.91	9	81.82	9	81.82	8	72.73	4	36.36	6	54.55	9	81.82	9	81.82	9	81.82
49	Land transport and transport via pipelines	104	81.89	103	81.10	93	73.23	66	51.97	86	67.72	59	46.46	40	31.50	39	30.71	76	59.84	69	54.33	84	66.14
50	Water transport	7	87.50	6	75.00	4	50.00	3	37.50	4	50.00	3	37.50	2	25.00	2	25.00	1	12.50	1	12.50	2	25.00
51	Air transport	14	100.00	12	85.71	10	71.43	10	71.43	11	78.57	11	78.57	4	28.57	3	21.43	12	85.71	10	71.43	10	71.43
52	Warehousing and support activities	66	86.84	62	81.58	57	75.00	35	46.05	47	61.84	37	48.68	21	27.63	20	26.32	43	56.58	45	59.21	52	68.42
53	Postal and courier activities	5	100.00	5	100.00	5	100.00	4	80.00	5	100.00	3	60.00	3	60.00	2	40.00	4	80.00	3	60.00	3	60.00
58	Publishing activities, Motion picture and Radio	63	98.44	54	84.38	56	87.50	40	62.50	48	75.00	31	48.44	36	56.25	31	48.44	49	76.56	50	78.13	41	64.06
59	Motion picture and Radio and Telecommunications	13	86.67	13	86.67	11	73.33	8	53.33	11	73.33	6	40.00	3	20.00	4	26.67	10	66.67	12	80.00	8	53.33
60	Land transport; transport via pipelines	6	100.00	6	100.00	5	83.33	3	50.00	6	100.00	4	66.67	2	33.33	2	33.33	4	66.67	4	66.67	2	33.33
61	Telecommunications	14	87.50	12	75.00	9	56.25	9	56.25	10	62.50	7	43.75	7	43.75	6	37.50	13	81.25	9	56.25	10	62.50
62	Computer programming, consultancy and related activities	116	100.00	108	93.10	109	93.97	88	75.86	94	81.03	71	61.21	81	69.83	65	56.03	91	78.45	96	82.76	76	65.52
63	Information service activities	16	88.89	14	77.78	13	72.22	10	55.56	11	61.11	7	38.89	9	50.00	8	44.44	15	83.33	15	83.33	12	66.67
64	Financial service activities	64	91.43	60	85.71	57	81.43	34	48.57	51	72.86	40	57.14	29	41.43	24	34.29	45	64.29	46	65.71	42	60.00
65	Insurance, reinsurance and pension funding,	44	100.00	42	95.45	39	88.64	28	63.64	43	97.73	32	72.73	20	45.45	23	52.27	34	77.27	38	86.36	34	77.27
66	Activities auxiliary to financial services	32	88.89	26	72.22	24	66.67	16	44.44	28	77.78	16	44.44	6	16.67	6	16.67	18	50.00	22	61.11	17	47.22
69	Legal and accounting activities	31	93.94	31	93.94	25	75.76	20	60.61	23	69.70	23	69.70	16	48.48	14	42.42	19	57.58	25	75.76	28	84.85
71	Architectural, engineering and related technical activities	65	92.86	65	92.86	56	80.00	43	61.43	46	65.71	38	54.29	41	58.57	40	57.14	47	67.14	51	72.86	47	67.14
71	Scientific research and development	25	100.00	23	92.00	24	96.00	17	68.00	22	88.00	19	76.00	23	92.00	22	88.00	22	88.00	23	92.00	20	80.00
73	Advertising, market research and public opinion polling	39	97.50	35	87.50	34	85.00	22	55.00	28	70.00	17	42.50	26	65.00	18	45.00	34	85.00	34	85.00	27	67.50
74	Other consultancy, scientific and technical activities	31	100.00	28	90.32	25	80.65	16	51.61	21	67.74	13	41.94	12	38.71	12	38.71	22	70.97	22	70.97	21	67.74
75	Veterinary activities	12	92.31	12	92.31	11	84.62	8	61.54	9	69.23	8	61.54	6	46.15	3	23.08	10	76.92	12	92.31	6	46.15
86	Human health activities	57	95.00	54	90.00	41	68.33	48	80.00	51	85.00	41	68.33	44	73.33	44	73.33	45	75.00	49	81.67	43	71.67
	Total	**3019**	**90.36**	**2946**	**88.18**	**2753**	**82.40**	**1886**	**56.45**	**2405**	**71.98**	**1854**	**55.49**	**1580**	**47.29**	**1417**	**42.41**	**2407**	**72.04**	**2323**	**69.53**	**2196**	**65.73**

Source: Author's own computation based on CIS 12

The empirical evidence illustrates that firms choose their R&D partners according to the objective they want to achieve. Innovative activities have different natures, they are designed with different time schedules, different deepness in terms of knowledge requirements, designed to achieve generalised solutions or just focusing in improving narrow topics.

It is commonly accepted that the very first option of firms will be using the internal sources; in consonance, *inside the firm* will be a very important source of information for the innovative activities. Throughout the CIS 6, CIS 8 and CIS 10, a significant proportion of firms mention the use of this source of information for their innovative activities.

The existence of a consistent strategy to develop internal R&D projects will enhance the development of cooperation with external sources, being the clients, competitors, and the suppliers the most frequently mentioned (Mowery and Rosenberg, 1989).

During the six year period of analysis, external agents in the same productive chain tend to be a very likely option. Firms repeatedly report, relying on their suppliers, their clients, their competitors and consultants for all the economic sectors.

Firms will have the possibility of relying on agents inside or outside their productive chain. The option for institutions outside the industry requires the existence of knowledge proximity as communication has to be established and successful. Drawing upon Universities and Government labs is an option chosen by a smaller proportion of firms due to the requirements in terms of human capital and bureaucratic organisation. The establishment of links with these sources is an option for complex and durable projects. Firms tend to use in a higher percentage scientific journals, conferences and entrepreneurial associations suggesting that simpler access to relevant information and informal connections are preferable.

Poor organisation and lack of finance will encourage firms to find partners in their chain of production as there is informal proximity based on commercial relations and daily contacts. Relying on external sources is an alternative for the scarcity of internal funds, whereas firms have difficulties in finding important the use of Universities and Government Labs as they feel the complexity in the connection (Teixeira and Costa, 2006).

Firms will choose the different innovation sources depending on the objectives they aim at reaching, knowledge sources will be complementary, drawing upon different

institutions will boost the absorptive capacity, in being “open”, firms will raise the odds of innovative success (Cohen and Malerba, 2001; Laursen and Salter, 2004).

2.8. Innovation purposes

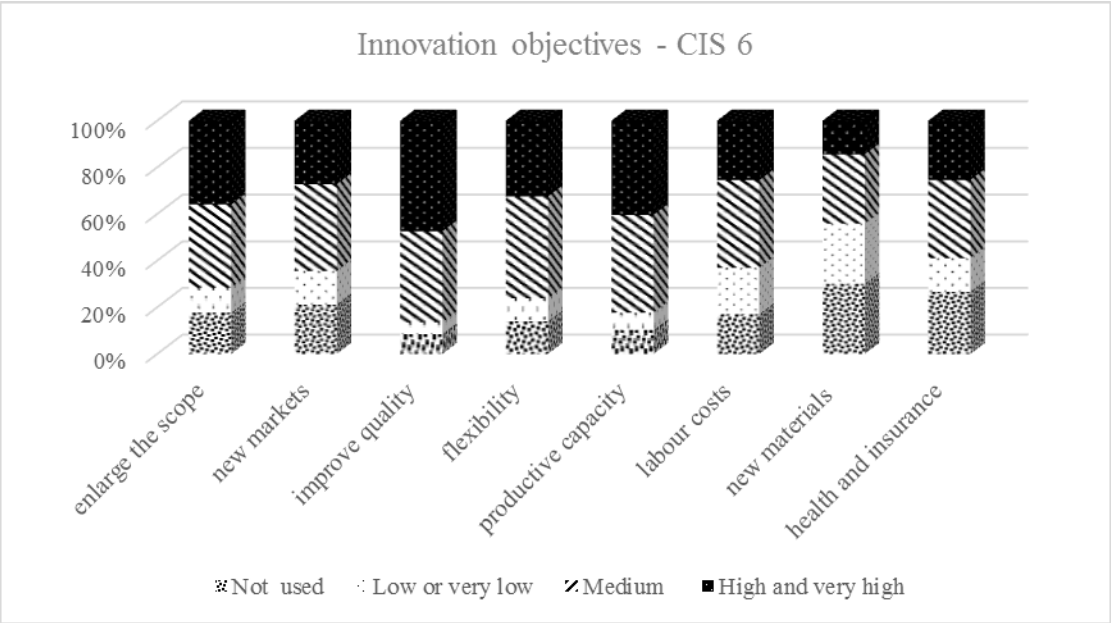
Basic research is the main driver for productivity at the firm level; expenditures in this area significantly contribute to productivity growth (Hall, Griliches and Hausman, 1986). Firms that invest a larger fraction of their total R&D on basic research are more productive (Mansfield, 1980). However, private returns to expenditures in R&D, that is returns to the firm or organisation undertaking the investment, are lower than social returns due to knowledge spillovers as a result; policy makers must incentive these actions.

The development of R&D, despite its nature is not a random activity. Firms pursuit different actions, choose different sources of information, choose different strategies and paces due to the existence of different innovation purposes.

In general, and regardless of their innovative strategy, firms find the different innovation objectives important. The proportion of respondents classifying any of the listed innovation objectives as irrelevant is small compared to the total. Even if facing eventual constraints, firms are aware of the importance of these issues.

The following graph illustrates the importance attributed to the different innovation activities by the firms in the CIS 6.

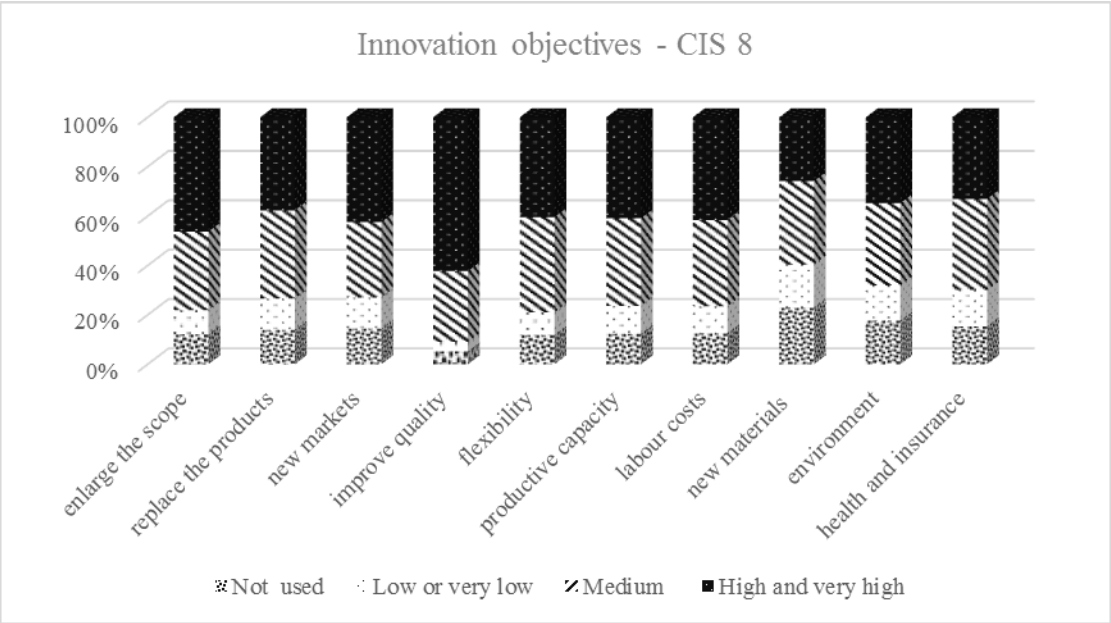
Graphic 11 - Relative importance of the different innovation objectives – CIS 6



Source: Author's own computation based on CIS 6

Analysing evidence from the CIS 6, quality improvements and the enlargement of the productive capacity are considered very important innovation objectives for an important proportion of the firms. The decrease in the incorporation of raw materials or the discovery of substitutes in the final products is very frequently considered as an irrelevant innovation objective.

Graphic 12 - Relative importance of the different innovation objectives – CIS 8

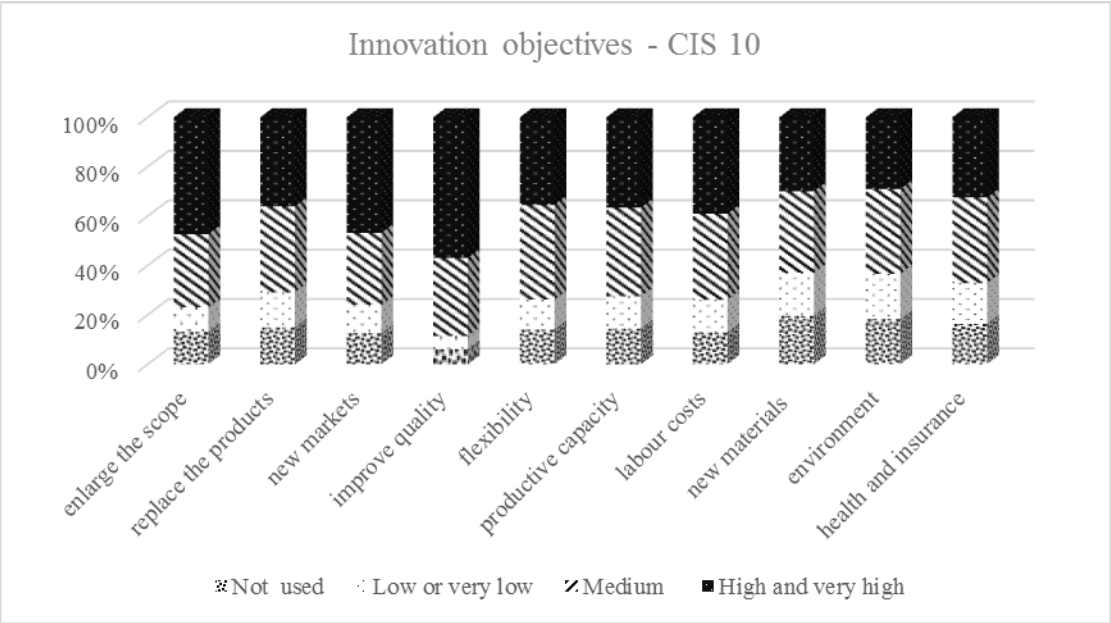


Source: Author's own computation based on CIS 8

Following a similar pattern than the biennium, the firms included in the CIS 8 found quality improvements as being a very important innovation objective as well as the enlargement in the scope of products supplied to the market and the enlargement of the productive capacity.

The use of new materials or the reduction in the use of the existing ones is, again considered irrelevant for an important proportion of the respondent firms. Conversely, quality improvements tend to be irrelevant to an insignificant proportion of the respondent firms.

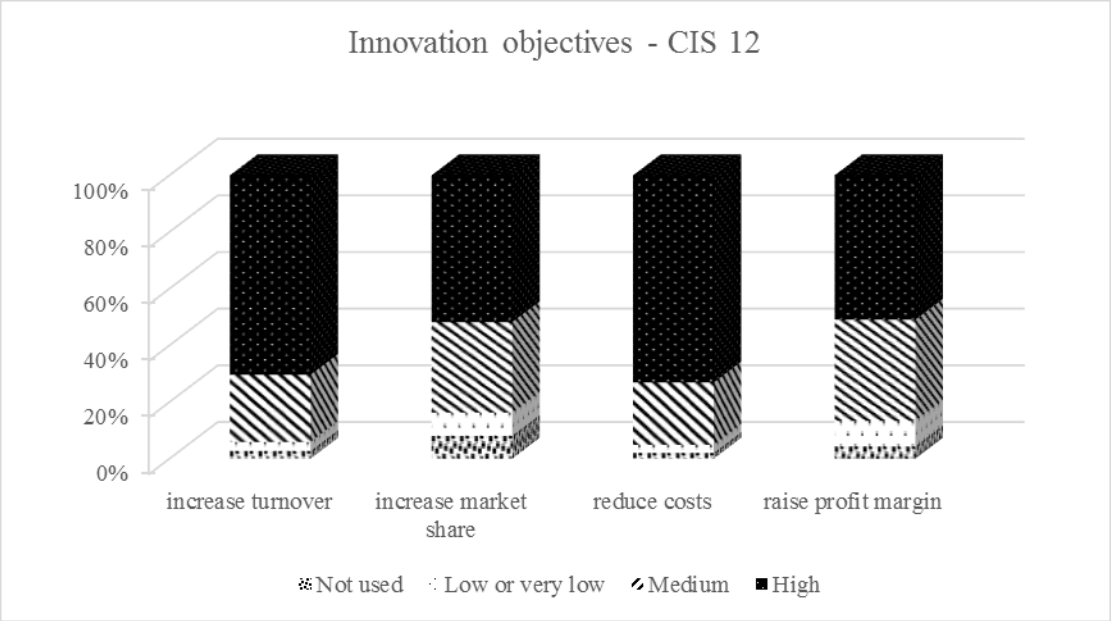
Graphic 13 - Relative importance of the different innovation objectives – CIS 10



Source: Author's own computation based on CIS 10

The responses obtained in the CIS 10 present a very similar pattern to the previous waves. Firms find very important innovations to reach quality improvements and the enlargement of products supplied to the market. As happened in former waves the reduction or change in the materials used for the production as well as environmental impacts are the more often mentioned innovation objectives considered irrelevant.

Graphic 14 - Relative importance of the different innovation objectives – CIS 12



Source: Author's own computation based on CIS 12

In the CIS 12, an important proportion of the firms (70%), found increasing the turnover a highly important innovation objective. Improving the efficiency of the business by reducing its cost structure is of high or medium importance for 95% of firms. Raising the profit margin is of high or medium importance for 87% of the firms. Very few of the firms find of low importance any of the objectives.

2.9. Innovation barriers/difficulties

Decisions about the innovation process are similar with other strategic decisions made inside the firm, when jeopardized must be postponed or even abandoned. Firms may decide to abandon because of conception failures, in this case there are very few resources invested, in its development stage or once it was launched to the market. The further we reach more resources are being used.

When deciding to abandon their innovative activities firms highlight several aspects; very commonly the underlying reasons are financial constraints. Innovative activities are, by nature, risky in presence of shortage of finance, makes firms postpone, prematurely stop, or abandon their innovative activities (Mohnen et al., 2008).

Financial constraints appear as being the most frequent barrier pointed by the firms. Although other reasons may be presented as hindering factors for innovation such as: firm strategy, use of external sources of knowledge, existence of funds, other obstacles, vulnerabilities (Landry, Amara and Becheikh, 2008).

The CIS asks firms about the importance of a set of factors in frustrating their innovative activities; they were grouped in three categories: funding factors (which include financing constraints both internal and external), knowledge factors (lack of qualified personnel, information about technology, information on markets, difficulty in finding cooperation partners) and market factors (market is dominated by large firms and uncertainty about demand). Firms were asked to classify each factor working as a barrier to innovation from irrelevant to very important. In the following table, firms were divided according to their economic sector and data was compiled in binary set meaning that being relevant, regardless of the intensity will, generate a count.

In the existing literature assessing barriers to innovation, financing constraints are the most widely mentioned. It is expected that firms mention different difficulties with different intensities depending on their economic sector, theirs size and technology intensity, in sum structural characteristics and individual heterogeneity expectably modify the perceived barriers to innovation.

In both waves all barriers are very often mentioned by firms, funding factors are quite similar from other factors. In general the second wave presents a higher percentage of firms reporting the perception of barriers.

Table 11 depicts the different innovation barriers mentioned by the firms according to the SIC Codes for the CIS6; immediately followed by table 12 which illustrates the same for the CIS 10.

Table 12 - Firms reporting different barriers concerning the innovation activities, CIS 6 (CAE Rev. 2.1)

SIC CODE	Economic Factors						Knowledge Factors								Market Factors			
	Lack of internal finance		Lack of external finance		Excessive costs innov		Lack of personnel		Lack of info technology		Lack of info mkts		Lack of info partners		Mkt established firms		Uncertainty about demand	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
11 - Mining and quarrying	71	68.27	62	59.62	81	77.88	75	72.12	71	68.27	68	65.38	58	55.77	70	67.31	74	71.15
15 - Manufacture of food, beverages and tobacco	170	71.13	160	66.95	190	79.5	183	76.57	164	68.62	159	66.53	140	58.58	171	71.55	182	76.15
17 - Manufacture of textiles	134	74.03	126	69.61	143	79.01	130	71.82	122	67.4	120	66.3	111	61.33	131	72.38	139	76.8
18 - Manufacture of wearing apparel; dressing and dyeing of fur	234	79.86	218	74.4	247	84.3	237	80.89	226	77.13	229	78.16	205	69.97	227	77.47	242	82.59
19 - Tanning and dressing of leather;	62	78.48	59	74.68	70	88.61	64	81.01	62	78.48	61	77.22	53	67.09	59	74.68	63	79.75
20 - Manufacture of wood and of products	86	75.44	84	73.68	96	84.21	92	80.7	89	78.07	78	68.42	81	71.05	82	71.93	89	78.07
21 - Manufacture of pulp, paper and paper products	39	75	34	65.38	44	84.62	41	78.85	35	67.31	33	63.46	31	59.62	38	73.08	45	86.54
22 - Publishing, printing and reproduction of recorded media	78	75	73	70.19	80	76.92	75	72.12	60	57.69	62	59.62	58	55.77	69	66.35	76	73.08
23 - Manufacture of coke and chemical products	85	60.71	82	58.57	104	74.29	92	65.71	88	62.86	91	65	83	59.29	95	67.86	94	67.14
25 - Manufacture of rubber and plastic products	78	73.58	72	67.92	85	80.19	86	81.13	81	76.42	80	75.47	70	66.04	85	80.19	79	74.53
26 - Manufacture of other non-metallic mineral products	102	66.67	96	62.75	112	73.2	111	72.55	104	67.97	103	67.32	94	61.44	101	66.01	108	70.59
27 - Manufacture of basic metals	39	66.1	36	61.02	40	67.8	43	72.88	39	66.1	36	61.02	32	54.24	35	59.32	37	62.71
28 - Manufacture of fabricated metal products	114	77.55	107	72.79	123	83.67	114	77.55	111	75.51	106	72.11	96	65.31	118	80.27	111	75.51
29 - Manufacture of machinery and equipment n.e.c	73	71.57	70	68.63	74	72.55	74	72.55	72	70.59	71	69.61	69	67.65	70	68.63	78	76.47
30 - Manufacture of machinery and comp., electrical machinery	53	67.09	48	60.76	62	78.48	53	67.09	51	64.56	53	67.09	46	58.23	54	68.35	58	73.42
32 - Manufacture of radio, television	36	78.26	28	60.87	35	76.09	35	76.09	28	60.87	27	58.7	24	52.17	28	60.87	30	65.22
33 - Manufacture of medical and optical instruments	26	70.27	22	59.46	29	78.38	24	64.86	27	72.97	25	67.57	23	62.16	21	56.76	26	70.27
34 - Manufacture of motor vehicles, trailers and semi-trailers	59	69.41	58	68.24	68	80	66	77.65	64	75.29	63	74.12	60	70.59	60	70.59	55	64.71
35 - Manufacture of other transport equipment	41	66.13	37	59.68	43	69.35	44	70.97	40	64.52	39	62.9	40	64.52	41	66.13	46	74.19
36 - Manufacture of furniture; others manufacturing act, n.e.c.	80	73.39	71	65.14	90	82.57	81	74.31	77	70.64	73	66.97	67	61.47	78	71.56	82	75.23
37 - Recycling	19	50	19	50	24	63.16	22	57.89	22	57.89	20	52.63	13	34.21	18	47.37	18	47.37
40 - Production and distribution of electricity	12	40	9	30	15	50	12	40	13	43.33	10	33.33	10	33.33	8	26.67	7	23.33
41 - Water collection, treatment and distribution	43	58.9	43	58.9	46	63.01	47	64.38	43	58.9	32	43.84	39	53.42	18	24.66	18	24.66
45 - Construction	123	64.4	125	65.45	141	73.82	136	71.2	132	69.11	132	69.11	122	63.87	146	76.44	140	73.3
51 - Wholesale trade and commission trade	376	59.49	363	57.44	435	68.83	402	63.61	384	60.76	377	59.65	341	53.96	403	63.77	415	65.66
52 - Retail trade	44	43.56	41	40.59	53	52.48	57	56.44	50	49.5	52	51.49	49	48.51	51	50.5	48	47.52
55 - Hotels and restaurants	8	28.57	10	35.71	11	39.29	14	50	13	46.43	13	46.43	14	50	11	39.29	11	39.29
60 - Land transport; transport via pipelines	120	69.36	104	60.12	134	77.46	121	69.94	116	67.05	109	63.01	105	60.69	109	63.01	116	67.05
61 - Water transport	13	56.52	13	56.52	15	65.22	11	47.83	12	52.17	8	34.78	8	34.78	10	43.48	9	39.13
62 - Air transport	7	53.85	6	46.15	9	69.23	10	76.92	8	61.54	7	53.85	5	38.46	8	61.54	7	53.85
63 - Supporting and auxiliary transport activities	84	57.53	79	54.11	92	63.01	84	57.53	77	52.74	72	49.32	77	52.74	80	54.79	88	60.27
64 - Post and telecommunications	28	62.22	26	57.78	34	75.56	28	62.22	24	53.33	26	57.78	22	48.89	28	62.22	29	64.44
65 - Financial intermediation, except insur and pension funding	20	31.75	12	19.05	33	52.38	38	60.32	36	57.14	35	55.56	30	47.62	23	36.51	32	50.79
66 - Insurance, pension funding	17	30.36	8	14.29	32	57.14	23	41.07	23	41.07	19	33.93	18	32.14	35	62.5	32	57.14
67 - Activities auxiliary to financial intermediation	27	50	20	37.04	34	62.96	29	53.7	27	50	25	46.3	21	38.89	32	59.26	33	61.11
72 - Computer and related activities and R&D	78	68.42	69	60.53	83	72.81	76	66.67	62	54.39	77	67.54	72	63.16	83	72.81	83	72.81
74 - Other business activities	375	57.69	339	52.15	416	64	378	58.15	356	54.77	345	53.08	314	48.31	378	58.15	392	60.31
TOTAL	**3054**	**64.69**	**2829**	**59.92**	**3423**	**72.51**	**3208**	**67.95**	**3009**	**63.74**	**2936**	**62.19**	**2701**	**57.21**	**3074**	**65.11**	**3192**	**67.61**

Source: Author's own computation based on CIS 6

Table 13 - Firms reporting different barriers concerning the innovation activities CIS 10 (CAE Rev. 3)

SIC CODE		Economic Factors						Knowledge Factors								Market Factors			
		Lack of internal finance		Lack of external finance		Excessive costs innov		Lack of personnel		Lack of info technology		Lack of info mkts		Lack of info partners		Mkt established firms		Uncertainty about demand	
		n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
7	Mining and quarrying	89	80.18	87	78.38	90	81.08	82	73.87	84	75.68	82	73.87	79	71	87	78.38	91	81.98
10	*Manufacture of food products*	110	76.39	96	66.67	119	82.64	106	73.61	100	69.44	104	72.22	84	58	108	75	114	79.17
11	*Manufacture of beverages and tobacco*	59	80.82	55	75.34	63	86.3	53	72.6	50	68.49	54	73.97	54	74	58	79.45	62	84.93
13	*Manufacture of textiles*	102	76.12	103	76.87	114	85.07	104	77.61	100	74.63	102	76.12	100	75	106	79.1	116	86.57
14	*Manufacture of wearing apparel*	63	76.83	61	74.39	65	79.27	53	64.63	50	60.98	51	62.2	49	60	60	73.17	60	73.17
15	*Manufacture of leather and related products*	102	76.69	98	73.68	107	80.45	105	78.95	100	75.19	101	75.94	96	72	98	73.68	106	79.7
16	*Manufacture of wood and of products of wood and cork*	192	87.27	193	87.73	204	92.73	181	82.27	178	80.91	172	78.18	157	71	182	82.73	191	86.82
17	*Manufacture of paper and paper products*	82	86.32	75	78.95	83	87.37	77	81.05	73	76.84	67	70.53	61	64	79	83.16	77	81.05
18	*Printing and reproduction of recorded media*	101	79.53	97	76.38	108	85.04	97	76.38	89	70.08	93	73.23	81	64	95	74.8	99	77.95
19	*Manufacture of coke and chemical products*	91	81.98	83	74.77	96	86.49	82	73.87	82	73.87	82	73.87	77	69	91	81.98	88	79.28
21	*Manufacture of basic pharmaceutical products*	34	72.34	34	72.34	39	82.98	33	70.21	33	70.21	33	70.21	35	74	36	76.6	36	76.6
22	*Manufacture of rubber and plastic products*	150	81.52	142	77.17	159	86.41	150	81.52	141	76.63	145	78.8	137	74	154	83.7	158	85.87
23	*Manufacture of other non-metallic mineral products*	218	82.58	209	79.17	233	88.26	207	78.41	193	73.11	198	75	189	72	210	79.55	233	88.26
24	*Manufacture of basic metals*	49	72.06	48	70.59	56	82.35	54	79.41	54	79.41	54	79.41	47	69	55	80.88	59	86.76
25	*Manufacture of fabricated metal products,*	483	82.71	480	82.19	510	87.33	476	81.51	460	78.77	461	78.94	432	74	474	81.16	482	82.53
26	*Manufacture of computer*	41	83.67	38	77.55	45	91.84	43	87.76	42	85.71	40	81.63	36	73	44	89.8	44	89.8
27	*Manufacture of electrical equipment*	79	79.8	74	74.75	87	87.88	78	78.79	77	77.78	77	77.78	74	75	81	81.82	89	89.9
28	*Manufacture of machinery*	188	81.03	189	81.47	201	86.64	186	80.17	176	75.86	179	77.16	173	75	189	81.47	195	84.05
29	*Manufacture of motor vehicles*	72	80	76	84.44	80	88.89	75	83.33	75	83.33	70	77.78	63	70	77	85.56	76	84.44
30	*Manufacture of other transport equipment*	40	86.96	40	86.96	40	86.96	39	84.78	36	78.26	36	78.26	37	80	40	86.96	40	86.96
31	*Manufacture of furniture*	132	85.71	126	81.82	135	87.66	129	83.77	129	83.77	132	85.71	114	74	125	81.17	138	89.61
32	*Other manufacturing activities*	111	73.51	107	70.86	120	79.47	108	71.52	100	66.23	104	68.87	92	61	114	75.5	122	80.79
33	*Repair, maintenance and installation*	103	70.07	99	67.35	111	75.51	106	72.11	99	67.35	100	68.03	93	63	106	72.11	113	76.87
35	Electricity, gas, steam, cold and hot water and cold air	22	57.89	24	63.16	27	71.05	19	50	20	52.63	21	55.26	22	58	23	60.53	21	55.26
36	Water collection, treatment and distribution	40	57.14	39	55.71	44	62.86	36	51.43	36	51.43	29	41.43	36	51	24	34.29	22	31.43
37	Collection, drainage and treatment of sewage	14	82.35	12	70.59	15	88.24	10	58.82	10	58.82	8	47.06	12	71	12	70.59	10	58.82
38	Waste collection and Remediation	107	74.83	114	79.72	112	78.32	100	69.93	99	69.23	98	68.53	102	71	105	73.43	103	72.03
42	Civil engineering	24	80	26	86.67	28	93.33	22	73.33	22	73.33	25	83.33	25	83	24	80	27	90
43	Specialised construction activities	15	88.24	15	88.24	15	88.24	12	70.59	13	76.47	13	76.47	13	76	13	76.47	13	76.47
46	Wholesale trade	618	71.36	598	69.05	667	77.02	628	72.52	600	69.28	598	69.05	579	67	648	74.83	672	77.6
47	Retail trade, except of motor vehicles and motorcycles	12	75	6	37.5	13	81.25	10	62.5	9	56.25	10	62.5	9	56	5	31.25	6	37.5
49	Land transport and transport via pipelines	208	78.2	208	78.2	219	82.33	184	69.17	182	68.42	179	67.29	170	64	194	72.93	203	76.32
50	Water transport	15	65.22	14	60.87	15	65.22	16	69.57	15	65.22	15	65.22	11	48	13	56.52	14	60.87
51	Air transport	12	57.14	13	61.9	13	61.9	11	52.38	11	52.38	12	57.14	11	52	14	66.67	13	61.9
52	Warehousing and support activities	67	59.29	55	48.67	68	60.18	59	52.21	52	46.02	52	46.02	50	44	59	52.21	62	54.87
53	Postal and courier activities	11	73.33	8	53.33	11	73.33	11	73.33	10	66.67	10	66.67	10	67	9	60	9	60
58	Publishing activities, Motion picture and Radio	80	76.92	75	72.12	85	81.73	77	74.04	66	63.46	74	71.15	70	67	79	75.96	83	79.81
61	Telecommunications	23	62.16	21	56.76	29	78.38	23	62.16	20	54.05	24	64.86	22	59	26	70.27	28	75.68
62	Computer programming, consultancy and related activities	115	78.77	111	76.03	125	85.62	109	74.66	99	67.81	115	78.77	107	73	118	80.82	122	83.56
63	Information service activities	24	80	23	76.67	26	86.67	22	73.33	23	76.67	23	76.67	22	73	22	73.33	25	83.33
64	Financial service activities	56	43.41	44	34.11	73	56.59	57	44.19	54	41.86	52	40.31	50	39	59	45.74	58	44.96
65	Insurance, reinsurance and pension funding,	24	44.44	15	27.78	37	68.52	34	62.96	30	55.56	27	50	22	41	29	53.7	41	75.93
66	Activities auxiliary to financial services	36	48.65	33	44.59	41	55.41	38	51.35	37	50	34	45.95	37	50	39	52.7	40	54.05
69	Legal and accounting activities	94	59.87	82	52.23	108	68.79	94	59.87	90	57.32	89	56.69	81	52	92	58.6	97	61.78
71	Architectural, engineering and related technical activities	128	74.85	125	73.1	139	81.29	117	68.42	112	65.5	115	67.25	122	71	129	75.44	132	77.19
72	Scientific research and development	13	92.86	13	92.86	13	92.86	12	85.71	10	71.43	10	71.43	11	79	13	92.86	12	85.71
73	Advertising, market research and public opinion polling	68	74.73	64	70.33	70	76.92	58	63.74	56	61.54	52	57.14	56	62	63	69.23	67	73.63
74	Other consultancy, scientific and technical activities	50	70.42	47	66.2	57	80.28	50	70.42	45	63.38	46	64.79	45	63	47	66.2	49	69.01
75	Veterinary activities	8	80	9	90	10	100	9	90	8	80	8	80	6	60	8	80	9	90
86	Human health activities	72	78.26	71	77.17	80	86.96	65	70.65	61	66.3	59	64.13	63	68	50	54.35	56	60.87
	TOTAL	4647	75.44	4475	72.65	5005	81.25	4507	73.17	4311	69.98	4335	70.37	4124	67	4586	74.45	4783	77.65

Source: Author's own computation based on CIS 10

Table 14 - Firms reporting different barriers concerning the innovation activities, CIS 12 (CAE Rev. 3)

	Portuguese Classification of Economic Activities (CAE)	Lack of internal finance		Lack of external finance		Excessive costs innov		Lack of personnel		Lack of info technology		Lack of info mkts		Lack of info partners		Mkt established firms		Uncertainty about demand	
	REVISION 3 - NACE Rev. 3 (1/1/2008- ….)	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
7	Mining and preparation of metal ores	69	94.52	67	91.78	67	91.78	47	64.38	65	89.04	52	71.23	63	86.30	59	80.82	64	87.67
10	*Manufacture of food products*	187	95.90	183	93.85	182	93.33	150	76.92	159	81.54	154	78.97	161	82.56	145	74.36	163	83.59
11	*Manufacture of beverages*	126	98.44	120	93.75	118	92.19	104	81.25	115	89.84	97	75.78	106	82.81	115	89.84	116	90.63
13	*Manufacture of textiles*	129	97.73	126	95.45	122	92.42	105	79.55	109	82.58	104	78.79	113	85.61	115	87.12	113	85.61
14	*Manufacture of wearing apparel*	106	92.98	103	90.35	101	88.60	84	73.68	88	77.19	94	82.46	96	84.21	95	83.33	97	85.09
15	*Manufacture of leather and related products*	172	91.49	171	90.96	160	85.11	144	76.60	147	78.19	159	84.57	157	83.51	155	82.45	154	81.91
16	*Manufacture of wood and of products of wood and cork. (…)*	195	96.06	188	92.61	186	91.63	161	79.31	175	86.21	161	79.31	179	88.18	178	87.68	176	86.70
17	*Manufacture of paper and paper products*	89	100.00	88	98.88	83	93.26	75	84.27	80	89.89	75	84.27	80	89.89	82	92.13	79	88.76
18	*Printing and reproduction of recorded media*	158	96.93	152	93.25	153	93.87	127	77.91	138	84.66	125	76.69	139	85.28	141	86.50	140	85.89
19	*Manufacture of coke. refined petroleum products and fuels briquettes*	113	97.41	108	93.10	111	95.69	90	77.59	104	89.66	88	75.86	98	84.48	99	85.34	104	89.66
21	*Manufacture of basic pharmaceutical products and pharmaceutical preparations*	43	93.48	43	93.48	41	89.13	44	95.65	41	89.13	38	82.61	41	89.13	42	91.30	42	91.30
22	*Manufacture of rubber and plastic products*	213	96.38	207	93.67	208	94.12	182	82.35	199	90.05	188	85.07	189	85.52	192	86.88	194	87.78
23	*Manufacture of other non-metallic mineral products*	324	97.30	316	94.89	323	97.00	267	80.18	287	86.19	272	81.68	286	85.89	296	88.89	287	86.19
24	*Manufacture of basic metals*	63	95.45	59	89.39	63	95.45	44	66.67	52	78.79	49	74.24	52	78.79	56	84.85	54	81.82
25	*Manufacture of fabricated metal products. except machinery and equipment*	636	97.25	610	93.27	616	94.19	522	79.82	552	84.40	573	87.61	565	86.39	581	88.84	565	86.39
26	*Manufacture of computer. communication equipment. electronic and optical products*	51	96.23	51	96.23	47	88.68	46	86.79	48	90.57	43	81.13	43	81.13	45	84.91	41	77.36
27	*Manufacture of electrical equipment*	89	97.80	89	97.80	90	98.90	78	85.71	79	86.81	76	83.52	76	83.52	80	87.91	78	85.71
28	*Manufacture of machinery and equipment n.e.c.*	197	97.04	191	94.09	190	93.60	174	85.71	174	85.71	172	84.73	167	82.27	186	91.63	173	85.22
29	*Manufacture of motor vehicles. trailers. semi-trailers and parts (…)*	101	94.39	100	93.46	103	96.26	88	82.24	94	87.85	91	85.05	98	91.59	95	88.79	92	85.98
30	*Manufacture of other transport equipment*	46	92.00	44	88.00	45	90.00	35	70.00	40	80.00	41	82.00	42	84.00	40	80.00	40	80.00
31	*Manufacture of furniture*	147	95.45	147	95.45	149	96.75	124	80.52	132	85.71	117	75.97	138	89.61	138	89.61	120	77.92
32	*Other manufacturing activities*	133	97.08	128	93.43	124	90.51	107	78.10	114	83.21	109	79.56	108	78.83	120	87.59	109	79.56
33	*Repair. maintenance and installation of machinery and equipment*	148	94.27	135	85.99	141	89.81	114	72.61	129	82.17	133	84.71	130	82.80	124	78.98	125	79.62
35	Electricity. gas. steam. cold and hot water and cold air	28	66.67	27	64.29	30	71.43	26	61.90	28	66.67	30	71.43	33	78.57	22	52.38	32	76.19
36	Water collection. treatment and distribution	18	27.27	23	34.85	39	59.09	8	12.12	8	12.12	37	56.06	51	77.27	15	22.73	45	68.18
37	Collection. drainage and treatment of sewage	9	50.00	9	50.00	10	55.56	7	38.89	5	27.78	11	61.11	12	66.67	6	33.33	12	66.67
38	Waste collection. treatment and disposal activities; materials recovery	132	83.54	124	78.48	127	80.38	106	67.09	114	72.15	114	72.15	133	84.18	111	70.25	136	86.08
42	Civil engineering	23	92.00	20	80.00	23	92.00	18	72.00	21	84.00	18	72.00	22	88.00	22	88.00	21	84.00
43	Specialised construction activities	11	100.00	10	90.91	10	90.91	9	81.82	10	90.91	10	90.91	11	100.00	10	90.91	10	90.91
46	Wholesale trade (include commission trade). except of motor vehicles (…)	1033	96.36	991	92.44	1003	93.56	839	78.26	922	86.01	823	76.77	830	77.43	829	77.33	869	81.06
47	Retail trade. except of motor vehicles and motorcycles	15	100.00	15	100.00	15	100.00	14	93.33	13	86.67	13	86.67	12	80.00	7	46.67	13	86.67
49	Land transport and transport via pipelines	284	90.73	263	84.03	295	94.25	213	68.05	239	76.36	246	78.59	252	80.51	221	70.61	253	80.83
50	Water transport	21	84.00	21	84.00	22	88.00	18	72.00	20	80.00	19	76.00	20	80.00	16	64.00	16	64.00
51	Air transport	26	96.30	26	96.30	26	96.30	22	81.48	22	81.48	19	70.37	22	81.48	20	74.07	23	85.19
52	Warehousing and support activities for transportation (include cargo handling)	158	90.29	136	77.71	154	88.00	119	68.00	130	74.29	129	73.71	117	66.86	108	61.71	132	75.43
53	Postal and courier activities	13	86.67	12	80.00	12	80.00	12	80.00	11	73.33	10	66.67	9	60.00	10	66.67	12	80.00
58	Publishing activities	101	94.39	102	95.33	104	97.20	94	87.85	97	90.65	92	85.98	95	88.79	92	85.98	87	81.31
59	Motion picture. video and television programme production. (…)	28	90.32	29	93.55	28	90.32	26	83.87	24	77.42	20	64.52	24	77.42	27	87.10	22	70.97
60	Radio and television activities	15	100.00	14	93.33	15	100.00	12	80.00	15	100.00	11	73.33	12	80.00	13	86.67	10	66.67
61	Telecommunications	31	96.88	30	93.75	29	90.63	26	81.25	26	81.25	23	71.88	27	84.38	23	71.88	25	78.13
62	Computer programming. consultancy and related activities	152	94.41	153	95.03	145	90.06	142	88.20	133	82.61	135	83.85	129	80.12	146	90.68	141	87.58
63	Information service activities	30	100.00	29	96.67	30	100.00	25	83.33	27	90.00	21	70.00	25	83.33	23	76.67	23	76.67
64	Financial service activities. except insurance and pension funding	116	79.45	116	79.45	119	81.51	107	73.29	112	76.71	92	63.01	77	52.74	78	53.42	104	71.23
65	Insurance. reinsurance and pension funding. except compulsory social security	54	98.18	52	94.55	52	94.55	49	89.09	49	89.09	37	67.27	27	49.09	30	54.55	41	74.55
66	Activities auxiliary to financial services and insurance activities	70	89.74	64	82.05	65	83.33	51	65.38	60	76.92	52	66.67	40	51.28	45	57.69	48	61.54
69	Legal and accounting activities	103	91.96	84	75.00	99	88.39	65	58.04	78	69.64	71	63.39	67	59.82	61	54.46	72	64.29
71	Architectural. engineering and related technical activities; (…)	126	89.36	124	87.94	133	94.33	98	69.50	122	86.52	106	75.18	112	79.43	118	83.69	113	80.14
72	Scientific research and development	24	80.00	26	86.67	24	80.00	25	83.33	24	80.00	20	66.67	24	80.00	25	83.33	25	83.33
73	Advertising. market research and public opinion polling	94	97.92	88	91.67	91	94.79	78	81.25	87	90.63	73	76.04	80	83.33	77	80.21	73	76.04
74	Other consultancy. scientific and technical activities	54	94.74	51	89.47	54	94.74	38	66.67	45	78.95	42	73.68	47	82.46	44	77.19	47	82.46
75	Veterinary activities	19	95.00	17	85.00	20	100.00	13	65.00	17	85.00	15	75.00	15	75.00	14	70.00	19	95.00
86	Human health activities	60	63.83	66	70.21	67	71.28	57	60.64	55	58.51	71	75.53	76	80.85	47	50.00	68	72.34
	Total	**6383**	**93.32**	**6148**	**89.88**	**6264**	**91.58**	**5229**	**76.45**	**5635**	**82.38**	**5371**	**78.52**	**5528**	**80.82**	**5439**	**79.52**	**5618**	**82.13**

Source: Author's own computation based on CIS

Table 15 - Aggregation of Innovation barriers per CIS wave and intensity

	Barrier		Barriers to innovation 2006				Barriers to innovation 2010			
			Irrelevant	Low or very low	Medium	High and very high	Irrelevant	Low or very low	Medium	High and very high
Economic Factors	Insufficiency of equity (internal finance)	n	1667	734	1306	1014	1513	1097	1867	1683
		%	35.31	15.55	27.66	21.48	24.56	17.81	30.31	27.32
	Lack of external sources of finance	n	1892	809	1131	889	1685	1119	1764	1592
		%	40.08	17.14	23.96	18.83	27.35	18.17	28.64	25.84
	Innovation costs excessively high	n	1298	527	1420	1476	1155	747	2079	2179
		%	27.49	11.16	30.08	31.26	18.75	12.13	33.75	35.37
Knowledge Factors	Lack of skilled labour force	n	1513	1083	1550	575	1653	1765	2132	610
		%	32.05	22.94	32.83	12.18	26.83	28.65	34.61	9.90
	Lack of information about technology	n	1712	1396	1299	314	1849	2092	1886	333
		%	36.26	29.57	27.52	6.65	30.02	33.96	30.62	5.41
	Lack of information about markets	n	1785	1386	1234	316	1825	2090	1871	374
		%	37.81	29.36	26.14	6.69	29.63	33.93	30.37	6.07
	Difficulty in finding innovation partners	n	2020	945	1150	606	2036	1491	1812	821
		%	42.79	20.02	24.36	12.84	33.05	24.20	29.42	13.33
Market Factors	Market dominated by established firms	n	1647	910	1353	811	1574	1412	2160	1014
		%	34.89	19.28	28.66	17.18	25.55	22.92	35.06	16.46
	Uncertainty about the demand	n	1529	844	1521	827	1377	1211	2245	1327
		%	32.39	17.88	32.22	17.52	22.35	19.66	36.44	21.54

Source: Author's own computation based on CIS 6 and CIS 10

The CIS monitors the perception of firms about innovation barriers each four years. In this case, information relates to the CIS 6 and the CIS 10. Hence, the CIS 12 includes a question concerning this issue. In each case, firms report the importance of the different obstacles to their innovative activities and how hindering that barrier was to the pursuit of the innovative activities.

In the CIS 6, nearly 35% and 40% of the firms found irrelevant the inexistence of either internal or external sources of finance; this percentage falls when posing the same question in the CIS 10. Conversely, equity problems are found as being highly important for an important percentage of firms in the CIS 10 (27 and 26% respectively).

The difficulty in finding innovation partners is more often mentioned as irrelevant; being 43% in the CIS 6 and 33% in the CIS 10.

Being uncertain about demand as well as finding innovation costs as being too high is frequently mentioned as a highly important barrier. This trend is verified in both waves.

2.10. Funds

Innovative activities are considered as merit goods, thus needing Government intervention to correct their low production based on their social desirability. Programs of assistance to innovative companies include several instruments helping the correction of this failure, such as subsidies, soft loans, public funding, fiscal benefits and grants.

Moreover, innovative activities generate knowledge spillovers due to the imperfect appropriability of the kknowledge embedded in innovations. As it becomes non-excludable (hence the returns of this action are not fully internalised by the investors), it discourages first movers. Due to the difficulty of internalising the returns of the investment, the Government must promote assistance to innovative firms re-establishing expected returns of R&D (Georghiou, 1994).

Given that R&D and other innovative activities require substantial financial investments, a lack of financial means could hinder innovation (Hyytinen and Toivanen, 2005).

According to the existing evidence, the effect of public funding in private companies is debatable. To Mansfield (1986), the effect of public funding on private R&D is very exiguous; quite differently, to Hall and Van Reenen (2000) public funding leads to

innovation success. To Lichtenberg (1987), public funds have a crowding out effect over private.

Innovation requires increasing financial investments, as well as greater uncertainty, meaning that it is harder to find investors to support these projects either inside or outside the firm. Firms have to face the dilemma: potential failure vs technological exclusion.

Due to shorter product life cycles, uncertainty about patenting, full appropriability and volatile economic environments, firms have severe difficulties in pursuing the optimal level of R&D activities. Therefore, they will strongly rely on funds to develop their innovative activities overcoming the insufficiency of the internal sources of finance.

Tables 14, 15 and 16 show the distribution of firms relying on the different types of funds per SIC code. This count refers to firms launching any type of Public financial assistance (comprising different instruments) to develop innovative activities. The high levels of risk combined with the lack of financial resources sometimes force firms to become non-innovative. Public funding is expected to play a major role in firms' innovative activities to release the burden of these investments.

Table 16 - Firms reporting relying on funds CIS 6 (CAE Rev. 2.1)

SIC CODE	Local Funds		Government Funds		EU Funds		Other Funds	
	n	%	n	%	n	%	n	%
11 - Mining and quarrying	0	0.00	8	21.62	4	10.81	1	25.00
15 - Manufacture of food, beverages and tobacco	8	6.78	12	10.17	14	11.86	5	35.71
17 - Manufacture of textiles	1	1.56	8	12.50	2	3.13	0	0.00
18 - Manufacture of wearing apparel; dressing and dyeing of fur	0	0.00	4	5.88	1	1.47	1	100.00
19 - Tanning and dressing of leather;	0	0.00	4	16.67	2	8.33	0	0.00
20 - Manufacture of wood and of products	0	0.00	6	9.68	8	12.90	3	37.50
21 - Manufacture of pulp, paper and paper products	0	0.00	3	11.11	2	7.41	0	0.00
22 - Publishing, printing and reproduction of recorded media	3	5.00	3	5.00	2	3.33	0	0.00
23 - Manufacture of coke and chemical products	2	2.20	20	21.98	6	6.59	1	16.67
25 - Manufacture of rubber and plastic products	0	0.00	4	7.27	1	1.82	1	100.00
26 - Manufacture of other non-metallic mineral products	2	2.56	10	12.82	3	3.85	2	40.00
27 - Manufacture of basic metals	0	0.00	8	27.59	1	3.45	0	0.00
28 - Manufacture of fabricated metal products	1	1.37	10	13.70	2	2.74	1	33.33
29 - Manufacture of machinery and equipment n.e.c	0	0.00	3	5.88	0	0.00		n.a.
30 - Manufacture of machinery and computers, electrical machinery	0	0.00	12	26.67	2	4.44	2	66.67
32 - Manufacture of radio, television	0	0.00	5	15.63	3	9.38	1	33.33
33 - Manufacture of medical and optical instruments	0	0.00	2	11.11	4	22.22	2	50.00
34 - Manufacture of motor vehicles, trailers and semi-trailers	2	3.45	11	18.97	1	1.72	0	0.00
35 - Manufacture of other transport equipment	1	3.45	2	6.90	4	13.79	4	100.00
36 - Manufacture of furniture; others manufacturing activities, n.e.c.	2	4.26	5	10.64	4	8.51	2	50.00
37 – Recycling	0	0.00	2	10.00	3	15.00	3	100.00
40 - Production and distribution of electricity	0	0.00	3	21.43	4	28.57	4	100.00
41 - Water collection, treatment and distribution	3	6.82	4	9.09	7	15.91	0	0.00
45 – Construction	3	4.00	12	16.00	7	9.33	1	12.50
51 - Wholesale trade and commission trade	5	1.89	22	8.30	11	4.15	2	18.18
52 - Retail trade	1	2.63	3	7.89	1	2.63	0	0.00
55 - Hotels and restaurants	0	0.00	1	8.33	1	8.33	1	100.00
60 - Land transport; transport via pipelines	3	3.85	7	8.97	2	2.56	2	100.00
61 - Water transport	0	0.00	1	11.11	2	22.22	0	0.00
62 - Air transport	0	0.00	1	12.50	2	25.00	0	0.00
63 - Supporting and auxiliary transport activities	3	3.85	6	7.69	11	14.10	3	25.00
64 - Post and telecommunications	0	0.00	1	3.33	3	10.00	3	75.00
65 - Financial intermediation, except insurance and pension funding	0	0.00	0	0.00	0	0.00		n.a.
66 - Insurance, pension funding	0	0.00	0	0.00	0	0.00		n.a.
67 - Activities auxiliary to financial intermediation	0	0.00	1	3.70	0	0.00		n.a.
72- Computer and related activities and Research and Development	1	1.22	24	29.27	19	23.17	12	60.00
74 - Other business activities	7	2.80	18	7.20	5	2.00	3	50.00
TOTAL	**48**	**2.20**	**246**	**11.25**	**144**	**6.59**	**60**	**37.74**

Source: Author's own computation based on CIS 6

Table 17 - Firms reporting relying on funds CIS 8 (CAE Rev. 3)

SIC CODE		Local Funds		Government Funds		EU Funds		Other Funds	
		n	%	n	%	n	%	n	%
7	Mining and quarrying	1	1.82	1	1.82	0	0.00	n.a.	
10	*Manufacture of food products*	2	2.27	9	10.23	1	1.14	1	100.00
11	*Manufacture of beverages and tobacco*	3	4.84	13	20.97	9	14.52	4	44.44
13	*Manufacture of textiles*	0	0.00	15	14.85	4	3.96	2	50.00
14	*Manufacture of wearing apparel*	0	0.00	5	7.94	1	1.59	0	0.00
15	*Manufacture of leather and related products*	0	0.00	6	6.52	7	7.61	5	71.43
16	*Manufacture of wood and of products of wood and cork*	1	0.99	12	11.88	9	8.91	6	66.67
17	*Manufacture of paper and paper products*	1	1.49	8	11.94	5	7.46	3	60.00
18	*Printing and reproduction of recorded media*	3	3.57	6	7.14	1	1.19	0	0.00
19	*Manufacture of coke and chemical products*	3	3.00	22	22.00	5	5.00	2	40.00
21	*Manufacture of basic pharmaceutical products*	1	3.57	12	42.86	8	28.57	2	25.00
22	*Manufacture of rubber and plastic products*	1	0.68	25	17.12	7	4.79	2	28.57
23	*Manufacture of other non-metallic mineral products*	2	1.23	16	9.88	10	6.17	2	20.00
24	*Manufacture of basic metals*	2	4.88	10	24.39	3	7.32	0	0.00
25	*Manufacture of fabricated metal products,*	9	2.19	49	11.92	22	5.35	8	36.36
26	*Manufacture of computer*	1	2.27	14	31.82	6	13.64	6	100.00
27	*Manufacture of electrical equipment*	2	3.23	19	30.65	5	8.06	1	20.00
28	*Manufacture of machinery*	1	0.94	19	17.92	4	3.77	4	100.00
29	*Manufacture of motor vehicles*	1	1.16	21	24.42	2	2.33	1	50.00
30	*Manufacture of other transport equipment*	0	0.00	1	6.25	1	6.25	1	100.00
31	*Manufacture of furniture*	1	1.04	9	9.38	4	4.17	1	25.00
32	*Other manufacturing activities*	2	2.38	6	7.14	2	2.38	2	100.00
33	*Repair, maintenance and installation*	1	2.00	5	10.00	6	12.00	4	66.67
35	Electricity, gas, steam, cold and hot water and cold air	0	0.00	3	15.79	4	21.05	3	75.00
36	Water collection, treatment and distribution	1	2.22	5	11.11	7	15.56	2	28.57
37	Collection, drainage and treatment of sewage	1	7.14	2	14.29	1	7.14	0	0.00
38	Waste collection and Remediation	2	2.25	11	12.36	8	8.99	2	25.00
42	Civil engineering	0	0.00	3	15.79	0	0.00	n.a.	
43	Specialised construction activities	0	0.00	2	20.00	1	10.00	0	0.00
46	Wholesale trade	8	1.74	36	7.83	14	3.04	4	28.57
47	Retail trade, except of motor vehicles and motorcycles	0	0.00	5	29.41	0	0.00	n.a.	
49	Land transport and transport via pipelines	4	2.74	23	15.75	7	4.79	1	16.67
50	Water transport	0	0.00	2	13.33	1	6.67	1	100.00
51	Air transport	0	0.00	1	6.25	0	0.00	n.a.	
52	Warehousing and support activities	4	4.55	6	6.82	7	7.95	3	42.86
53	Postal and courier activities	0	0.00	0	0.00	0	0.00	n.a.	
58	Publishing activities	4	5.88	10	14.71	4	5.88	3	75.00
59	Motion picture, Radio and Telecommunications	0	0.00	4	12.12	5	15.15	3	60.00
62	Computer programming, consultancy and related activities	4	2.94	44	32.35	22	16.18	17	77.27
63	Information service activities	0	0.00	3	14.29	2	9.52	1	50.00
64	Financial service activities	1	0.93	4	3.70	1	0.93	1	100.00
65	Insurance, reinsurance and pension funding,	0	0.00	0	0.00	0	0.00	n.a.	
66	Activities auxiliary to financial services	0	0.00	2	4.55	0	0.00	n.a.	
69	Legal and accounting activities	0	0.00	3	6.12	1	2.04	0	0.00
71	Architectural, engineering and R&D	2	2.11	21	22.11	10	10.53	8	80.00
73	Advertising, market research and public opinion polling	0	0.00	0	0.00	1	1.59	0	0.00
74	Other consultancy, scientific and technical activities	0	0.00	1	8.33	2	16.67	1	50.00
75	Veterinary activities	0	0.00	1	20.00	0	0.00	n.a.	
86	Human health activities	5	8.33	13	21.67	16	26.67	4	25.00
	TOTAL	**74**	**1.93**	**508**	**13.26**	**236**	**6.16**	**111**	**47.23**

Source: Author's own computation based on CIS 8

Table 18 - Firms reporting relying on funds CIS 10 (CAE Rev. 3)

SIC CODE		Local Funds		Government Funds		EU Funds		Other Funds	
		n	%	n	%	n	%	n	%
7	Mining and quarrying	2	5.56	9	25.00	2	5.56	1	50.00
10	*Manufacture of food products*	5	6.58	18	23.68	4	5.26	1	25.00
11	*Manufacture of beverages and tobacco*	5	10.00	14	28.00	8	16.00	3	37.50
13	*Manufacture of textiles*	0	0.00	19	28.79	3	4.55	2	66.67
14	*Manufacture of wearing apparel*	0	0.00	5	20.83	1	4.17	0	0.00
15	*Manufacture of leather and related products*	2	3.70	13	24.07	7	12.96	4	57.14
16	*Manufacture of wood and of products of wood and cork*	3	2.78	29	26.85	8	7.41	2	25.00
17	*Manufacture of paper and paper products*	2	3.51	11	19.30	7	12.28	0	0.00
18	*Printing and reproduction of recorded media*	2	3.17	7	11.11	2	3.17	1	50.00
19	*Manufacture of coke and chemical products*	2	2.27	22	25.00	9	10.23	3	33.33
21	*Manufacture of basic pharmaceutical products*	0	0.00	16	45.71	3	8.57	1	33.33
22	*Manufacture of rubber and plastic products*	2	1.72	44	37.93	19	16.38	5	26.32
23	*Manufacture of other non-metallic mineral products*	4	3.25	37	30.08	13	10.57	3	23.08
24	*Manufacture of basic metals*	1	2.33	15	34.88	2	4.65	0	0.00
25	*Manufacture of fabricated metal products,*	4	1.24	79	24.46	26	8.05	3	11.54
26	*Manufacture of computer*	0	0.00	13	33.33	8	20.51	4	50.00
27	*Manufacture of electrical equipment*	1	1.35	25	33.78	7	9.46	3	42.86
28	*Manufacture of machinery*	3	2.10	45	31.47	15	10.49	3	20.00
29	*Manufacture of motor vehicles*	0	0.00	29	49.15	7	11.86	1	14.29
30	*Manufacture of other transport equipment*	0	0.00	4	15.38	4	15.38	2	50.00
31	*Manufacture of furniture*	1	1.02	28	28.57	7	7.14	1	14.29
32	*Other manufacturing activities*	0	0.00	15	18.52	6	7.41	2	33.33
33	*Repair, maintenance and installation*	0	0.00	18	27.27	4	6.06	2	50.00
35	Electricity, gas, steam, cold and hot water and cold air	0	0.00	6	30.00	5	25.00	4	80.00
36	Water collection, treatment and distribution	1	2.78	2	5.56	8	22.22	1	12.50
37	Collection, drainage and treatment of sewage	0	0.00	0	0.00	0	0.00	0	0.00
38	Waste collection and Remediation	3	3.90	17	22.08	8	10.39	3	37.50
42	Civil engineering	0	0.00	6	26.09	1	4.35	0	0.00
43	Specialised construction activities	0	0.00	4	33.33	1	8.33	0	0.00
46	Wholesale trade	15	3.46	62	14.29	26	5.99	5	19.23
47	Retail trade, except of motor vehicles and motorcycles	1	7.69	1	7.69	0	0.00	0	0.00
49	Land transport and transport via pipelines	4	3.03	23	17.42	8	6.06	1	12.50
50	Water transport	0	0.00	1	11.11	1	11.11	1	100.00
51	Air transport	0	0.00	1	11.11	0	0.00	0	0.00
52	Warehousing and support activities	1	1.61	7	11.29	11	17.74	5	45.45
53	Postal and courier activities	0	0.00	2	25.00	0	0.00	0	0.00
58	Publishing activities, Motion picture and Radio	3	4.35	19	27.54	8	11.59	4	50.00
61	Telecommunications	2	9.52	7	33.33	7	33.33	3	42.86
62	Computer programming, consultancy and related activities	3	2.42	51	41.13	22	17.74	11	50.00
63	Information service activities	1	4.17	9	37.50	2	8.33	1	50.00
64	Financial service activities	0	0.00	5	7.35	0	0.00	0	0.00
65	Insurance, reinsurance and pension funding,	1	2.27	1	2.27	0	0.00	0	0.00
66	Activities auxiliary to financial services	0	0.00	1	2.94	0	0.00	0	0.00
69	Legal and accounting activities	2	3.64	0	0.00	1	1.82	0	0.00
71	Architectural, engineering and related technical activities	3	3.23	20	21.51	9	9.68	1	11.11
72	Scientific research and development	0	0.00	10	76.92	4	30.77	2	50.00
73	Advertising, market research and public opinion polling	1	2.04	7	14.29	0	0.00	0	0.00
74	Other consultancy, scientific and technical activities	0	0.00	8	17.02	6	12.77	2	33.33
75	Veterinary activities	0	0.00	1	33.33	0	0.00	0	0.00
86	Human health activities	4	5.71	11	15.71	12	17.14	2	16.67
	TOTAL	**84**	**2.47**	**797**	**23.40**	**312**	**9.16**	**93**	**29.81**

Source: Author's own computation based on CIS 10

Table 19 - Firms reporting relying on funds CIS 12 (CAE Rev. 3)

		Local Funds		Government Funds		EU Funds		Technical Development Funds		Other Funds	
7	Mining and preparation of metal ores										
8	Other mining and quarrying										
9	Mining and quarrying related service activities	1	5.26	5	26.32	6	31.58	1	5.26	0	0
10	*Manufacture of food products*	9	9.09	30	30.30	12	12.12	2	2.02	0	0
11	*Manufacture of beverages*	2	2.78	25	34.72	22	30.56	2	2.78	0	0
12	*Manufacture of tobacco products*										
13	*Manufacture of textiles*	2	2.78	29	40.28	16	22.22	4	30.86	0	0
14	*Manufacture of wearing apparel*	1	3.03	4	12.12	3	9.09	0	27.55	0	0
15	*Manufacture of leather and related products*	4	5.80	27	39.13	10	14.49	3	21.00	0	0
16	*Manufacture of wood and of products of wood and cork. (...)*	1	1.18	25	29.41	17	20.00	4	23.53	0	0
17	*Manufacture of paper and paper products*	1	2.13	10	21.28	5	10.64	0	22.63	0	0
18	*Printing and reproduction of recorded media*	4	5.71	10	14.29	6	8.57	1	12.24	0	0
19	*Manufacture of coke. refined petroleum products and fuels briquettes*	1	1.27	28	35.44	10	12.66	4	5.06	0	0
20	*Manufacture of chemicals. chemical products and man-made fibers. (...)*										
21	*Manufacture of basic pharmaceutical products and pharmaceutical preparations*	2	6.25	21	65.63	7	21.88	1	3.13	0	0
22	*Manufacture of rubber and plastic products*	5	3.52	34	23.94	19	13.38	4	2.82	0	0
23	*Manufacture of other non-metallic mineral products*	4	2.60	44	28.57	18	11.69	3	1.95	0	0
24	*Manufacture of basic metals*	0	0	12	34.29	3	8.57	0	0.00	0	0
25	*Manufacture of fabricated metal products. except machinery and equipment*	11	3.74	86	29.25	33	11.22	4	1.36	0	0
26	*Manufacture of computer. communication equipment. electronic and optical products*	3	6.98	26	60.47	11	25.58	2	4.65	1	2.33
27	*Manufacture of electrical equipment*	0	0	21	33.87	9	14.52	1	1.61	0	0
28	*Manufacture of machinery and equipment n.e.c.*	1	0.86	30	25.86	12	10.34	2	1.72	0	0
29	*Manufacture of motor vehicles. trailers. semi-trailers and parts (...)*	1	1.35	32	43.24	10	13.51	1	1.35	0	0
30	*Manufacture of other transport equipment*	2	6.90	5	17.24	3	10.34	1	3.45	0	0
31	*Manufacture of furniture*	2	2.67	24	32.00	12	16.00	3	4.00	0	0
32	*Other manufacturing activities*	2	2.99	14	20.90	12	17.91	2	2.99	0	0
33	*Repair. maintenance and installation of machinery and equipment*	3	4.62	16	24.62	5	7.69	2	3.08	0	0
35	*Electricity. gas. steam. cold and hot water and cold air*	0	0	9	40.91	7	31.82	4	18.18	0	0
36	Water collection. treatment and distribution	0	0	3	8.57	3	8.57	1	2.86	0	0
37	Collection. drainage and treatment of sewage	0	0	2	22.22	1	11.11	0	0.00	0	0
38	Waste collection. treatment and disposal activities; materials recovery	3	3.61	11	13.25	18	21.69	2	2.41	0	0
39	Remediation and similar activities										
42	Civil engineering	1	6.67	6	40.00	1	6.67	0	0	0	0
43	Specialised construction activities	0	0	3	75.00	0	0	0	0	0	0
46	Wholesale trade (include commission trade). except of motor vehicles (…)	18	4.07	63	14.25	40	9.05	10	2.26	0	0
47	Retail trade. except of motor vehicles and motorcycles	0	0	1	9.09	0	0	0	0	0	0
49	Land transport and transport via pipelines	7	5.51	24	18.90	7	5.51	4	3.15	0	0
50	Water transport	0	0	2	25.00	0	0.00	0	0	0	0
51	Air transport	2	14.29	0	0	1	7.14	0	0	0	0
52	Warehousing and support activities for transportation (include cargo handling)	4	5.26	8	10.53	8	10.53	4	5.26	1	1.32
53	Postal and courier activities	0	0	0	0	1	20.00	0	0	0	0
58	Publishing activities	5	7.81	19	29.69	11	17.19	4	6.25	0	0
59	Motion picture. video and television program production. (…)	0	0	2	13.33	0	0	0	0	0	0
60	Radio and television activities	0	0	1	16.67	2	33.33	0	0	0	0
61	Telecommunications	0	0	6	37.50	3	18.75	1	6.25	0	0
62	Computer programming. consultancy and related activities	5	4.31	53	45.69	25	21.55	10	8.62	0	0
63	Information service activities	1	5.56	7	38.89	3	16.67	1	5.56	0	0
64	Financial service activities. except insurance and pension funding	0	0	4	5.71	1	1.43	0	0	0	0
65	Insurance. reinsurance and pension funding. except compulsory social security	2	4.55	3	6.82	0	0	0	0	0	0
66	Activities auxiliary to financial services and insurance activities	1	2.78	0	0	0	0	0	0	0	0
69	Legal and accounting activities	2	6.06	2	6.06	2	6.06	1	3.03	0	0
71	Architectural engineering and related technical activities; (…)	2	2.86	19	27.14	14	20.00	4	5.71	0	0
72	Scientific research and development	3	12.00	19	76.00	12	48.00	9	36.00	0	0
73	Advertising. market research and public opinion polling	2	5.00	6	15.00	3	7.50	0	0	0	0
74	Other consultancy. scientific and technical activities	1	3.23	8	25.81	8	25.81	1	3.23	0	0
75	Veterinary activities	1	7.69	1	7.69	0	0	0	0	0	0
86	Human health activities	4	6.67	12	20.00	11	18.33	3	5.00	0	0
	TOTAL	**126**	**3.77**	**852**	**25.50**	**443**	**13.26**	**106**	**3.17**	**2**	**0.06**

Source: Author's own computation based on CIS 12

Quite surprisingly, the number of firms seeking this source of finance for their innovative activities is quite reduced in all economic sectors. In the three CIS types analysed, Government Funds are those in which firms rely more often (246 firms in the CIS 6, 508 firms in the CIS 8 and 797 firms in the CIS 10), immediately followed by European funds. Local funds are neglected during the three biennia, being used by a small fringe of the respondent sample.

Across the waves, sectors such as *scientific research and development*; *electricity, gas, steam, cold and hot water and cold air*; *manufacture of rubber and plastic products*; *manufacture of leather and related products* present above average performances with important proportion of firms using funds to support their innovative activities.

Moreover, most companies perform simultaneous strategies to access knowledge, thus relying on different sources of finance and information. The choice of the partner will depend on the aim being pursued.

The ability to generate internal R&D will enhance the use of external sources of information for innovation (Mowery, 1983). There is interdependence between internal and external knowledge production (Mowery and Rosenberg, 1989). The existence of absorptive capacity, allows for the identification, absorption and exploitation of knowledge arising from the external environment. Cohen and Levinthal (1990) firms with internal endowments will present kinship with external sources thus speeding up the pace of innovative activities. “Open” firms will have improved capacity to develop innovative activities (Laursen and Salter, 2004). This suggests that firms may not seize the use of funds due to their inability to gather these underlying competences.

When breaking down the use of funds per firm size, the higher proportion of firms that rely on Funds regardless of their origins, are medium sized and large. Even though there is a common pattern in terms of the origin of the assistance, local funds are quite unused while Government and European funds are more often mentioned as being used by firms.

Due to the existence of a more organised structure, and wider human capital, large firms will be more likely to have the absorptive capacity that allows for these grants.

Table 20 - Firms reporting relying on funds per size (CIS 6)

SIZE (No. employees)	Local Funds		Government Funds		EU Funds		Other Funds	
	n	%	n	%	n	%	n	%
20 to 49	24	2.00	90	7.51	59	4.92	19	31.67
50 to 249	17	2.50	92	13.55	64	9.43	27	38.03
250 or more	7	2.27	64	20.71	21	6.80	14	50.00
Overall	**48**	**2.20**	**246**	**11.25**	**144**	**6.59**	**60**	**37.74**

Source: Author's own computation based on CIS 6

The use of Government funds is an alternative to overcome the lack of internal funds. There is an expectation that firms will use this opportunity to boost the ability to gather finance to devote to the development of innovative activities. In the CIS 6, 11.25% of the firms in the respondent sample mentioned the use of Government Funds. This percentage is quite below the expectation, this, means that firms are not particularly interested in this source of finance for their innovative activities. Hence, firms may be interested in Government financial support, despite being incapable of reaching the requirements.

When moving to other funds (unspecified), the percentage of affirmative responses rises to 37.74% which is higher than the other achievements but below the expectations.

Table 21 - Firms reporting relying on funds per size (CIS 8)

SIZE (No. employees)	Local Funds		Government Funds		EU Funds		Other Funds	
	n	%	n	%	n	%	n	%
20 to 49	61	1.98	302	9.81	148	4.81	36	43.37
50 to 249	6	1.52	101	25.57	44	11.14	56	51.38
250 or more	7	1.96	105	29.33	44	12.29	130	46.76
Overall	**74**	**1.93**	**508**	**13.26**	**236**	**6.16**	**236**	**6.16**

Source: Author's own computation based on CIS 8

In the CIS 8, firms scantly relied on local funds as they did in the former biennium. Government funds were used by 13% of overall respondents; in absolute figures, small firms achieved 302 affirmative responses, which represent 10% of the total. The most commonly used financial aid is "other funds".

Table 22 - Firms reporting relying on funds per size (CIS 10)

SIZE	Local Funds		Government Funds		EU Funds		Other Funds	
(No. employees)	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
20 to 49	56	2.96	320	16.93	139	7.35	37	26.62
50 to 249	21	1.74	366	30.32	132	10.94	132	33.33
250 or more	7	2.27	111	35.92	41	13.27	41	29.27
Overall	**84**	**2.47**	**797**	**23.4**	**312**	**9.16**	**93**	**29.81**

Source: Author's own computation based on CIS 10

As in the former editions, the CIS 10 reinforced the previous results. Government and EU funds are pointed by firms as the most commonly used source of finance for innovative activities.

Table 23 - Firms reporting replying on funds per size (CIS 12)

SIZE	Local Funds		Government Funds		EU Funds		Other Funds	
(No. employees)	**n**	**%**	**n**	**%**	**n**	**%**	**n**	**%**
20 to 49	78	1.69	344	7.47	184	3.99	42	0.91
50 to 249	34	1.84	391	21.14	202	10.92	49	2.65
250 or more	14	3.66	117	30.55	57	14.88	15	3.92
Overall	**126**	**1.84**	**852**	**12.46**	**443**	**6.48**	**106**	**1.55**

Source: Author's own computation based on CIS 12

In the same vein, the CIS 12 presented Government and EU funds as being the most frequently mentioned by the firms. Local funds as well as other funds are rarely mentioned as sources of finance for innovative activities.

2.11 R&D Intensity

This measure compares the total amount spent in R&D activities (meaning spending in knowledge and technology, regardless of the area) to the firm turnover, for the purpose of achieving innovation. It is the most prevalent measure of innovation input. This ratio proxy the relative financial effort devoted to the production of knowledge.

The Frascati Manual, OECD (2002), defines R&D as "creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications". Its intensity will illustrate the proportion of the firm turnover applied in these types of actions.

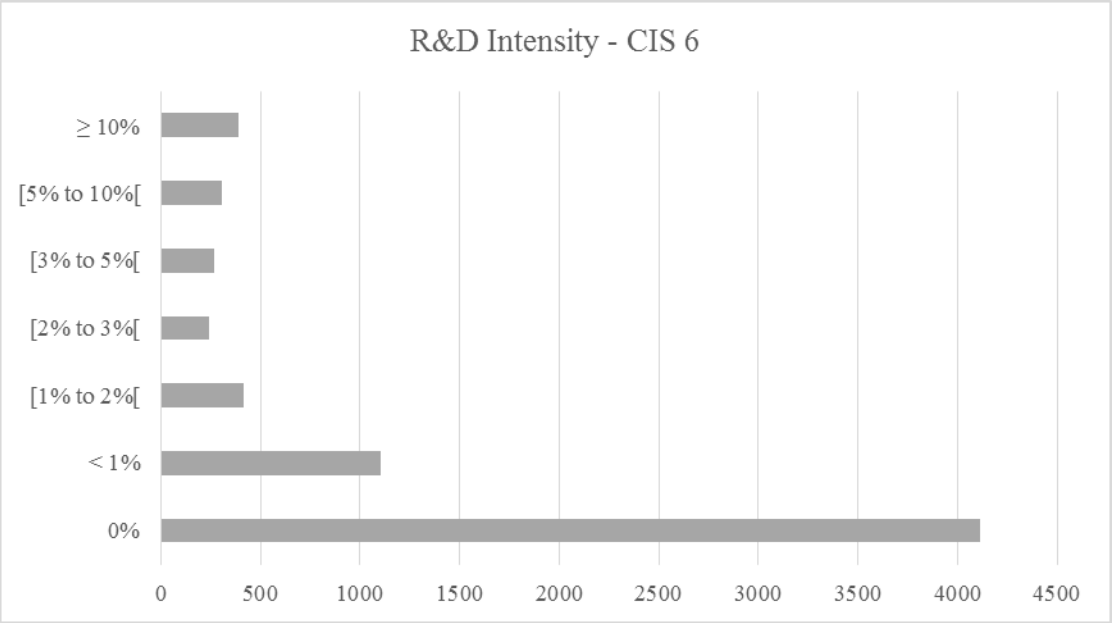
The R&D intensity is measured by the division of the total expenditure in research and development activities compared to the total output. This ratio, at the individual level, describes the importance given to innovative activities in the managerial strategy; at the aggregate level it is an indicator of progress. The Lisbon Agenda (in the so called Barcelona target) points to a 3% R&D investment at the aggregate level as European target. The difference between industrial sectors provides a plausible explanation for different R&D intensities due to the intrinsic nature of the economic activity despite the managerial options. The highest proportion of firms in the respondent sample referred not devoting resources to these activities.

Supplier dominated sectors present feeble in-house R&D, as this category includes traditional manufacturing sectors. However these internal sources may be involved in the introduction of entirely new products. Scale–intensive firms will rely on either internal or external sources, thus presenting potential high levels in terms of R&D intensity. Specialised suppliers will naturally present strong intramural R&D to be traded with other firms. Non-surprisingly, Science-based firms will present strong intramural and extramural R&D activities with strong ties to Universities and Labs (Pavitt, 1984).

In the CIS 6, an important number of firms, 3049 reported a nil value in this indicator which means that during the period there were no R&D expenditures. There were

695 firms whose R&D intensity scaled up to 1%, 238 between 1% and 2%, 153 between 2% and 3%. There were 586 firms reporting 3% or more.

Graphic 15 - Distribution of firms according to their R&D intensity - CIS 6

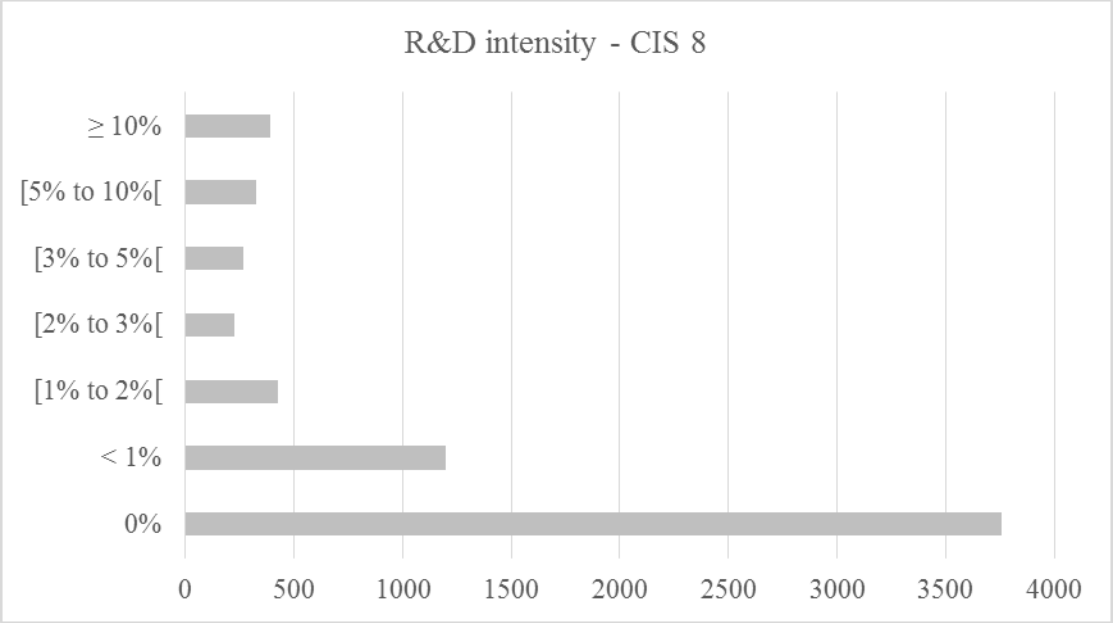


Source: Author's own computation based on CIS 6

The European goal is reaching a 3% average of R&D intensity. The respondent sample is quite heterogeneous; 3049 firms have mentioned not devoting any resources to R&D activities; 695 firms mentioned an R&D intensity of up to 1%, additionally, 238 firms reported from 1 to 2% intensity, moreover 153 firms referred from 2 to 3%.

Only 586 firms have mentioned R&D intensities above the European target. For the CIS 6 the overall R&D intensity (corrected from outliers) reaches 2.12%.The general results for the Portuguese sample are quite positive, although it is worth analysing the significant number of firms with nil R&D activities.

Graphic 16 - Distribution of firms to their R&D intensity - CIS 8

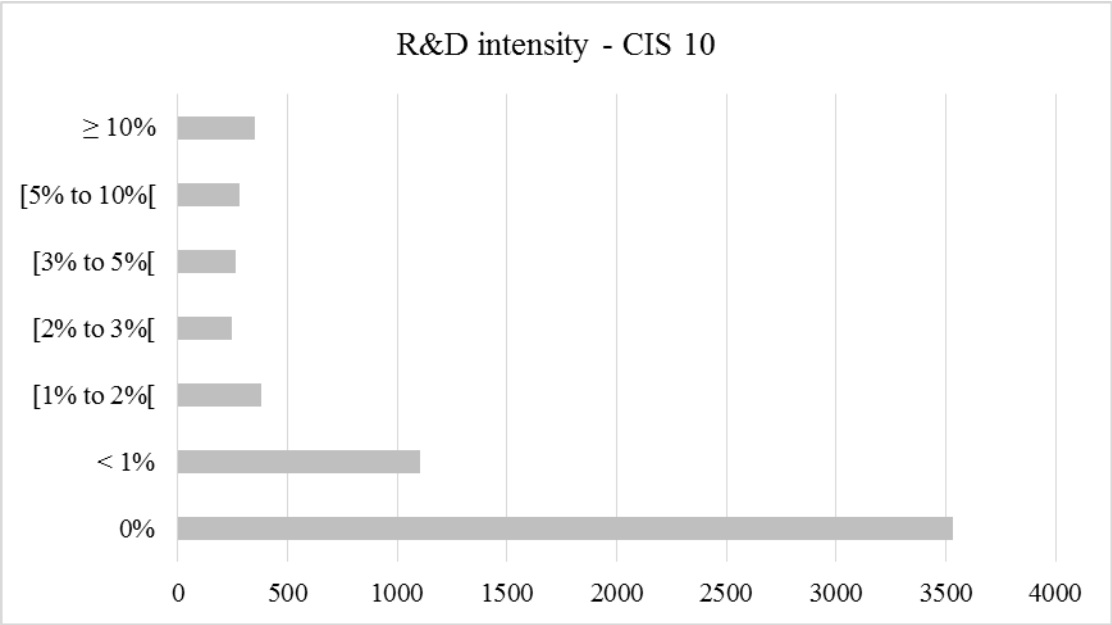


Source: Author's own computation based on CIS 8

The general results presented for the CIS 8 (correcting for outliers) is higher than the former edition, reaching 2.26%. It illustrates an improvement in the average performance of the respondent firms. Hence, the number of respondent firms mentioning nil R&D activities rose to 3758. These results increased the asymmetry between the firms with no R&D from those with above average proportions. The number of firms reporting positive R&D expenditures up to 3%, was 1845. The proportion of firms presenting an above the target R&D intensity went up to 985. These results were more positive than those presented in the former biennium but drawing a similar pattern.

To address a deeper understanding of the reality in terms of R&D intensity more variables and correlations should be analysed, although the result is positive and on track to achieve the European recommendations. The most important aspect to be analysed has to do with firms not performing R&D, to get a deeper understanding about the underlying reasons for this strategic behaviour.

Graphic 17 - Distribution of firms to their R&D intensity - CIS 10



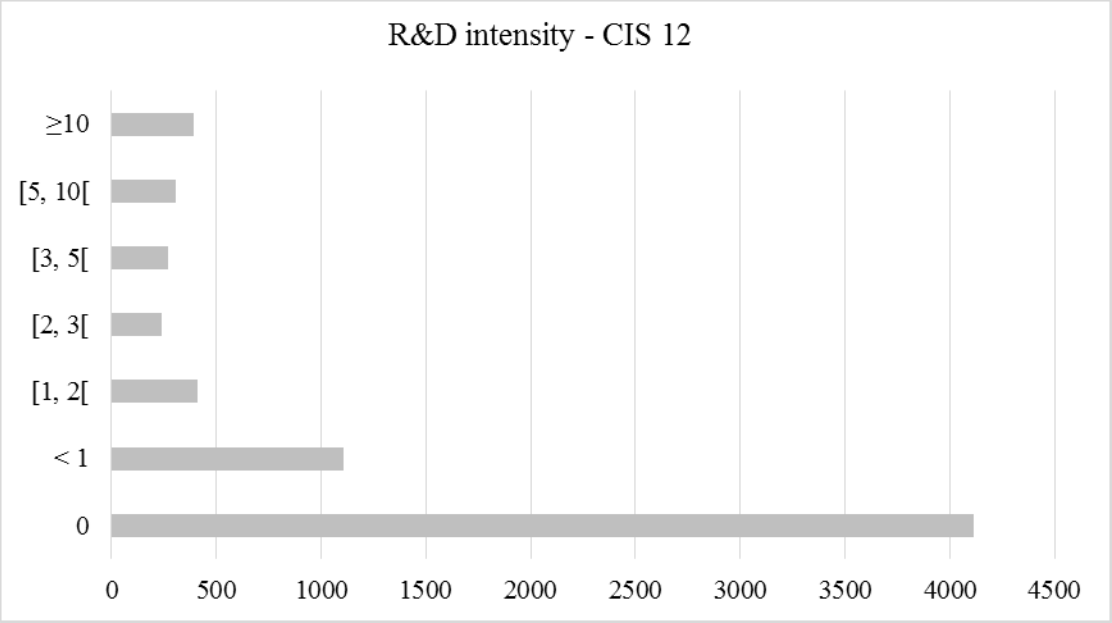
Source: Author's own computation based on CIS 10

The CIS 10 presents an overall performance with a similar pattern than the firmer editions. The proportion of firms not performing any type of R&D activity is high, as it was in the past. Regardless of their sector, there were 3530 firms.

The number of firms reporting R&D expenses up to 3% went up to 1731, with a similar distribution than the former biennia. The proportion of firms with more than 3% of R&D intensity went up to 899, this value is far above the former results. The average proportion of R&D intensity in the respondent sample 2.15% (correcting for outliers).

Over this period the patterns described by the respondent sample are very similar, and remarkably there is a significant asymmetry between those who did not perform any type of innovative activity and those with abnormally high intensities.

Graphic 18 - Distribution of firms to their R&D intensity - CIS 12



Source: Author's own computation based on CIS 12

The results for the CIS 12 present a similar pattern from the previous editions. An important part of the firms do not devote any resources to R&D activities; even though, more than a thousand firms use 1% of their turnover to perform R&D, and the same number goes up to 5%. The asymmetries among firms continue to exist perhaps due to the strategic options, so, one can find different R&D behaviours.

3. Innovation Union Scoreboard (IUS) – Portuguese Performance

3.1. Initial considerations

In this section the Portuguese performance on the innovation union scoreboard is described in general and details terms. At first a time series analyses is made, followed by an analyses per component. Finally an overall conclusion is made to describe the findings

3.2. Description of the IUS

In the Lisbon European Council that took place in 2000 emerged the resolution that Europe had to be the most competitive and dynamic power in the world in the first decade of the 21st century. The European Union is particularly concerned about innovation activities as well as innovation policy due to the general belief that it is the engine of economic growth. EU-Members regard innovation as being particularly important. Fostering innovative activities will allow firms to expand productive performance and economic efficiency.

Innovation efficiency is considered as a major vector of the innovation policy. It can be measured as the ability to transform innovation inputs into innovation outputs; by comparing the inputs to the outputs the country performance is measured, although it is important to remind that sometimes they are not contemporary as current investments may flourish in the future.

The European Innovation Scoreboard (EIS) is a composite indicator that has been compiled since 2001. It was initially named EIS, but in 2011, its name changed to Innovation Union Scoreboard (IUS). The methodology was almost invariant along the entire period, thus enabling time series analysis of countries.

The IUS offers an annual assessment regarding the innovative performance of the EU members in different fields along with the world's innovative leaders (such as: US, Japan and South Korea). It provides a comprehensive analysis of the research and innovation performance of countries designing the strengths and weaknesses of their systems of innovation. Examining the IUS figures will allow for the observation of achievements in the implementation of "Europe 2020 Innovation Union" strategy.

The assessment of this indicator will produce reliable information to policy makers, entrepreneurs and other economic agents about relevant actions to be taken in order to improve their innovative performance. Country policy combined actions do not necessarily

respond to the country's specific innovation challenges and could be made more effective by a reorientation. The framework of this composite indicator will illustrate the advantages as well as the hampering factors.

Country performance, considering this composite index, will rank from 0 to 1 according to the methodological framework (Summary Innovation Index – SII). Results are produced based on three major groups of indicators: *Enablers* (innovation performance external to the firm); *Firm Activities* (innovation efforts at firm-level), and *Outputs* (effects of firms' innovation activities on the economy). The first and the second group are considered as innovation inputs, while the third is an innovation output. The vectors of analysis have suffered minor modifications since the first edition.

The *Innovation Drivers* evaluate the structural conditions to develop the innovation potential. *Knowledge Creation* assesses the investments in R&D, vital for a knowledge-based economy. *Innovations and Entrepreneurship* considers the internal efforts of firms to develop innovative activities. *Applications*, weigh the labour and business activity in the innovative sector; *Intellectual Property* illustrates accomplishments in knowledge creation (European Innovation Scoreboard, 2006).

The EU members are ranked into four groups according to their performance compared to the average. The top innovators are classified as *Innovation Leaders*, the second *Innovation Followers*; the third are *Moderate Innovators* and lastly *Modest Innovators*.

Once more, Portugal was classified as *Moderate Innovator* ranking below the European average on the SII. According to the IUS 2015, it is ranked as the 6th EU-Member below the average. This result represents an improvement compared to the 7th position reached in the IUS 2014. Both in 2013 and 2008 Portugal was in the 6th position below the European average. Although it is worthwhile to highlight that in 2011 Portugal ranked 5th below average, in 2010 it ranked 4th, and it was 3rd below average in 2009.

When analysing the data at the aggregate level in the different waves of the survey, innovation leaders present a balanced accomplishment drawing an almost perfect cobweb and performing, not surprisingly, above average in all dimensions. This suggests that their performance is due to their balanced innovation system.

As mentioned in the IUS reports, leaders present a National Research and System of Innovation (NrSI) in which firms' activities play a major role along in public-private

collaboration (one of the components analysed in the *Linkages and Entrepreneurship*). When an individual analysis is performed among leaders, with no exceptions, the scores in Public-private co-publications are high which may indicate the need for good linkages among external sources of innovation.

In order to replicate the leaders' achievements (whose performance is balanced in the different innovation dimensions), the production of a well-adjusted NrSI requires policy actions' fine tuning considering the country's specificities (as there are differences among groups and individual constraints in each country).

Consequently, it is worth analysing the European Commission recommendation which advises the development of specific policy design for each country: the analysis of funding applications; the incentive to create industry-science solid collaborations and a deeper understanding of the role of grants in supporting innovation activities.

On average, moderate innovators perform poorer in *Open, Excellent Research Systems, Linkages & Entrepreneurship*, and *Intellectual Assets*. It is in the *Human Resources* component where the gap between countries, in all groups, is smaller.

In 2001, Portugal was labelled as "falling further behind". This innovative scenario is worth analyzing as it means that the achievements are below the European average and present a negative trend.

Major drawbacks consisted of poor education (e.g. participation in life-long learning) as well as the lack of innovative SME's and the absence of high-tech venture capital investment. The overall performance in terms endowments of human resources is poor (tertiary education levels and long life learning) as the results fall below the average. There is also limited creation of knowledge and its transmission regarding the scarce public and private R&D expenditures.

In terms of innovation finance, output and market component the Portuguese performance is closer to the European average; the strengths were based on the ICT expenditure, product innovation and high-tech patenting despite a noticeable increasing trend.

In 2002, the Portuguese overall performance was quite similar from the former despite the differences in specific indicators. Major weaknesses were focused in educational issues such as tertiary education and lifelong learning, and the scarce availability of venture capital and other capital. Whereas R&D intensity (in public and

private sectors) the existence of new graduates ICT networks were pointed as positive aspects.

Intellectual assets is the vector in which Portugal has the poorest performance over time; it goes in the same way as the European average: "one of the main concerns over time has been a lower rate of patenting by European firms (European Innovation Scoreboard, 2006: 26)". Two possible explanations are presented: the difference in the industrial structure or the different attitude towards Intellectual Property.

The Scoreboard includes three major components dividing the factors in the innovation system into enablers, firm activities and outputs. The major weakness of the Portuguese framework is included in the Firms Activities, in particular, Intellectual Assets. Portuguese entrepreneurs face severe difficulties in the register of patents, trademarks or designs. The SII is a general indicator, is presents the overall performance of the country regardless the asymmetries or the *apports* of the diverse economic sectors or even the innovation methods. The contribution of the different industries is unknown, and as any average there is no concrete perception about the real diversity.

There is no solid tradition in terms of patenting in Europe, Portugal is not exception, and there are poor results in this aspect, scoring below the average. The difference between Europe and the USA in terms of the innovative performance is not purely based on technological innovation; the entrepreneurial sector is more dynamic, opens and proactive, anticipating product life cycles by means of innovation. There is an innovative tradition among American entrepreneurs and the ties with the Universities are very strong. The National Innovation System of the European countries is far more rigid, with formal ties, with complex and bureaucratic relations among institutions slowing down the pace of cooperation and probably the odds of producing new patents, trademarks or licenses.

There is an important gap between Europe and the World innovation leaders. The productivity growth of the US over Europe is not exclusively a matter of technology. Firms use different methods to innovate thus creating different innovation patterns.

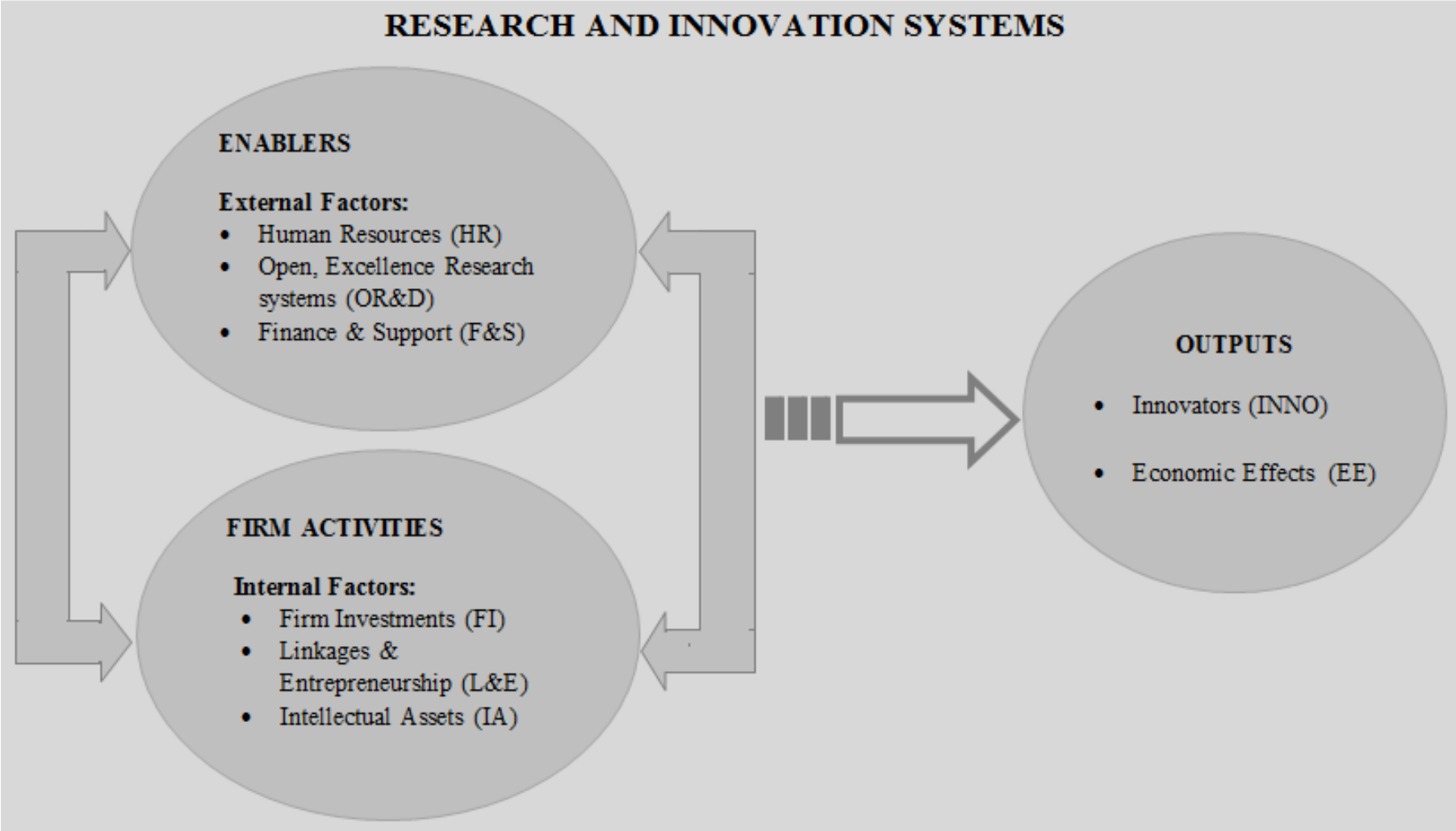
American firms are able to reshape their organisations, management methods maximizing the return of the technology. Internal flexibility in different areas is determinant to transform technological innovation into new markets.

The economic crisis that started in 2007 was expected to severely reduce the innovation levels, especially in the sectors where innovation expenditures are higher. The empirical evidence provided by the EIS showed that these expectations were likely mistaken: firms with high innovative intensity did not change their strategy despite the crisis, firms performing R&D in a regular base continued their innovative path; the effect of the crisis will affect expenditures in R&D and innovation in mid-low tech sectors and sectors. Broader innovation strategies were not intensely affected by expenditure cuts. There are no differences between small and large firms concerning the eventual cuts in innovation expenditures.

According to the Innovation Union Scoreboard (IUS) of 2014 “The impact of economic crisis upon innovation was not as severe as expected”. Countries were converging at the same rate as in 2009.

Figure 1 present a scheme of a research and innovation system organising according to the general topics and the functioning of the framework. So, one can observe the interconnectedness among the components.

Figure 1 - Factors in the research and innovation system



Source: Author's organisation based on the IUS framework

3.3. Portuguese performance in the Scoreboard – Yearly Analysis

The SII produces an overview of the innovative performance of countries considering a multidimensional analysis. It reflects the ability to produce and commercialise knowledge, which requires a complex set of factors (Veugelers, 2007).

Innovation inputs: *innovation drivers* reflect the underlying structural conditions to develop innovation potential, focusing on education levels, and other characteristics of the human resources; *knowledge creation* is the basis of a successful knowledge-based economy, it measures the investments in R&D activities from public and private agents as well as the use of public funds; *Innovation and entrepreneurship* efforts towards innovation at the firm level, comprising expenditures innovative activities in several aspects, the presence of venture capital.

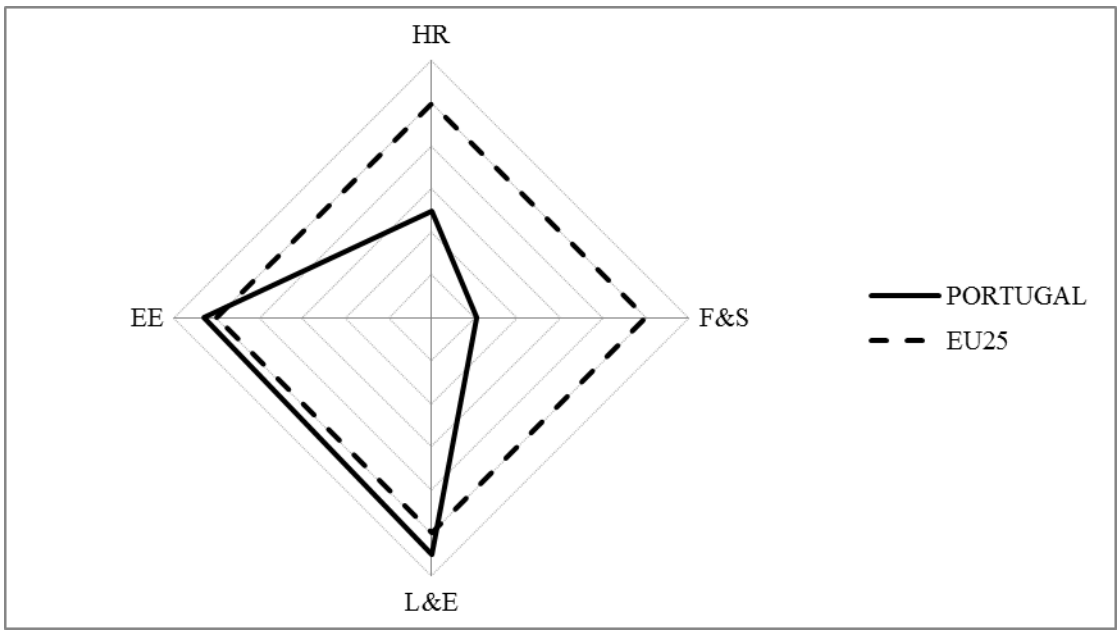
Innovation outputs: *applications* measuring the performance, in terms of labour and business activities and their value added, it includes employment in high-tech, the impact of innovation on sales. *Intellectual property* measures the successful know-how in terms of patents and their applications.

3.3.1. Portuguese performance in the EIS 2004

The illustration of the Portuguese innovation performance in terms of the EIS 2004 is made using four vectors of analysis: the *economic effects* (measuring the returns of innovation), the *human resources* (evaluating the skills of the labour force , namely the proportion of individuals with doctorates, tertiary and secondary education), *finance and support* (illustrating the R&D expenditures in the public sector and the availability of venture capital); and finally *linkages and entrepreneurship* (representing the intramural R&D activities; the establishment of linkages with other sources of information to perform innovative activities; and the existence of public-private co-publications).

The Portuguese achievements (bold line) will be compared to the European average (dashed line). In this period, the results felt below the European average, the efforts performed over the following moments permitted granting the classification as Moderate Innovator.

Graphic 19 - Innovation scoreboard - Portuguese performance EIS 2004



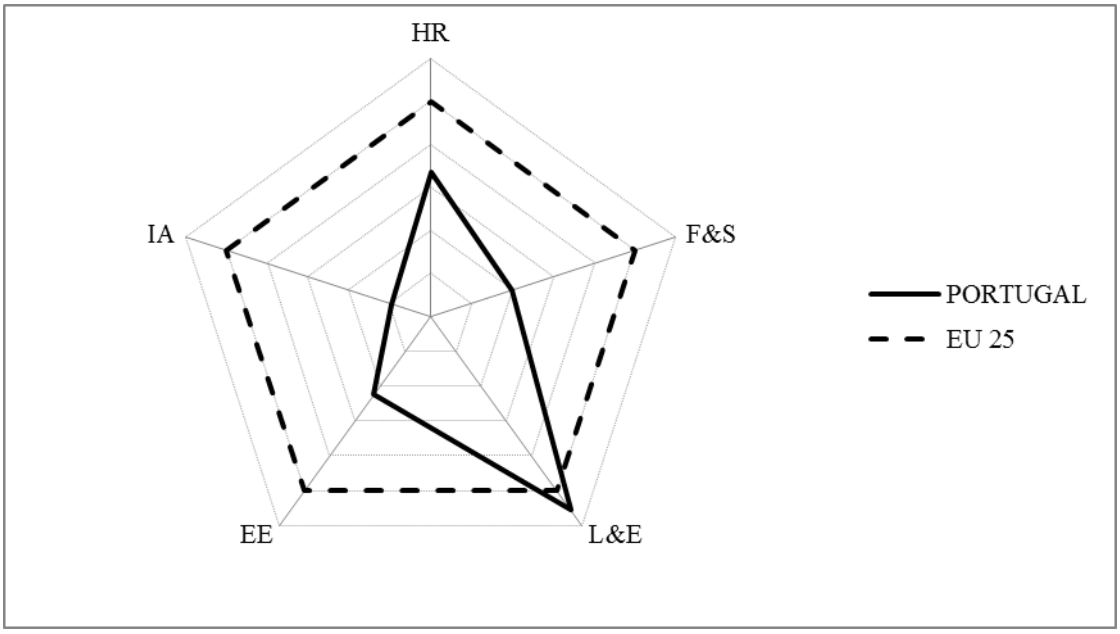
Source: Author's computation based on EIS data (2004)

The Portuguese performance in the EIS 2004 is made relying on four vectors. It illustrates that the major distance from the European average is in terms of *finance and support*; it reaches only one fifth of the EU 25 score. In terms of the *human resources* vector the result is also half the European average. Concerning the existence of *linkages and entrepreneurship*, the performance outweighs the average, being the major strength of the country, immediately followed by the economic effects that are also higher than the average.

3.3.2. Portuguese performance in the EIS 2005

The country's overall performance will be described by means of a five vector diagram. This framework directly follows the data provided by the EIS in the SII index. Each vector represents a different component of the research and innovation system.

Graphic 20 - Innovation scoreboard - Portuguese performance EIS 2005



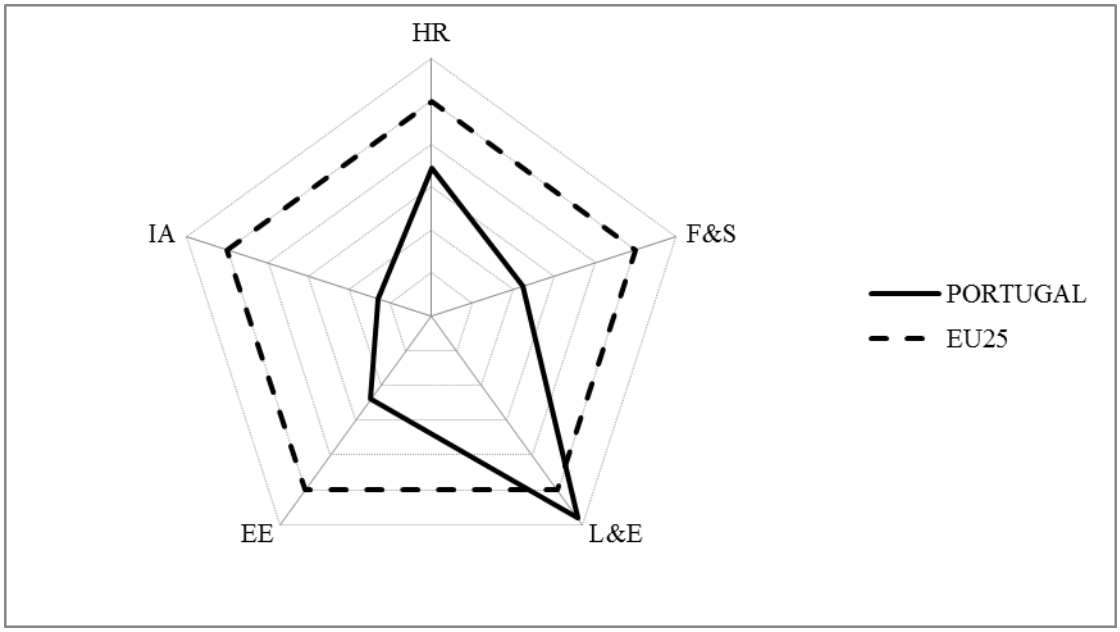
Source: Author's computation based on EIS data (2005)

In 2005, five components were included to appreciate the Portuguese performance; the additional issue includes intellectual assets. The results are quite similar than those of the former year concerning the human resources component and the finance and support, staying below the European average.

In terms of the linkages and entrepreneurship component, the result obtained for 2005 is once more above the average, with a close achievement than the former year. The economic effects component felt, although its composition has changed compared to 2004, it is nearly 50% of the European average. The intellectual assets component has a poor achievement; the Portuguese overall is nearly one fifth of the European average. This means that the ability to generate patents and other protections of the intellectual property is scant.

3.3.3. Portuguese performance in the EIS 2006

Graphic 21 - Innovation scoreboard - Portuguese performance EIS 2006

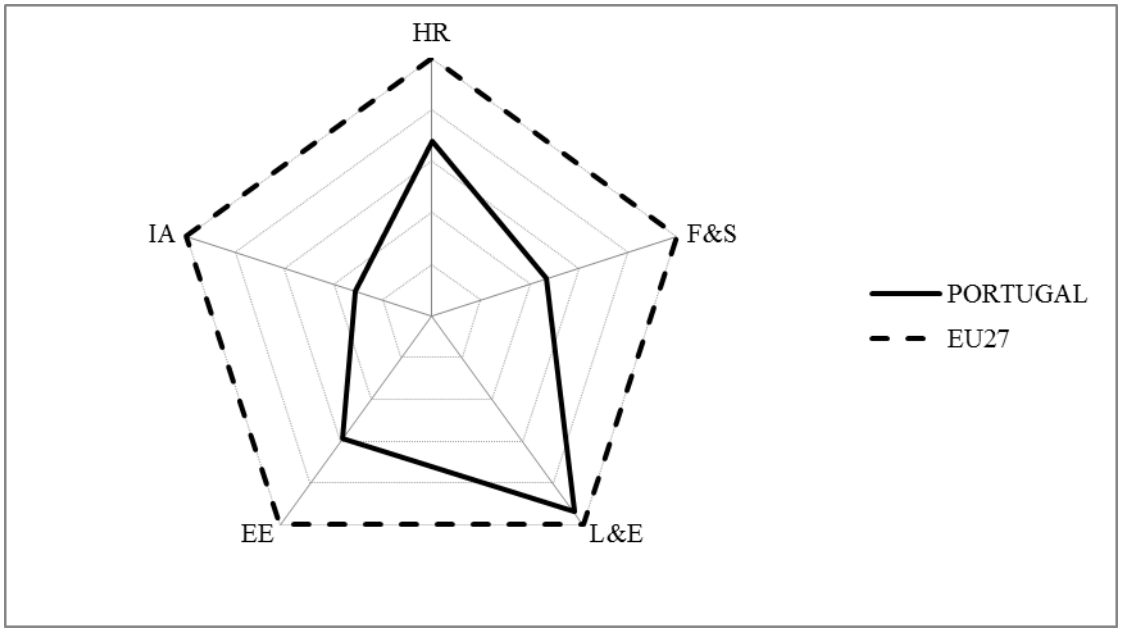


Source: Author's computation based on EIS data (2006)

The Portuguese performance in the EIS 2006, in general terms, is very similar than the 2005's. Intellectual assets and finance and support are the major drawbacks, immediately followed by the economic effects, despite their general improvement compared to the former results. The strengths still rely in linkages and entrepreneurship. This result illustrates the ability of SME's to develop in-house innovative activities along with establishing connections with other firms as well as institutions.

3.3.4. Portuguese performance in the EIS 2007

Graphic 22 - Innovation scoreboard - Portuguese performance EIS 2007



Source: Author's computation based on EIS data (2007)

In 2007 the analysis was enlarged to 27 European countries, which will naturally influence the average results. Nevertheless, the Portuguese performance stayed almost unchanged. The results present little ability to produce intellectual assets, additionally to the meagre availability of venture capital and R&D expenditure in the public sector (F&S component). Linkages and entrepreneurship felt below the average, differently from the former years, notwithstanding being the nearest to the European average.

3.3.5. Portuguese performance in the EIS 2008

Graphic 23 - Innovation scoreboard - Portuguese performance EIS 2008

Source: Author's computation based on EIS data (2008)

The analysis for 2008 comprised additional aspects, breaking down some of the former vectors, which means a more detailed picture of the Portuguese innovative performance. *Firm investment* components were analysed in separate, including the expenditures in R&D, technology and non-R&D. Another component analysed in detail was *innovators*, this component observed the ability to generate product, process or organisational innovation and cost reduction achievements.

The Portuguese performance was coherent with the former results, with *intellectual assets* being the major weakness; there were generalised improvements in terms of the other components approaching the European average.

Quite remarkable, the improvement in terms of the *human resources* vector, reaching the European average, the improvement in terms of the economic effects, which is a synonym of the positive evolution of the employment in high tech sectors. Finance and support also approached the European average, which represents additional availability of both venture capital and public investments in R&D.

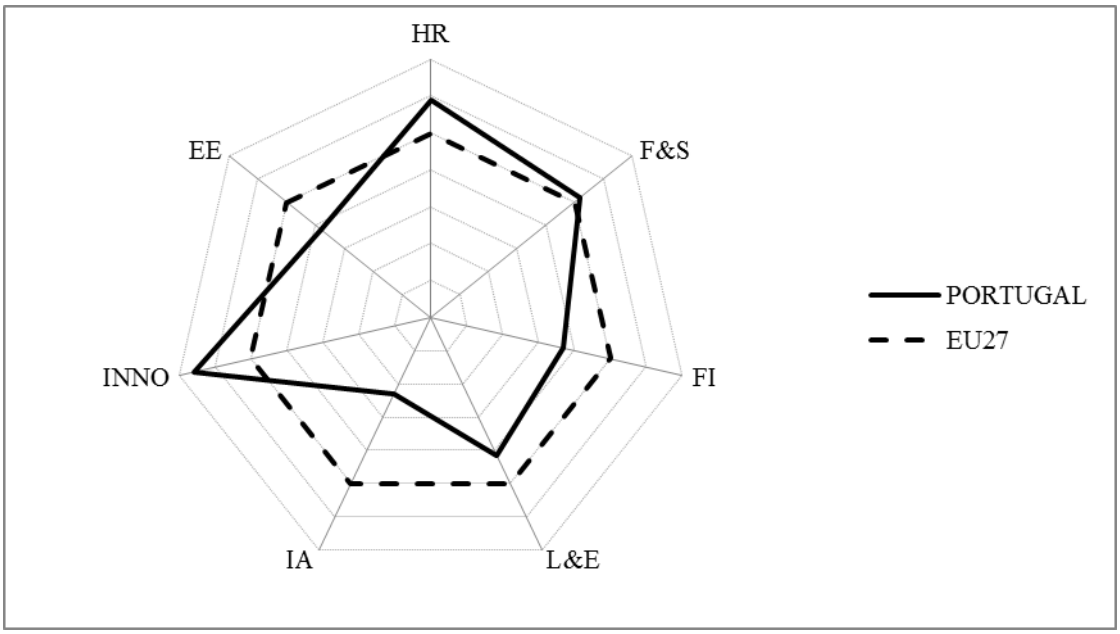
The major strength relies on innovators, illustrating the dynamism of Portuguese SME's in pursuing innovative activities independent on their nature.

In general terms, 2008 is the year in which Portugal performs a major growth is all vectors, approaching the European path in terms of innovative performance, reducing the gap from the innovation leaders.

3.3.6. Portuguese performance in the EIS 2009

In the 2009 edition, once more, seven vectors if the innovative analysis were include to describe the Portuguese innovative performance compared to the European average.

Graphic 24 - Innovation scoreboard - Portuguese performance EIS 2009



Source: Author's computation based on EIS data (2009)

The achievements in terms of intellectual assets continue to underperform compared to the European average, this is, by far, the major weakness of the Portuguese results.

The economic effects are also below the average, meaning that the employment in knowledge intensive activities and the impact of the innovations among sales are smaller than the European average.

Firm investments presented an improvements compared to the former edition relative to the European average in the same vein than linkages and entrepreneurship.

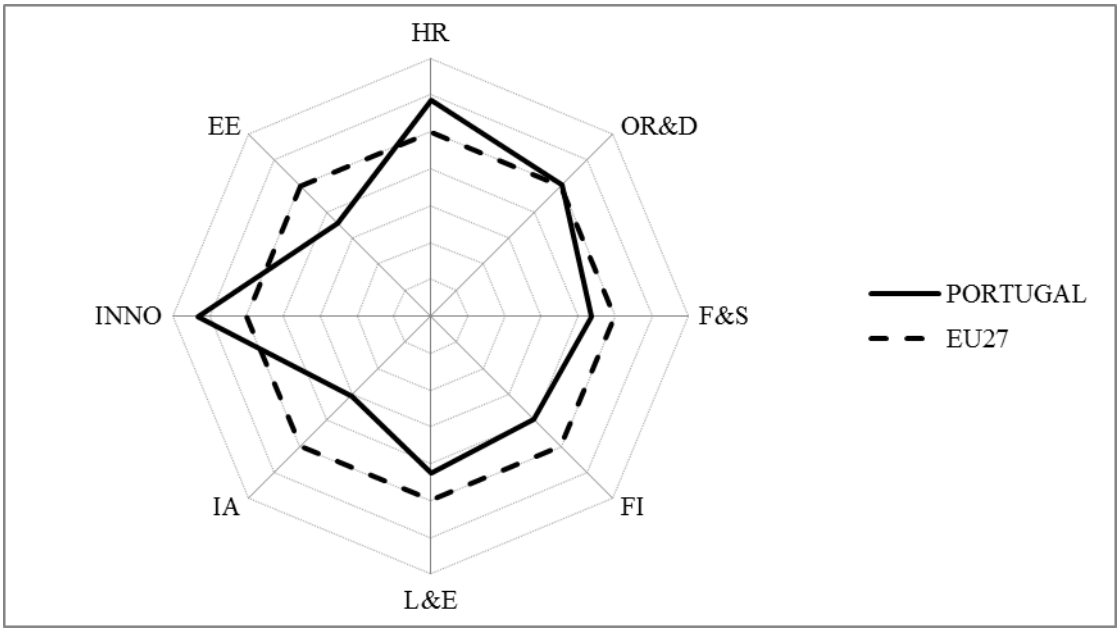
Concerning the *human resources, innovators, finance and support* the Portuguese performance exceeds the European average.

The major strength of the Portuguese framework is directly connected to the innovation, which is measured by the introduction of new products and services or implementing organisational innovations.

3.3.7. Portuguese performance in the EIS 2010

The EIS 2010, analysed the Portuguese innovative performance concerning eight vectors. This is the very first moment in which the innovation is observed in such detail.

Graphic 25 - Innovation scoreboard - Portuguese performance EIS 2010



Source: Author's computation based on EIS data (2010)

The performance in 2010 was quite similar from the former year. The drawbacks continue in the *intellectual assets* component; the *economic effects* component also underperforms in the same path than they did in the past.

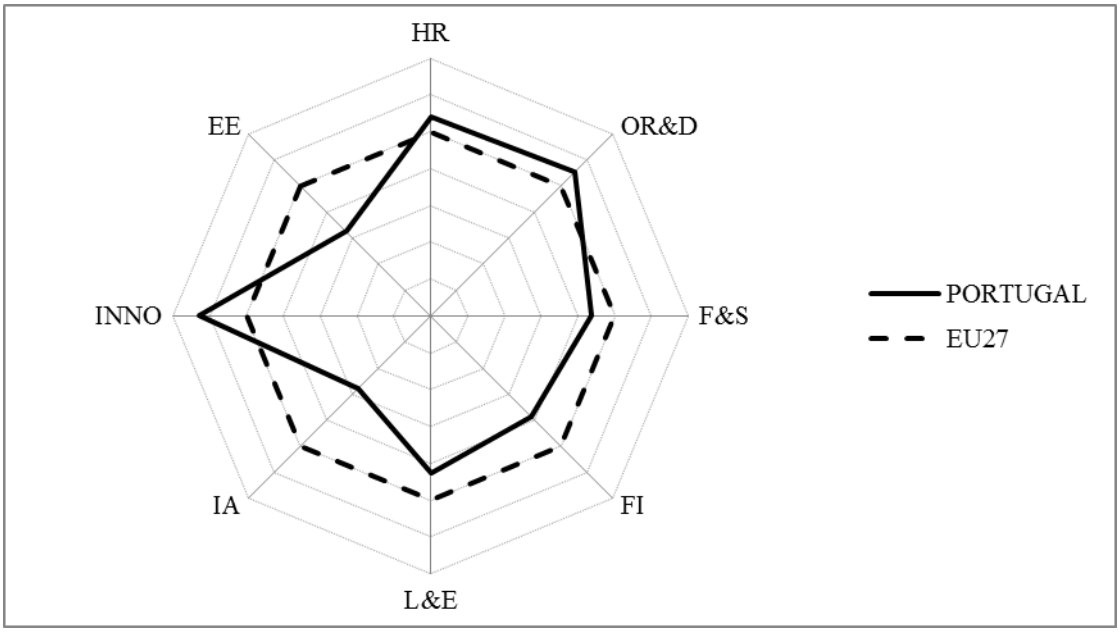
The *innovators* performance, as well as the *human resources* and *open, excellent and attractive research systems*, are above the European average. The other components present a similar performance than in the former years, underperforming but near the European average.

3.3.8. Portuguese performance in the IUS 2011

In 2011 the European authorities decided to change the name of European Innovation Scoreboard. This is the very first session in which the SII index will be analysis with the denomination of Innovation Union Scoreboard (IUS), despite the change if terms of the acronym, the components and the methodology remain unchanged. Time series analysis is, for consequence feasible providing an accurate overview.

The analysis from 2011 includes the same vectors than 2010 and the overall results carry forward the achievements of the former year.

Graphic 26 - Innovation scoreboard - Portuguese performance IUS 2011



Source: Author's computation based on IUS data (2011)

The graph of the Portuguese innovative performance for 2011 is close to the one presented for the former year. It is quite noticeable that the Portuguese research system continues to improve. The Human Resources component is above the European average, but it slightly decreased compared to the former year.

Policy-makers continue to be incapable of boosting the intellectual assets component which underperforms as it did from the very first moment. It has been pointed as the major weakness among all the vectors presented.

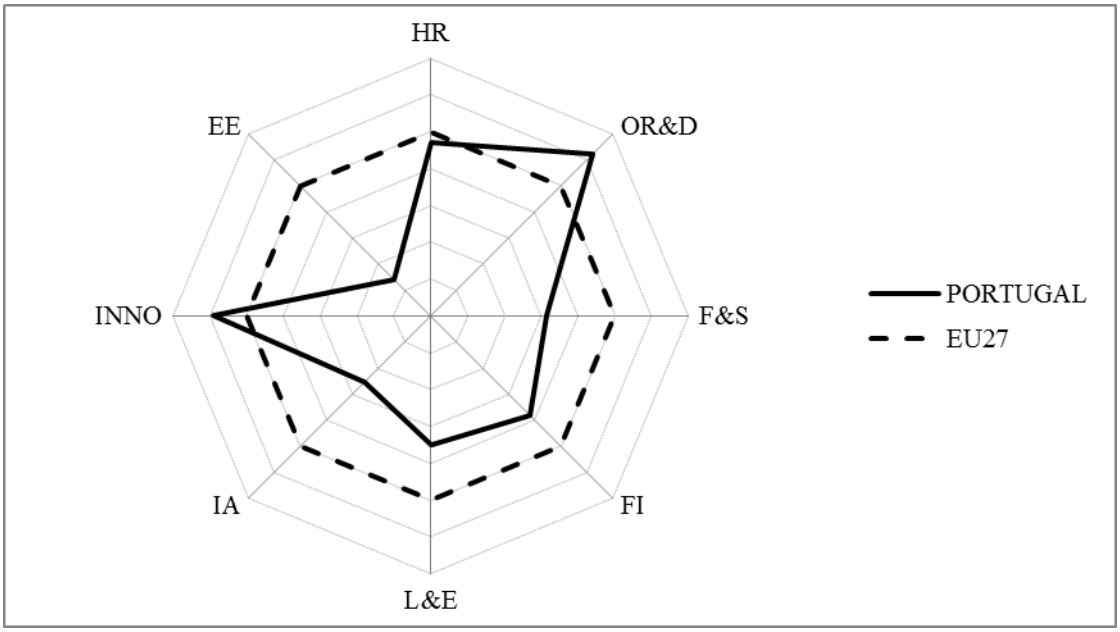
There is no information for 2012, the time series depicted so far will have a break concerning this period. The next period taken into analysis will be the year of 2013.

3.3.9. Portuguese performance in the IUS 2013

The portrait of the Portuguese innovation framework for 2013 is very different from the former achievements. The results of the innovative performance could be attributed to the economic crisis and the need for bail out of the Portuguese economy as well as the requests of restrictive policies compulsorily implemented by the creditors.

Important changes were noticed over this period for the different vectors.

Graphic 27 - Innovation scoreboard - Portuguese performance IUS 2013



Source: Author's computation based on IUS data (2013)

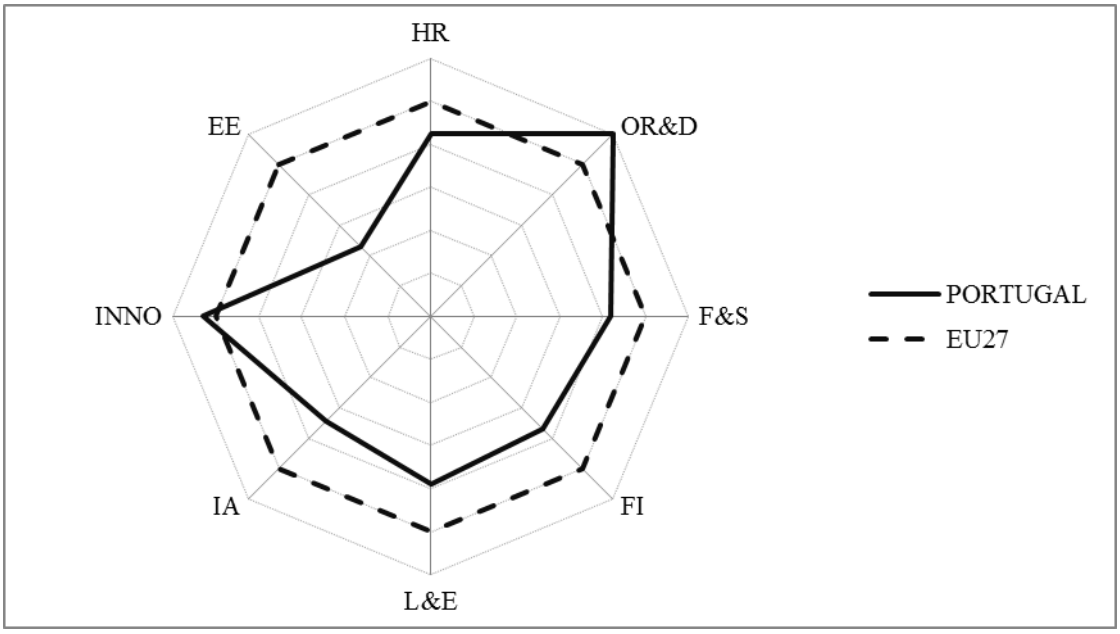
Intellectual assets continued with poor achievements; the Portuguese performance is nearly one half of the European average. Human resources accomplish in the same path than the European average, worsening former results. *Linkages and entrepreneurship* performed in the similar way than in 2011, despite worsening in relative terms. Concerning *firm investments* the performance is under the European average and similar to the former edition. *Finance and support* was also a vector whose performance worsened.

The *economic effects* component dramatically felt during this period; compared to the former years it decreased to one third of the European average. In this year this vector is the major weakness. The *research system* is a component over performing, it presents an increasing trend. *Innovators*, the vector that includes the different types of innovations developed by the firms is a strong component in the Portuguese system, as in the past.

3.3.10. Portuguese performance in the IUS 2014

The picture of the IUS for 2014 is very close to 2013. The Portuguese innovation framework continues in the same path. Policy makers continue being incapable to stimulate the intellectual assets component as well as the economic effects. In 2014, the intellectual assets component approaches the European average.

Graphic 28 - Innovation scoreboard - Portuguese performance IUS 2014



Source: Author's computation based on IUS data (2014)

There is a generalised improvement of the results in terms of the SII. There is a recovery from the poor performance of 2013.

The *intellectual assets* performance is the nearest to the European average since the first year of analysis. This component presented an important improvement reflecting efforts in terms of formal knowledge production. The *research and development*

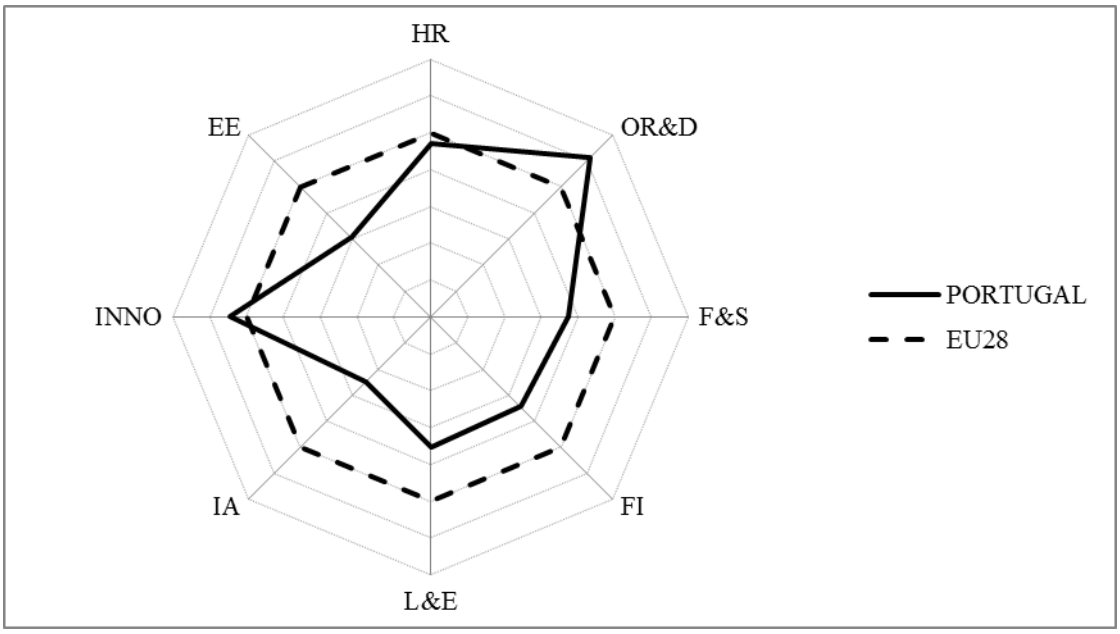
system maintains a positive performance compared to the average; the results are similar from those of 2013's.

Quite surprisingly, the *human resources* component is underperforming and with a negative trend. This suggests that there is a divergent trend in terms of new doctorates, population with secondary and tertiary education. The other components presented a smooth evolution, in the same line with the former years, not achieving the borderline despite very close to the European average.

3.3.11. Portuguese performance in the IUS 2015

The last accomplishments in terms of the Portuguese innovative performance are reported in the IUS 2015. The overall picture is very close to the former year. The strengths and the weaknesses are still the same.

Graphic 29 - Innovation scoreboard - Portuguese performance IUS 2015



Source: Author's computation based on IUS data (2015)

Innovators and *research and development systems* are the stronger components inter overall results, the distance above the European average diminished, and in terms of the *human resources* it is very close to the European average.

The *intellectual assets* component presented a poorer performance than in the former year, although it is at a higher level than in the other types, in 2015 it halved the European average.

The economic effects are in the same level than in the former edition, as well as the firm investments and linkages and entrepreneurship.

The major achievement is the balancing of the innovative framework; in the former editions the strengths and the weaknesses worked almost as outliers, one indicator being importantly above and the other significantly below. As time passes the system of innovation is becoming more balanced and approaching the European average. The pace of the approach was desirably to be faster, but, bearing in mind the economic context worse could be expected.

3.4. Portuguese performance in the Scoreboard – Factor Analysis

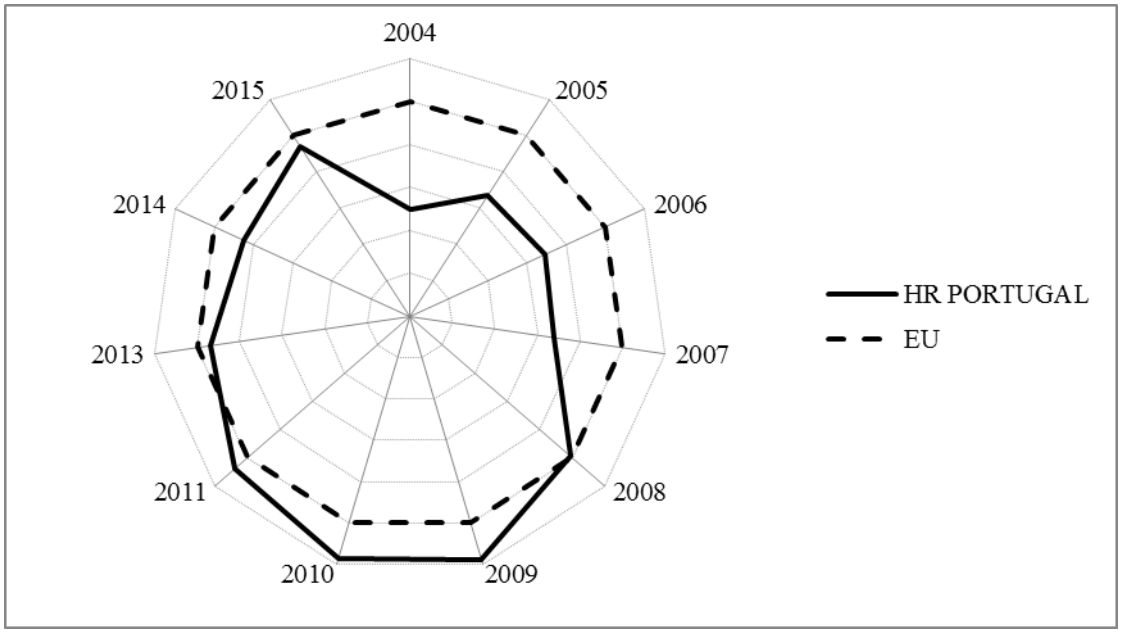
The European authorities design their policy actions in terms of innovation based on the measurements and recommendations presented in the IUS. As mentioned, these reports depict the overall innovation activity of the member countries and their achievements in their Research and innovation systems. The Summary Innovation Index is a composite indicator which will encapsulate three types of indicators: the *Enablers*, *Firm activities and outputs*.

By measuring the *enablers* the results will produce a picture of the innovation performance outside the firm, thus including the human resources (analysing the skills of the workforce). Concerning the research systems, the variables will depict competitiveness in terms of the science system. The third component of the enablers will consider finance and support (measuring the availability of finance from venture capital or the public institutions). This vector of analysis will illustrate the aspects that influence innovative activities exogenous of the firm.

3.4.1. Enablers – Portuguese time series behaviour

The first component of the enablers will describe the performance of the human resources, including the number of doctorates, individuals with secondary and tertiary education.

Graphic 30 - Human resources - Portuguese time series performance



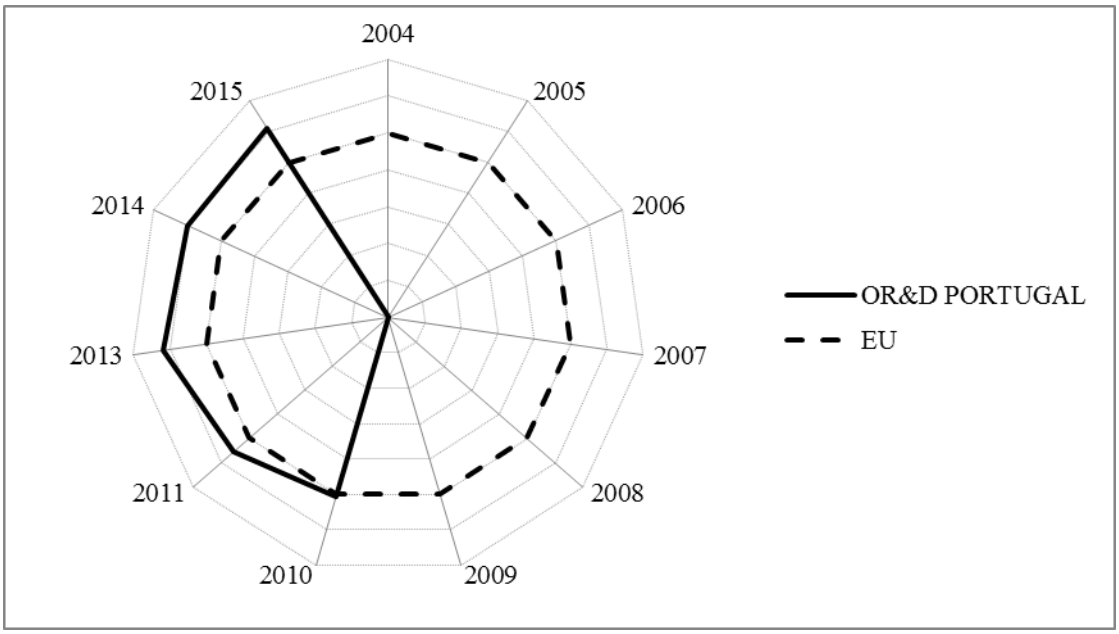
Source: Author's own computation based on EIS/IUS data

The human resources component presented a positive evolution in the time series. At first, the achievements were far below the European average; since 2007 this indicator rose at a high pace, speeding up the Portuguese convergence to the European levels.

In 2008, Portugal reached the European average, and ranked above the average in the next three types. Since 2013 the results are decrease. The figures put Portugal below the European average, despite the recovery presented for 2015 (this can be associated to the negative economic environment and the reduced opportunities in the job market).

Regarding the quality of the research systems, the time series is shorter. Available data allows the analysis in between 2001-2015.

Graphic 31 - Open, excellent and attractive research systems - Portuguese time series performance



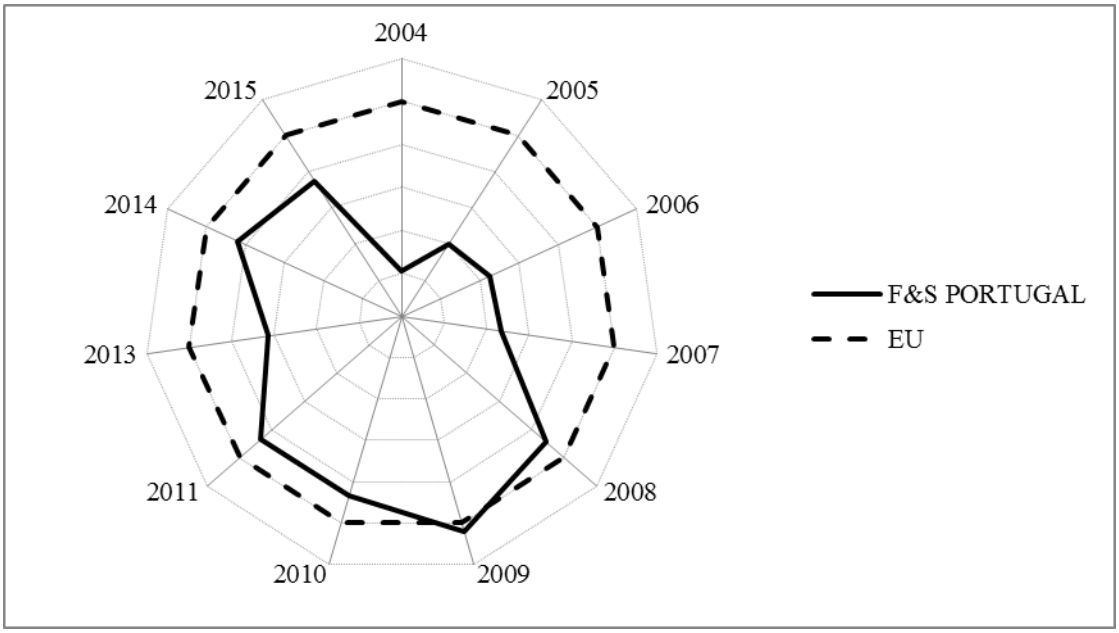
Source: Author's own computation based on EIS/IUS data

The quality of the research system was never a drawback to the Portuguese performance; the country performed on average or over the average. The quality of the system rose over time, presently ranking above the European average.

This indicator is built upon items such as scientific publications both at the national and international level, these achievements are strongly tied to the skills of the labour force; as science evolves based on the quality of the scientists.

The series for Finance and support includes data from 2004 until 2015. It comprises items connected to the availability of finance (both private and public).

Graphic 32 - Finance and Support - Portuguese time series performance



Source: Author's own computation based on EIS/IUS data

The performance of this vector in 2004 was very humble, the Portuguese results scored nearly one fifth of the European average.

The scarce availability of finance is the innovative system is considered in the literature as an important hampering factor of the innovative activities. Very often firms have few internal resources to develop these activities, so, if the system does not provide them support, they will have to postpone or even abandon these initiatives.

The performance is this vector strongly imporved over time, and in 2009, the Portuguese figures were similar from the European average. This is due to the Governmental and European funding of the innovative actions, which was extensively implemented in Portugal, directly sponsored by European funds.

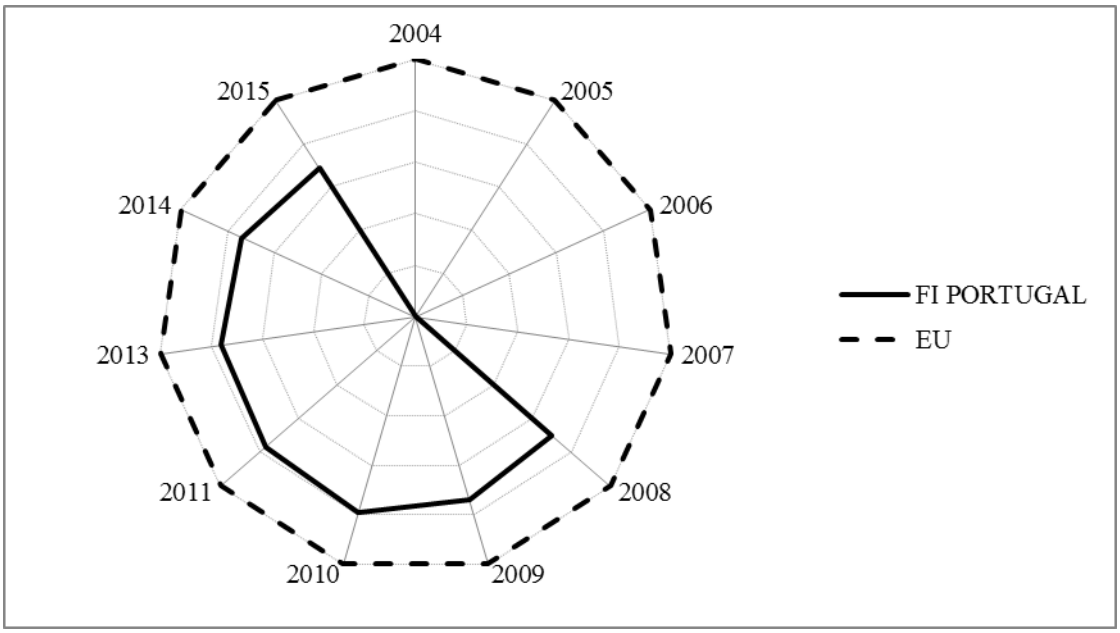
Unfortunately the scores worsened from 2010 onwards which is connected, among others, to the adverse economic context and the scarcity of funding.

3.4.2. Firm activity - Portuguese time series behaviour

Firm activities is the second major component included in the SII, this branch, will observe the firm activities by means of its internal factors. In doing so, it will be analysed the performance of the firm in devoting its own resources to the innovative activities and its contribution to the innovative system.

Concerning firm investments the SII measures the expenditures in R&D and non-R&D innovation. The period of analysis will comprise the interval 2008-2015.

Graphic 33 - Firm Investments - Portuguese time series performance



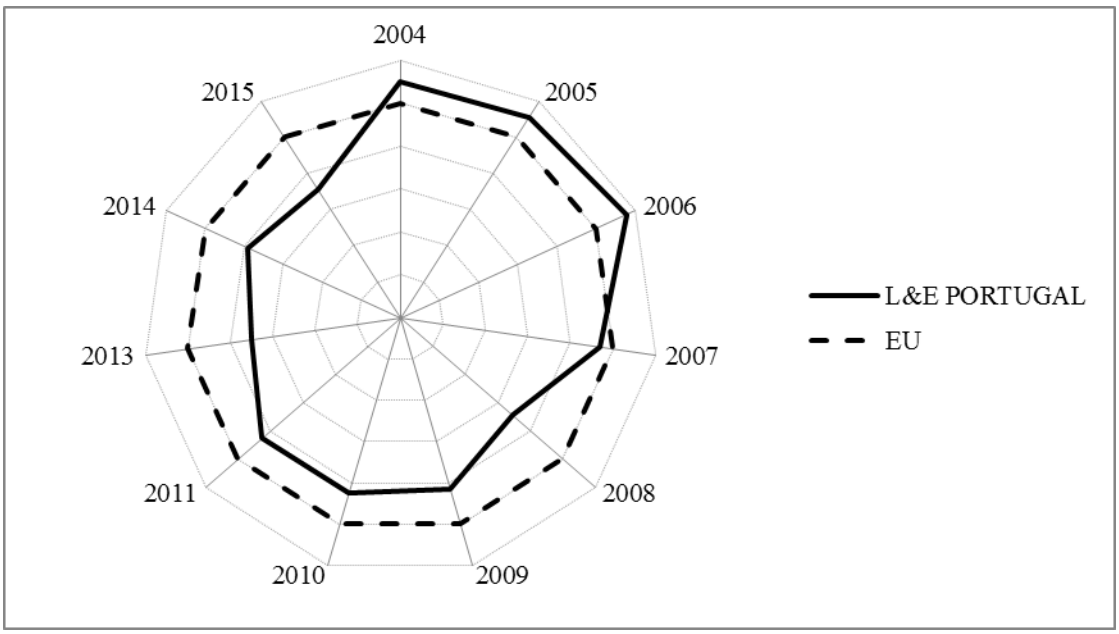
Source: Author's own computation based on EIS/IUS data

In terms of this aspect, Portugal was always incapable of reaching the European average, the results invariably scored below and always at analogous percentages.

During the period of analysis Portugal was incapable of pulling of this poor performance, meaning that the expenditures in R&D is scant compared to other countries. The likely reason for the meagre spending will be connected to the scarcity of financial means. Presently this indicator presents a slight decreasing trend, in the same line as other components which can be attributed to the financial crisis.

The ability to establish linkages with external institutions; developing collaborations with other agents in the NSI, foster connections with different sources of information to develop innovative activities, was never a drawback to the Portuguese firms. This vector over performed compared to the European average.

Graphic 34 - Linkages and Entrepreneurship - Portuguese time series performance

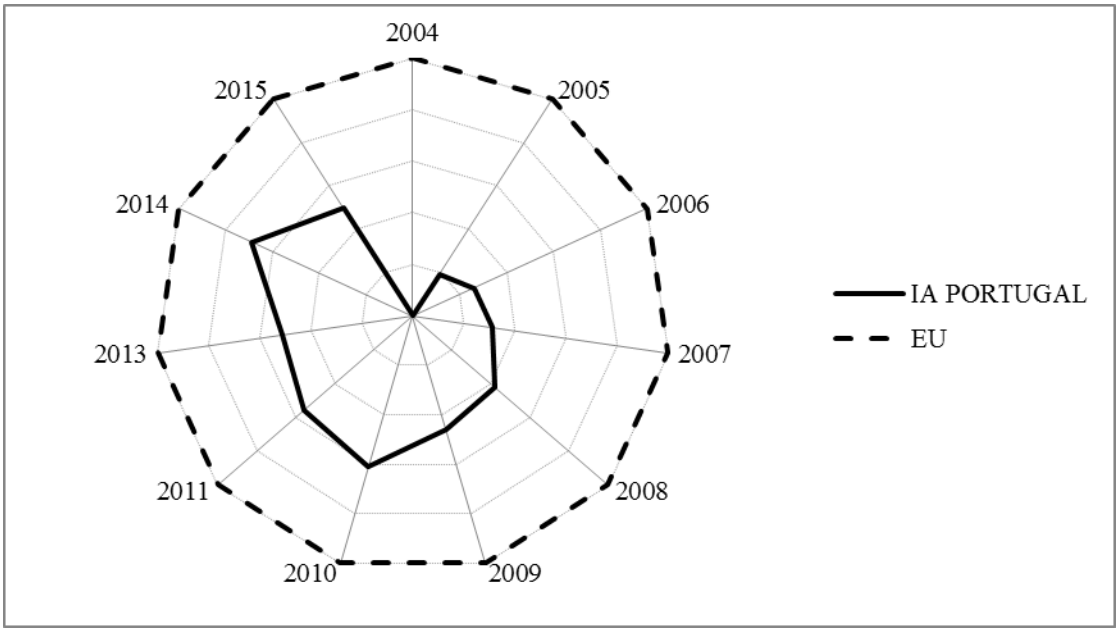


Source: Author's own computation based on EIS/IUS

Conversely from other fields of analysis, the establishment of linkages was considered as strength in the Portuguese reality. Unfortunately the results are presenting a decreasing trend and the indicator was above the European average in the first three years of analysis then moving to an underperforming trend which became poorer from 2007 onwards. The results achieved for 2015 are the worst since the beginning of the series.

The production of intellectual assets was ever since the major weakness of the Portuguese innovation system. The results are very low compared to the European average, and the best achievements poorly halved the European average. This indicator was particularly unstable along the period of analysis.

Graphic 35 - Intellectual Assets - Portuguese time series performance



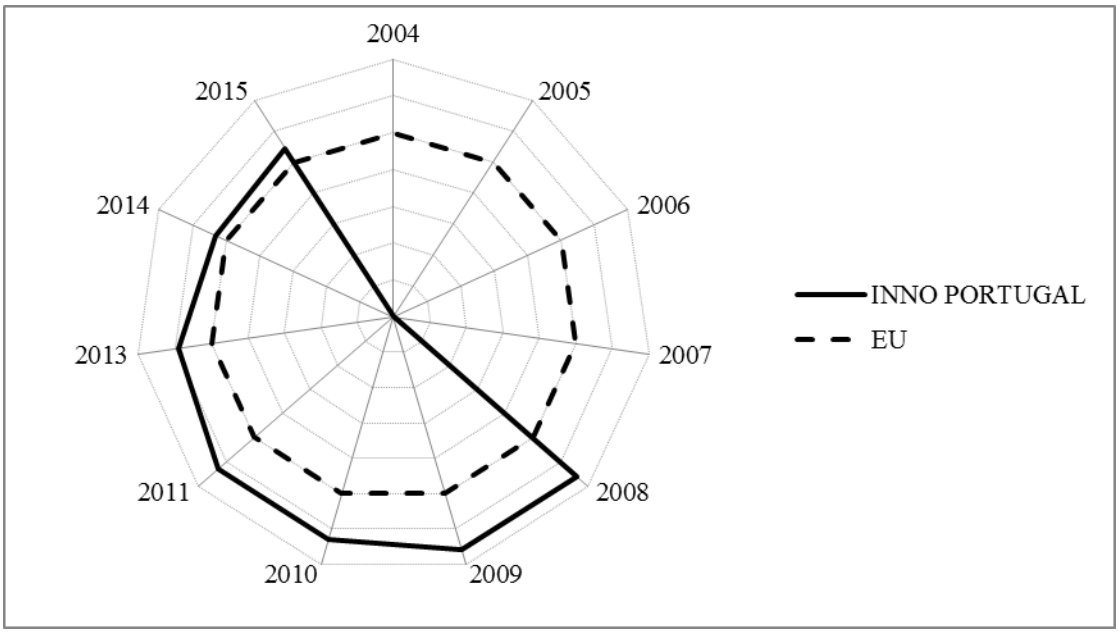
Source: Author's own computation based on EIS/IUS

The production of patents and other kinds of knowledge protection is very little among Portuguese firms. The inexistence of this strategic behaviour possibly is connected to several handicaps such as the lack of finance to register the improvements, inexistent protection culture, insignificant disruptive attainments deserving register, preference for non-product innovation.

3.4.3. Outputs - Portuguese time series behaviour

The third major vector of the SII is connected to the innovation outputs. It captures the economic and non-economic effects of the innovative actions performed by the firms. It includes two major effects: the innovation effect (nature and impact of the innovative activities) and the economic effects (weighting the impact of these actions in the Irma overall performance, proxying the success). For the innovators component, the Portuguese available data produces a series from 2008 till 2015.

Graphic 36 - Innovators - Portuguese time series performance



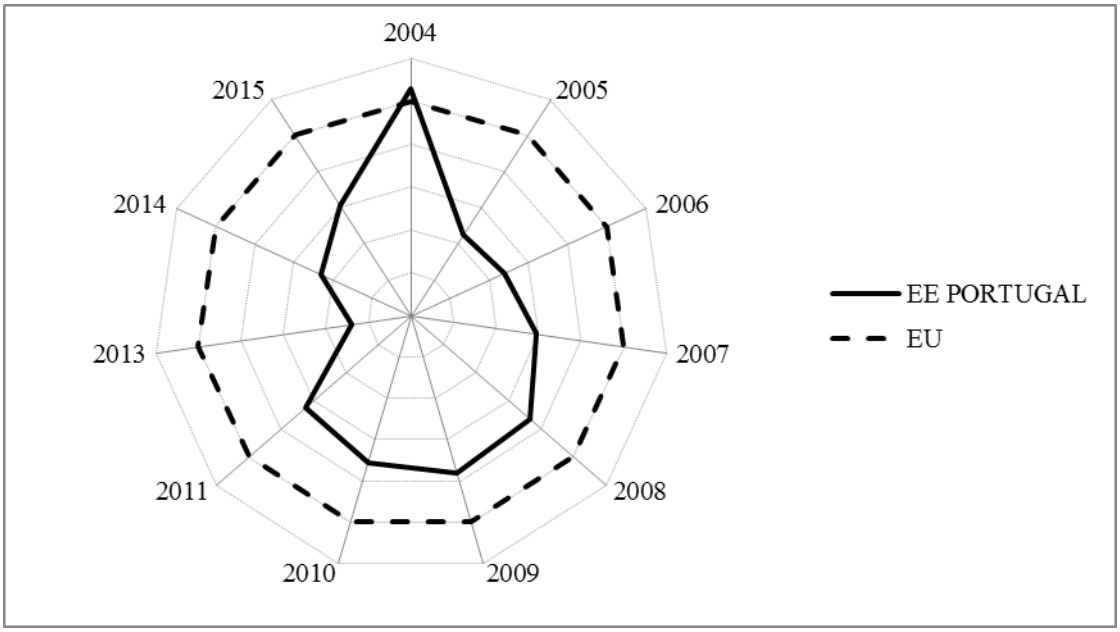
Source: Author's own computation based on EIS/IUS data

Generally, Portugal over performed in the indicator. Invariably the results were over the average. Although there is a decreasing trend more severely felt since 2011.

This indicator proves that Portuguese firms are innovatively dynamic as there is a significant proportion of them introducing new product or services to the market; developing process innovation or implementing organisational or marketing modifications to consolidate their position on the market.

The innovation economic effects are an unstable indicator in the Portuguese performance along the time series. The available data allows for the analysis since 2004 which was by far the best result among all.

Graphic 37 - Economic Effects - Portuguese time series performance



Source: Author's own computation based on EIS/IUS data

The economic effects of innovations were diverse over time. For the year of 2004 Portugal had a very positive achievement, immediately followed by a significant fall if 2005. Henceforth there were fluctuations in terms of the results, but the indicator invariably underperformed. The periods of 2006, 2013 and 2014 were particularly negative in terms the economic effects for Portugal.

3.5. Overall performance – Portuguese positioning

Qualification of the labour force will determine the success in terms of the creation and diffusion of innovative activities. According to the Scoreboard, Portugal has made an important attempt to improve the quality of its labour force, the overall skilling of the population rose with special emphasis in the tertiary education. Although, the last two years, the Portuguese performance in terms of the "Human Resources" component diverged from the European average, and the results, compared to the average went back to 2008. Analysing by individual results, the scenario becomes more worrying as Portugal was granted the second worst performance among EU members.

The possible reason for this poor achievement is connected to the uneven evolution of top educated workers and the doctorates compared to long life learning and secondary education. Despite the important achievements in terms of the skilling of new doctorate graduates (3rd among member countries in 2010) who will supply the market with knowledge during the same period, there is a poor attendance of upper secondary level education and the conclusion of tertiary education of the youth. Moreover, attendance of doctorate programs is very specific and aiming at fulfilling positions in specific industries and institutions; this indicator will reach a steady-state.

Recent developments in the job market, with poor recognition of these skills reinforce the mistrust of candidates in pursuing these levels of education. Financial constraints, fewer scholarships and other socio-economic difficulties force the students to seek for immediate sources of income rather than postponing their entry in the workforce.

Portuguese scientific research is still unsubstantial; an important effort to diffuse knowledge by means of scientific publications has been made in the last decade. This achievement goes along with the improvements in terms of the number of doctorates. The number of publications ranks above the European average, although impacting below.

The establishment of linkages among institutions inside the NSI incipient; public-private scientific co-publications are at lower levels than the European standard. This value represents a major drawback in the overall innovative performance as the joint production of knowledge will speed up the pace and reduce the cost of innovations.

In the present Portugal is incapable of attracting a significant number of foreign high-skilled doctorate students. This fact will jeopardize knowledge creation and furthermore its diffusion (as countries should generate a net brain gain and continuous

supply of researchers). The creation of strong ties with highly skilled international networks will boost the competences of the Portuguese institutions concerning the production of basic knowledge as well as their ability to solve the industry problems.

It has been empirically proved that the role of Government as well as public institutions is detrimental to knowledge production. Public R&D expenditures are low but not too far from the European average. Nevertheless, a remarkable increase in the last years was noticed.

There is acceptance that the production of knowledge for innovative activities is developed in both internal and external activities to the firm, and these sources will act as complements. Intramural knowledge creation is a powerful engine of innovation; science based sectors evolve based upon the new knowledge developed in their R&D laboratories.

Developing internal R&D activities aiming at innovation requires the availability of finance; moreover, innovation is risky, with unpredictable connection between inputs and outputs. The access to financial resources is essential in pursuing innovative activities. When the economic environment points to the predominance of SMEs, the existence of external sources of finance such as grants, funds and venture capital will allow overcoming these difficulties.

The Portuguese performance, in terms of venture capital plunges below the average has a decreasing trend. Insufficient financing sources will hamper innovative activities as well as the development of new firms based on precise innovative ideas. SME's and start-ups have particularly weak finance, thus requiring external sources.

According to the Lisbon strategy, Europe is expected to be a leading innovative power. Therefore important efforts are being made to boost the innovative activities by means of promoting R&D, the European target for 2020 is 3%. The R&D intensity, at the aggregate level is proxied by the ratio of R&D expenditures compared to the GDP. Despite the target being 3%, the acceptable level is above 2%.

Most of the European countries still underperform compared to the Barcelona target, important policy actions have to be implemented to boost the entrepreneurial dynamism in terms of the R&D activities. Portugal is underperforming compared to the European average, after 2010 the country initiated a decreasing trend.

To generate successful innovations, along with R&D expenditures, firms need to perform investments in equipment and machinery and the acquisition of patents and

licenses. Portuguese firms behave similarly to the rest of the Europe, in developing activities complementary to the R&D.

The effectiveness of the R&D activities will be measured by the introduction of any new or significantly improved products or production processes (SMEs innovating in-house); in the Portuguese case, results are higher than average. The cooperation among innovative firms is also higher than the average, and growing.

The protection of innovation is made by patent licensing. The register of patent applications for industrial and societal purposes reflects the country dynamism; Portugal presents a poor performance in licensing. Trademarks and designs reflect the evolution of the products mainly in the service sector. In the first Portugal is below and in the second above.

Technological innovation is determinant for manufacturing SMEs; it is measured by the introduction of new products (goods or services) and processes. Besides, the introduction of marketing or organisational innovations reflects progress through non-technological innovation. In Portugal all those indicators achieve results far above the average. Employment in knowledge-intensive activities (industries where at least 33% of employment has a university degree) is one of the lowest in the EU.

The commercialisation of the R&D results in foreign countries reflects the specialisation pattern. Countries aim at selling abroad medium and high-technology products and services because of their growing potential and impact in value added; Portugal stands below the average.

Firms expect high return on their innovation. Turnover of new or significantly improved products and includes both products which are only new to the firm and products which are also new to the market it captures state-of-the-art technologies and its diffusion, Portuguese firms behaved above the average. Sales of new-to-market products capture the creation of modern technologies, Sales of new-to-firm products capture the diffusion of these technologies, in the Portuguese case this products represent half of the total turnover.

Technology acquisition is an alternative to internal innovation; hopefully firms sell their knowledge abroad, increasing the return on their successful innovation, Portuguese firms achieved a poor performance.

The perception of the effects over innovation of the financial crisis of 2007 came to is with a time lag of one year, this means that the full impact of the crisis will be shown by 2008.

The financial crisis that took place in 2008 was expected to affect firms and their innovative strategies. Innovative firms were therefore expected to focus in productive activities and reducing their expenses in innovation. Contrarily to the forecasts of the existing literature, empirical evidence shows that more innovative firms have cut less in innovation expenditures than others. In other words, it seems that most innovative firms will be less affected by the crisis than expected. This suggests that the innovative activities are part of the managerial strategy rather than subject to the economic environment.

Performing R&D activities will raise the probability of producing successful innovation. Firms will perform their R&D activities drawing on different innovation sources. The use of internal sources tends to be the first option, although the external sources will act as complements. Nevertheless innovations may have different intensities or importances or even of significant improvement for the firm rather than the entire market or the country.

Understanding the different types of innovators and the innovation modes will raise the efficiency of policy as lines of action to different sectors will be defined. Firms can be classified according to their innovation modes, two criteria are normally used: the level of novelty of the firm's innovations and the creative effort that the firm devotes to in-house innovative activities. Firms that introduce non-technological changes are not classified as innovators, although not all innovation relies on R&D, firms can buy critical know-how or adopt new technologies.

Non-technical innovation is pointed as being the missing piece of the innovation puzzle, preventing Europe to fully exploit the technological opportunities. The SII includes one vector of analysis by means of a component called "non-technological change" comprising management techniques, organizational structures, aesthetic appearance (Portuguese performance ranks above the average).

Firms do not perform innovations in the same manner, thus R&D is not always an essential activity. Although, these activities will be boosted in different ways by the different types of innovating companies. The European Innovation Scoreboard (2004) proposes four major sub-groups: s***trategic innovators,*** firms that consider innovation as a

relevant vector of their strategic behavior; performing R&D activities in a continuous base. These firms will be innovation producers and their developments will be diffused to other firms.

Intermittent innovators, these firms will perform R&D and innovation relying on intramural resources, whereas, innovation is not a core activity in their managerial options. Their R&D efforts will consider adapting new technology developed by others adapted to their own needs. They will have the ability to produce their own innovation or adapt innovation produced elsewhere.

Technology modifiers will change their existing products or processes through non-R&D based activities. They will not develop product innovators, adopting other firms' improvements. Their strength is to implement process innovation by means of production engineering. The ***technology adopters*** have as a major source of innovation the adoption of innovations created by other firms or organisations.

The EIS has produced a framework dividing the countries into the categories. Countries with a similar profile to Portugal are classified as intermittent.

Consequently, Portuguese firms will prefer the use of intramural resources, despite not innovating in a regular base. These firms will adapt the new technologies to fulfil their own needs. These firms will, at first, rely on someone else's innovations adapting it to their own needs, and then, if needed they will develop their own projects.

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PERSISTENCE OF INNOVATIVE BEHAVIOUR IN FIRMS LOCATED IN A MODERATE INNOVATOR

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Abstract

Innovation is a major determinant of firm performance. The competitive advantage of firms' is strongly connected to their ability to continuously innovate over long periods of time (Le Bas and Scellato, 2014).

The concept of persistence in innovation is perceived since the early debate on cumulative creation (Schumpeter, 1942). It underlines the influence of past and present innovations on future innovations. There is a positive correlation between past and present innovations which under the correct environment transforms innovation into a routine (Nelson and Winter, 1982).

The analysis of persistence in innovation, his drivers and frameworks can improve the understanding of firm dynamics, anticipate the effects of the different policy actions, correct macroeconomic disequilibria, help in designing the correct policies to boost R&D and consequently generate prosperity.

This paper debates the persistence of innovation using a dynamic panel comprising 1099 firms operating in all economic sectors; firms are observed in three waves of the Portuguese part of the Community Innovation Survey (CIS), covering the time span from 2004 to 2010 (i. e. the CIS 6, the CIS 8 and the CIS 10). Innovation Persistence is analysed using the general concept of having performed any type of innovation during the period and additionally, the concept is broken down into the different types of innovation: product, service, process, organisational and marketing.

The first empirical approach to persistence uses transition probabilities, allowing for a simple understanding of the panel dynamic behaviour in each innovation type as well as the firms' trajectory. This framework depicts the firm behaviour in each period, given its state in the former. The results expressively vary according to the innovation type in analysis, the proportion of firms mentioning the achievement of either product or service

innovation is quite small compared to process, organisational or marketing innovations. The last period of observation included in the panel, 2008-2010, non-surprisingly depicts a generalised fall in terms of innovation performance, perhaps caused by the economic crisis, although the difference is emphasised for product or service innovation.

The empirical analysis continues with the construction of two econometric models, using the random effects probit model; Model 1 depicts a general panel and Model 2 differentiates innovative behaviour in a time perspective, in both cases we control for firm-level characteristics and the use of public funds to perform innovative activities. The construction of an alternative model discriminating past innovative behaviour (non-innovative, persistent, new or sporadic) is of particular interest as the persistence hypothesis fails to be corroborated in the general model for most of the innovation types, while the use of innovative behaviour sub-types produces different results.

Former innovation options are in most cases statistically significant in determining present innovative behaviour. The results vary according to the innovation type in analysis, which is of particular interest, as most of the existing studies only consider product innovation, and only a few consider as well organisational and process innovation.

The panel allows analysing persistence of innovation in all economic sectors. Across our models services and industry seem to behave differently towards persistence, this aims at fulfilling some gap as the existing literature mostly provides empirical evidence only for industry.

Persistence of innovation is empirically explored mostly using the case of innovation leaders or followers, which may not apply to countries with poorer performances in terms of innovation. Studying the case of a moderate innovator may shed some light into the different conditions of firms and their attitude towards persistence, as well as the adoption of different policy actions to observe this heterogeneity.

The results sustain the construction of a solid debate in terms of firm strategy in terms of persistency of innovation in the context of a moderate innovator. Moreover, perceived downturn in the innovative performance over time, in line with the results presented for the Portuguese part of the Innobarometer will permit drawing some policy recommendations, and required adjustments in terms of smart policy making.

1. Introduction

Several works such as those of Geroski et al. (1997), Dosi (1997), Antonelli (2011), Colombelli and von Tuzelmann (2011) underline the importance of continuity in innovative activities, promotion of R&D, its diffusion, and accumulation processes. Thus, firms are recommended to consistently produce innovative output (Latham and Le Bas, 2006), or to persistently innovate as this determines their competitive advantage.

Innovation persistence is defined as the number of consecutive years during which firms report achieving innovative outputs innovate, being the later often measured by patents, R&D outputs or major innovations (Le Bas et al., 2011). Persistence increases the odds of accommodating changes and maintaining the innovative path, it is connected to the innovative behaviour of dynamic firms**,** allowing for the development of competences and resources (Nelson and Winter, 1982, Teece et al., 1997, Latham and Le Bas, 2006, Le Bas and Scellato, 2014).

Geroski et al., (1997) and Dosi (1997) empirically prove continuity, emphasising the role of explicit investment to generate technological and organizational improvements. There might be lock-in effects arising from innovation, which will put the firm in a forefront position to seek new innovations in a continuous path (Antonelli, 1997).

The existing research discusses persistence under the perspective of a narrow definition of innovation: product and/or process. The non-technological types of innovation such as service, organizational or marketing, are far unexploited. Moreover, in the context of a moderate innovator these vectors seem as being of major importance due to the characteristics of firms and the system of innovation.

Persistence was empirically tested in different countries, most notably, the UK (Cefis, 2003; Frenz and Prevezer, 2013); France (Duguet and Monjon, 2004) – France; Duflos (2006) - USA; Peters (2009) – Germany; Raymond et al. (2010) – Netherlands; Antonelli et al. (2012 and 2013) - Italy; Clausen et al. (2013) – Norway;) – UK; Le Bas and Poussing (2014) – Luxembourg; Tavassoli and Karlson (2015) – Sweden.

Despite the use of different time periods and empirical methodologies these studies have proved the existence of persistence in innovative activities. Very often, persistence is approached by the repport of patents, although, the degree of innovation depends on the indicator that is used (Duguet and Monjon, 2004). Furthermore, recent studies have drawn

diverse patterns of persistence combining different types of innovation (e.g. Antonelli et al. 2012, Le Bas and Poussing, 2014).

Stable environments are the underlying condition of empirical papers on persistence. In this context, past actions tend to facilitate subsequent success. However, if market conditions change, firms must redesign their strategy. These models fail to define what to expect.

Pure past or path-dependence is somehow unfeasible (Le Bas and Scellato, 2014), and it will limit the ability to respond to the environmental challenges. Accumulated resources and capabilities will constraint new innovative projects, despite their inadequacy to the new setting, thus, former decisions will stick. Changes in economic or institutional conditions influence the type of profitable innovations. Nonetheless, past innovations may not serve for the present and the innovative strategy will be forced to change.

The exception, with all the differences that may apply, is the study for Argentina (Suárez, 2014). Under this unstable economic environment, the hypothesis of persistence is rejected. Under uncertainty, past-dependence may become worthless as the results of the cumulative process seem inadequate to the altered economic environment causing the disruption of the innovative course. Given the new circumstances, firms rationally consider all the possibilities in terms of (dis) continuity of innovation projects.

Moderate Innovators due to the composition of their industrial structure as well as the nature of their Technological Innovation Systems (TIS) frequently face instability; the conditions arising from the external environment will likely affect their innovative decisions with high importance.

This paper aims at giving the insights of the innovative strategy and the characteristics of the innovation systems to boost the followers' capacity to persistently innovate or to absorb the new technology, creating a favourable environment to become a fast mover and spread the innovations to consolidate new practices. Additionally, we aim at understanding if there is homogeneity in persistence patterns across the different innovation types. If so, policy makers must take into account eventual specificities of these vectors when designing and targeting Innovation policies, specifically support programs. Moreover, the existence of intermittent innovative strategies must reawaken the debate in terms of public funding goals to promote innovation in a persistent base.

Empirical evidence will be drawn from the Community Innovation Survey (henceforth CIS), in its different waves. To consider the case of the 2008 crisis a firm panel was constructed comprising data included in CIS6 (2004-2006), CIS8 2006-2008), and in CIS10 (2008-2010).

2. Literature review on persistence of innovative activities

The analysis of the determinants of persistence in innovative activities will allow an understanding of industry dynamics and the monitoring of the effects of the policy actions in terms of the support of R&D and innovative activities.

The effective degree of innovation persistence depends on the indicator considered, when using patents persistence tends to be low, while when considering product or process innovation it is higher (Duguet and Monjon, 2004). Moreover, there are combinations of innovation types which draw different patterns of persistence (Antonelli et al., 2012; Clausen et al. 2013 Le Bas and Poussing, 2014).

The factors affecting persistence can be divided into internal and external. Concerning the first we will consider factors such as the size, success in former R&D activities, availability of internal funds (Cefis and Ciccarelli, 2005; Latham and Le Bas, 2006; Peters, 2009; Clausen and Pohjola, 2013), concerning the second we consider the access to local knowledge stocks (Antonelli et al. 2012).

Le Bas and Scellato (2014) point three complementary frameworks to assess the motivations and spin-offs of persistence, namely; knowledge accumulation, success-breeds-success and sunk cost in R&D activities.

Knowledge is cumulative and non-extinguishable generating a permanent advantage enhancing the probability of persistence. The systematic interaction between the knowledge stock and the productive routines converts innovation in a competitive advantage (Antonelli et al., 2013). Former innovations generate financial availability for the future, as past success will raise profitability and credibility towards external sources (Latham and Le Bas, 2006).

The development of R&D activities tends to be persistent as the investment in an R&D laboratory is considered as sunk, its pay-back requires multiple years; this action,

once pursued will force the firm to continue this strategy as well as it will disincentive sporadic actions (Antonelli et al., 2013).

These approaches act as complementary and self-reinforcing; virtuous cycles will emerge from the dynamic interaction between the “knowledge accumulation” and the “success breeds success” in which, the returns from present R&D will retro-feed new ones (Latham and Le Bas, 2006).

The concept of persistence is explained by the continuity on innovative investments (inputs) and not by the results (outputs). Firms have to decide, as part of their managerial strategy, to develop innovative activities in a sporadic or a continuous basis. It is likely that innovators continue to innovate as well as non-innovators not changing their strategical view (Cefis and Orsenigo, 2001).

The option for persistence innovations is part of the innovative process thus determining technological change. It is essential for firms to continue investing in these projects in order to respond to the changing economic environment. Hence, a strong cleavage is perceived among firms as persistence will be verified among “great innovators” (Cefis, 2003).

Managers may opt for pursuing innovation in a regular base, perceiving the fact that there is some inertia in the process, the innovative behaviour over time is not a random process, if the firm is targeted to the market (market drive) the propensity to become a persistent innovator will raise, as well as if it is R&D intensive or Science based (Clausen et al., 2011).

Innovation will not behave in the same manner for its different types, the requirements of product and process innovations appear as being more complex therefore weighing the managerial strategy in a different manner. There is strong persistence in what concerns these components, so, we expect firms performing innovations in these areas to be found as persistent innovators, while other innovative actions may be more volatile. Product innovators are more affected by strategic factors and process by market constraints (Roper and Hewitt-Dundas, 2008).

Firms that cut off path dependence and lock-in were able to fully understand the changed environment, figuring out innovations suitable for the new market, thus being successful (Suaréz, 2014).

Throughout unstable periods, where innovation heritage is worthless, present decisions must be disconnected from the past. During these phases, firms perform short term innovations with low impact on capabilities and resources. Therefore, these actions do not retro-feed future persistence. With regards to long term innovations and considering path dependence and lock-in, the past is rescheduling present achievements of results.

The economic crisis is, to many, seen as a major problem in what concerns continuing the innovative activities; however, if firms seize the competences in terms of human factors, technology and structural factors, downturns will not jeopardise the development of innovative activities (Filippetti and Archibugi, 2010).

The sources of persistence can be explained by alternative frameworks such as Knowledge accumulation, success-breeds-success and sunk costs in R&D. These views are complementary and self-reinforcing rather than substitutes. These concepts will explain the micro-mechanisms underlying persistent innovation.

Due to strategic options, firms decide to invest in R&D, this cost is considered as sunk, and therefore, it will rationally be supported in the long-run. Innovative firms create a certain stock of knowledge, this process enhances the success-breeds-success hypothesis, and the profits generated with the ongoing innovative process will retro-feed the system, financing new R&D activities enabling the system to continue working. This setting portraits a virtuous cycle in which the learning process will indefinitely continue.

The innovation process itself can be explained by to alternative properties: past dependence or path dependence.

Past dependence claims that the determinants' of the innovative process and its results are fully determined by the initial conditions. Mansfield's (1961) epidemic model of technological diffusion describes this process relying on the number of innovation pioneers, the speed of diffusion foreseeing the contagion process. Persistence will be conditional to the first innovation, and the generation of long-lasting innovative skills.

Conversely, path dependence explains that, in a localized context in which knowledge is planted, an "historical accident" occurs, followed by another in a random process. The success of innovation will depend on the ability of the firm to benefit from the "accident". Therefore innovation will be strongly tied to existing competences and networking. Persistence will be contingent to the exploitation of complementarities and interdependencies under the proper institutional environment (Collombelli and von

Tunzelmann, 2011). The access to knowledge pools, reinforcement of networks, linkages among firms will therefore be strongly recommended.

2.1 Knowledge Accumulation

Persistence dynamics can be analysed in terms of the firms' conditions in the past or the existence of a path. The development of innovations in the past will enhance the innovative potential at present, having a former innovative path will raise the odds of starting new innovation projects as well as the likelihood of the achievement of effective innovations. Moreover, the innovative strategies firms pursued in the past will capitalise in the present **(**Antonelli: 1997, 2008, 2010).

The persistence of the innovative activities is based on the combination of both external and internal factors. The availability of a knowledge pool and a competitive market, as well as the structural traits of the firms concerning the R&D policy, the skills and education of the labour force (Antonelli et al., 2013), are all important factors.

Past innovative projects are classified as sunk costs due to their irreversibility and they also generate scale economies due to their indivisibility. Strategic decisions made in the past will produce results in the present and even in the future. Firms will exploit these actions until they are profitable.

Innovation is a dynamic process, characterised by persistence and path dependence. The dynamics of local attractors will determine the innovation success in a continuous base. This process is path dependent rather than past dependent; as the past will not fully determine the present, the shape of the process will be determined by a localised context of action (Colombelli and von Tunzelman, 2011).

Past innovations will positively influence the current ones if their impact is strong enough to transfer the effects to the present. For example, one could expect that market leaders will persist as monopolists, fed by the need to maintain the dominance (Duflos, 2006).

Changing the innovative strategy is also a feasible option, even though it may generate important opportunity costs which must be taken into account when analysing the new innovative projects (Antonelli: 1997, 2008).

Innovative firms have increased means of finance due to their past behaviour and as a result they have resources and capabilities. In the path dependence approach, innovative firms have extended capabilities and important opportunity costs concerning their innovative options. Financial constraints play a major role in what concerns innovation barriers and, therefore. The availability of finance will play a determinant role to the maintenance of the innovative behaviour (Savignac, 2008; Mohen et al., 2008).

2.2. Success breeds success

Persistence emerges from the feedback of past innovations, present investments and future innovations. Innovations are achieved as a result of a regular activity, and when successful, they are repeated. The persistence of routines will impact the innovative outcome, thus reinforcing or obstructing new cycles (Nelson and Winter, 1982).

Firms achieving innovations will be considered as successful, standing out from their competitors due to their abnormal profits which will be reinvested in the development of new innovative activities, hereby forming a virtuous cycle (Nelson and Winter, 1982).

When a firm reaches innovation, it conquers market power, achieves higher profit levels, thus creating an advantage from its competitors. Past innovations will generate the finance to support present innovative activities which are very likely to generate future innovations.

2.3. Sunk Costs in R&D

Conversely, due to great uncertainty relating to innovation projects, weak finance availability will discourage the start-up of innovation routines. Furthermore, the cost of external capital for this purpose may be too high or even unavailable.

The hypothesis of persistence is confirmed by deliberate managerial strategies, covering diverse aspects such as investments in physical capital, intangible assets, human capital. Persistence is therefore observed if the organisation does perform these actions in a continuous base to boost the institutional evolution and the improvement of the overall efficiency level (Clausen et al., 2012; Frenz and Prevezer, 2012; Le Bas et al., 2011; Peters, 2009, Raymond et al., 2013).

The virtuous cycle approach considers innovative firms as organisations with innovation routines, gaining extra-profits which generate natural barriers to their potential competitors. Regardless of the approach, there is a positive correlation between past and present innovation. Past innovations will trigger new innovative activities, naturally increasing the probability of reaching innovation again, thereby closing the innovation cycle, Phillips (1971), Mansfield (1961), Geroski et al., (1997).

Firm environment includes the economic actors in the system, establishing a complex set of interactions. The firm may design a new innovation strategy due to the changes in the economic environment and not simply based on former innovation decisions (Freeman, 1982a; Lundvall, 1992).

In sum, in volatile environments, continuity in innovative activities will be an expression of deliberate strategic behaviour rather than sheer time correlation. Persistence generates feedback and accumulation but they are indeed the outcome of continuous innovative strategies. The framework of persistence will be designed by the managerial strategy as well as the dynamic interaction of the firm and its environment (Suárez, 2014).

Thus, in contrast to what one would expect in the context of stable environments, one might find past successful innovative behaviour to have no impact or even a detrimental impact on future innovative behaviour in contexts of changing (or uncertain) environments.

As noted by Nelson and Winter (1982) this could happen if, for example, past successful innovative behaviour generated from specific problem-solving processes that are not necessarily useful for the new environment. On the other hand, the new environment may create opportunities for previously non-innovative firms. These innovative firms may therefore be more likely to innovate in the future if their innovation process is adapted, from the start, to the new environment.

This same line of reasoning suggests, however that the persistence of different types of innovative behavior may differ according to the types if innovation. For example, past successful innovative behavior may have a positive effect on future innovative behavior if the innovation we are referring to is product innovation, but have a negative effect if the innovation is organizational innovation.

In such instances, any analysis that pools the two kinds of types may find no effect of past behavior on future innovative behavior. To our knowledge, no such analysis by innovation type has so far been done.

Organisational innovation practices such as knowledge management and external partnerships speed up the pace of technological innovation hereby generating persistence (Le Bas et al., 2011).

Strategic behaviour of firms, in some cases, points to non-innovative strategies as being the more effective; conversely, in other cases, the most efficient option is to invest in innovation. The empirical evidence points to the fact that some innovative actions generate new innovative actions; albeit others fail to boost the virtuous cycle of innovation.

This leads to four possible innovation trajectories in each time threshold: non-innovative, if the firm decides not to innovate in the two time periods; sporadic innovator if the firm stops innovating from one moment to the other; new innovator if the firm commences the innovative process; or persistent innovator if the firm continues to innovate from one moment to the other. This analysis constitutes a further contribution to the persistence literature, discussing the different innovative strategies over time in the context of a moderate innovator. Moreover, it depicts the innovation trajectories dividing the innovative behavior into different innovation types as the literature points to dissimilar perspectives according to the type of innovation in scrutiny.

2.4. Hypothesis in test

Existing literature usually describes persistence as a pure time dependence between past innovation results and future innovation strategies, Therefore modelling persistence as an autoregressive process, independent on the specification model adopted (Duguet and Monjon, 2004). This fact, points up persistence more as serial correlation rather than an independent option taken in each period of time. Apart from time inertia, reiterating innovative practices will generate strategic advantages; these will permit firms benefiting from feedback and accumulation (Nelson and Winter 1982).

Under the conventional persistence hypothesis, present innovation outcomes are explained by past innovation achievements, subject to the extension of investments in resources and capabilities (investments in R&D and machinery, skilled human resources)

and firm's structural characteristics (size, sector, age, capital ownership), (e.g. Le Bas and Scellato, 2014).

Empirical evidence shows that firms carry forward, commence, stop or withdraw innovative processes in an array of patterns to which conventional persistence seems to be scant. In addition, innovation strategies over time are different when analysing the different types of innovation.

The following analysis of persistence will be divided into two major branches: the first will feature pure persistence using the conventional concept (time dependence), and will be broken down into the different innovation types; the second will analyse discontinuous innovation strategies and it will also detail on the different innovation types.

Given that three time periods are considered, meaning two time thresholds, eight alternative innovation paths may be pursued by firms; the following classification will arise according to the strategy adopted in the transition from one period to the other.

Table 24 - Alternative innovative strategies

Innovative strategies (3 time periods)	**DESCRIPTION**
Continuous	The firm reports having performed innovative activities in all periods of analysis
Continuous - Sporadic	The firm reports having performed innovative activities in the first and the second period of analysis, and stopped innovating in the third
Sporadic - New	The firm has innovated in the first period, stopped innovating in the second and started innovating in the third
Sporadic - Non innovative	The firm has performed innovative activities in the first period of analysis and stopped in the next two
New - Continuous	The firm did not perform innovative activities in the first period, commenced in the second and continued in the third
New - Sporadic	The firm did not innovate in the first period, has innovated in the second, immediately stopping in the third
Non - innovative - New	The firm did not innovate in either the first and the second period and started innovating in the third
Non - Innovative	The firm did not innovate at all in all periods of analysis

Source: Author's own computation based on CIS data

In the first hypothesis [H1] pure time persistence will be tested ignoring other possibilities than being innovative in the former period of time. Under this assumption we

will not consider the possibility of changing the innovative strategy over time due to eventual changes in the firm or in the economic environment. Therefore, past innovative achievements will influence the present (considering innovation inputs and structural controls).

According to existing literature, independent of the conceptual framework, having innovated in the past will positively influence the probability of innovating at present. Former ***continuous innovators*** will persist in their innovative strategies.

This construction aims at understanding if, for moderate innovators the framework of conventional persistence dos hold. This hypothesis will be tested in the first model run to each innovation type.

The empirical evidence shows that frequently firms change their attitude towards innovation from one period to the other; most of the works unveil persistence given certain characteristics, or non-innovativeness, but, very few explain the transition from one to another. The following hypotheses will depict the managerial strategies that comprise changes along the period. The strategic changes will be detailed in three alternative hypotheses:

[H2] – Being a ***continuous innovator*** in the transition from t-2 to t-1, will ***enhance the probability*** to continue innovation in the transition to t. In other words, if the firm did innovate two periods ago and was carry forward in the former period, it is more likely to be an innovator at present as well.

[H3] – ***Sporadic innovators*** in t-1 will have a ***decreased probability*** to pursuit innovation in t. In other words, firms that did innovate in t-2, but which have stopped innovation in t-1, will have fewer chances to innovate in t.

[H4] – Firms that are ***new to innovation*** in t-1, so to say that they started innovation in the transition from t-2 to t-1, (non innovative in t-2 and innovative in t-1), have an ***increased probability*** to continue innovation at present. This means that the innovation wave started in t-1 will influence innovation in t.

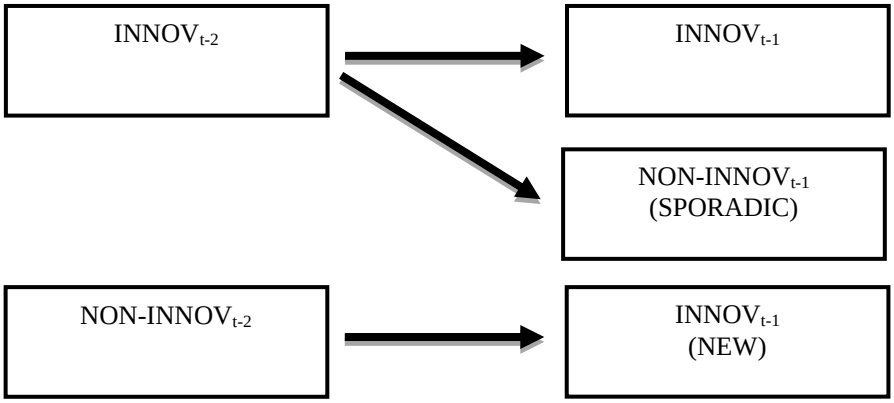
In analysing the previous hypothesis, the concepts connected to persistence, in both continuous and intermittent strategies will be tested along with the hypothesis of intermittence [H2] [H3] and [H4].

Summarising:

CONVENTIONAL HYPOTHESIS - continuous innovation in the past will enhance present innovation

[H1]

(UN) CONVENTIONAL STRATEGIES – discontinuous innovation in the past and their effects in the present



[H2]

[H3]

[H4]

3. Database and descriptive results

3.1. Database and sample

This section details the underlying methodology for the panel construction considering three CIS waves. Portugal participates in the Community Innovation Survey since its second edition, this questionnaire is run in most of the European countries and it is the most extensive in this field undergoing through the innovation details according to the recommendation of the European authorities.

The innovative behaviour of firms is naturally shaped by endogenous and exogenous constraints; the Portuguese economy went through one of the most serious

crisis of the last decades in 2008, which is still to overcome, and it is expectable that firms have changed their innovative behaviour during this period. In this research we aim at understanding how did firms reacted to this adverse environment.

Measuring the connection between past and present innovations requires the construction of a dynamic panel, monitoring the innovative behaviour during the time span. To support this investigation question, a panel of firms operating in all economic sectors was constructed. This panel will comprise three biennia, and the information will be collected from the CIS in three waves: CIS 6, CIS 8 and CIS 10.

The panel will be strongly balanced as only firms that were present in the three inquiry moments were maintained. In doing so, 1099 firms were observed during the three periods, which means that we will have three observations for each of the 1099 firms. The survey collects information from the former years of operation, in concrete, the CIS 6 grasps information from the 2004-2006 period; the CIS 8 collects information from 2006-2008, and the CIS 10 from 2008-2010. When the investigation was performed, these were the last three editions available.

Even though, a preliminary analysis of the entire sample of each CIS edition was made, to understand the overall performance of the firms for each type of innovation.

Table 25 - Innovative firms per innovation type (entire CIS sample)

		Product innovation	Service innovation	Process innovation	Organisational innovation	Marketing innovation	Innovation in general
CIS 6	**n**	990	912	1763	2537	1770	3159
	%	20.97	19.32	37.34	53.74	37.49	66.91
CIS 8	**n**	2111	1826	3193	2844	2370	4278
	%	32.02	27.7	48.43	43.14	35.95	64.89
CIS 10	**n**	1818	1422	2846	2694	2431	4161
	%	29.51	23.08	46.2	43.73	39.46	67.55

Source: Author's own computation based on CIS data

The proportion of firms reporting product innovation is small compared to organisational and process innovation. Marketing innovation has been performed by an

increasing proportion of firms in the sample. This preliminary analysis depicts a reality in which firms are more likely to implement improvements, modifications rather than to register patents.

3.2. Exploratory analysis of the panel

3.2.1 Structural traits of the entire panel

The CIS 6, the CIS 8 and the CIS 10 have thousands of respondents, as discussed in the previous chapters. Due to theoretical reasons, it was required to construct a balanced panel; as a consequence, only firms that have responded to the three waves of the CIS were considered. The fully balanced panel comprises 1099 firms observed in the three time periods. A brief description of its traits will follow; further descriptive statistic highlighting the structural traits of the panel is done in appendix 8.

The panel is essentially composed by medium size firms (44%); small firms represent 35% and large firms represent 21%. The Portuguese entrepreneurial environment is mainly composed by SME's thus the panel will accurately reproduce the real scenario. Firms in the secondary sector represent 62% (all industries), the primary sector reaches 2%, and services achieve 36% of the total. Half of the firms belong to an economic group the other half does not

Half the firms belong to a high tech sector, one fifth to a low tech and one third to a mid tech (following Pavitt's taxonomy (1984)). High tech firms are naturally expected to be far more innovative than others, therefore more prone to rely on the innovative sources to pursuit their projects.

The R&D intensity illustrates the amount of resources devoted to innovative activities compared to the total turnover; 45% of firms do not perform R&D activities, on the contrary 41% of the firms achieve R&D intensity of up to 3%.

The number of workers with undergraduates or educational titles is often used as a proxy for education intensity. In the panel, 86 firms have no workers with a top education profile, thus all their workforce is classified as unskilled. Conversely, 53 firms report between 75% and 100% of their workforce as being highly skilled.

Almost 9% of the firms in the panel have reported innovative activities in all the mentioned types, contrarily one quarter of the firms in the respondent panel did mention

not performing any innovative activity during the period of analysis. There were 371 firms reported not finding relevant any source of information for their innovative activities.

Three quarters of the firms have mentioned not relying on any type of external funds, this result is remarkable as one would expect the innovation policy to reach form more firms.

3.2.2. Structural traits of the extreme groups

The aim of the research is to describe the determinants of innovation persistence allowing for the possibility of discontinuous innovative strategies; one may expect that continuously innovative firms and non-innovative firms behave differently. Based on the belief that persistent innovators and non-innovators have a cleavage in their structural traits, one has performed an analysis of their structural traits to have a preliminary understanding of their differences. The results have demonstrated that the two extreme groups have important differences.

Most of the persistent innovators belong to an economic group; conversely, the non-innovative do not. Concerning R&D intensity, most of the persistent innovators have outstanding performances compared to the poor performances of the non-innovative. The openness indicator has a cleavage: persistent innovators are very open, non-innovators very close. These results corroborate the findings of the literature. Respectively to the size, economic sector and the education intensity no significant differences are found among the two sub-samples. The support from public funds is used by an important percentage of the persistent innovators, contrarily, non-innovators not to draw upon public finance.

In sum, the general traits of the persistent innovators allow us to understand that these firms establish strong connections with other institutions, possibly enhanced by the human capital factors they seize, as well as a return of their expenditures in R&D. Their dynamism allows the use of public funding which is a handicap for the non-innovators. Further details of this evidence can be found in appendix 7.

3.3. Transitions frequencies

In each period, firms face binary decisions: whether or not to invest in innovation. In dynamic terms it is transformed into stopping or starting/continuing innovative activities. During the period of analysis, firms may maintain their strategy: persistent innovators or non-innovators, or change their strategy: stopping or starting innovating. For a three period panel, this will produce eight typified outcomes.

There are two major objectives arising from the empirical analysis: the understanding of unchanged strategies - persistent and non-innovative firms; and the determinants of transition. In both cases it is expected to shed some light into the determinants of this strategic behaviour and the role of policy makers in helping firms to take the most accurate decisions.

The respondent panel was divided in several categories according to the nature of the response regarding development of innovative activities. Then, the innovative behaviour of firms in the transition from one period to the following had four possibilities: persistent (a double yes to the performance of innovative activities), non-innovative (a double no to the performance of innovative activities), sporadic (a yes/no sequence) and a new innovator (no/yes sequence).

The transition was operated twice, the firs moving from the CIS 6 to the CIS 8 and the second from the CIS 8 to the CIS 10, which produced eight possible strategies over the six-year period.

The exploratory analysis shed some light into possible differences among firms depending on the innovative type being used. At first, we have decided to analyse the innovative behaviour of the firm under a general perspective, which means that the firm did perform innovative actions in at least one of the possible types.

Secondly, we did move forwards analysing each type in separate based on the belief that the difference in the complexity, duration and requirements of the innovation types will naturally influence the innovative strategy of continuing stopping or starting.

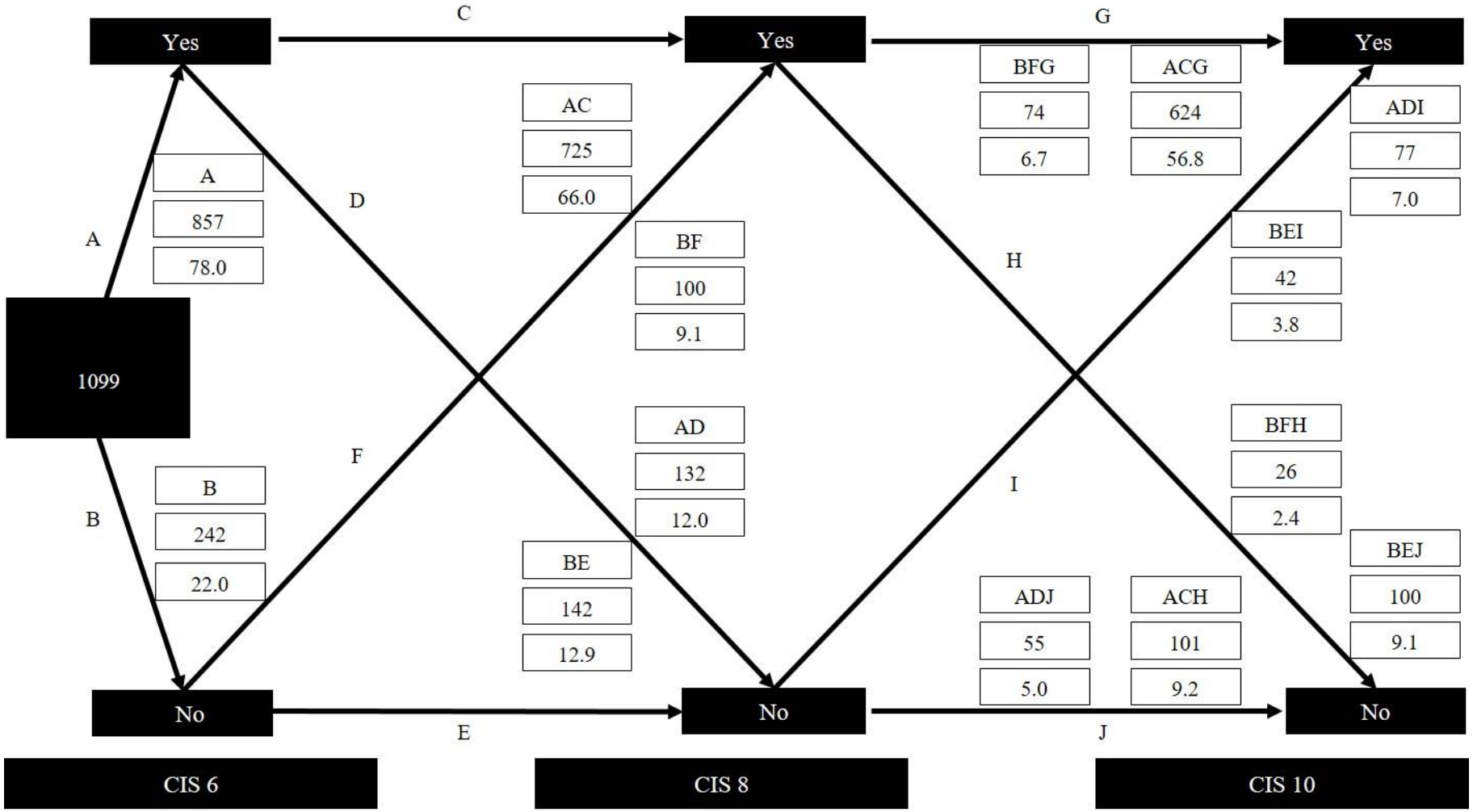
The following figures illustrate the transition frequencies reporting the firm's innovative strategy and group the firms accordingly. One can observe that in the constructed panel, almost half of the firms were classified as "non-innovative" concerning product innovation; for service innovation the portion of non-innovative is higher even

higher (520). Relating to the other innovation components (process, organisational and marketing), the number of non-innovators falls.

The persistent innovators represent nearly one fifth for product innovation, 130 firms for service innovation and, for process and organisational innovation the number of firms importantly rises (347 and 345 firms). Intermediate strategies present a more homogeneous distribution; there is no important cleavage according to the innovation types.

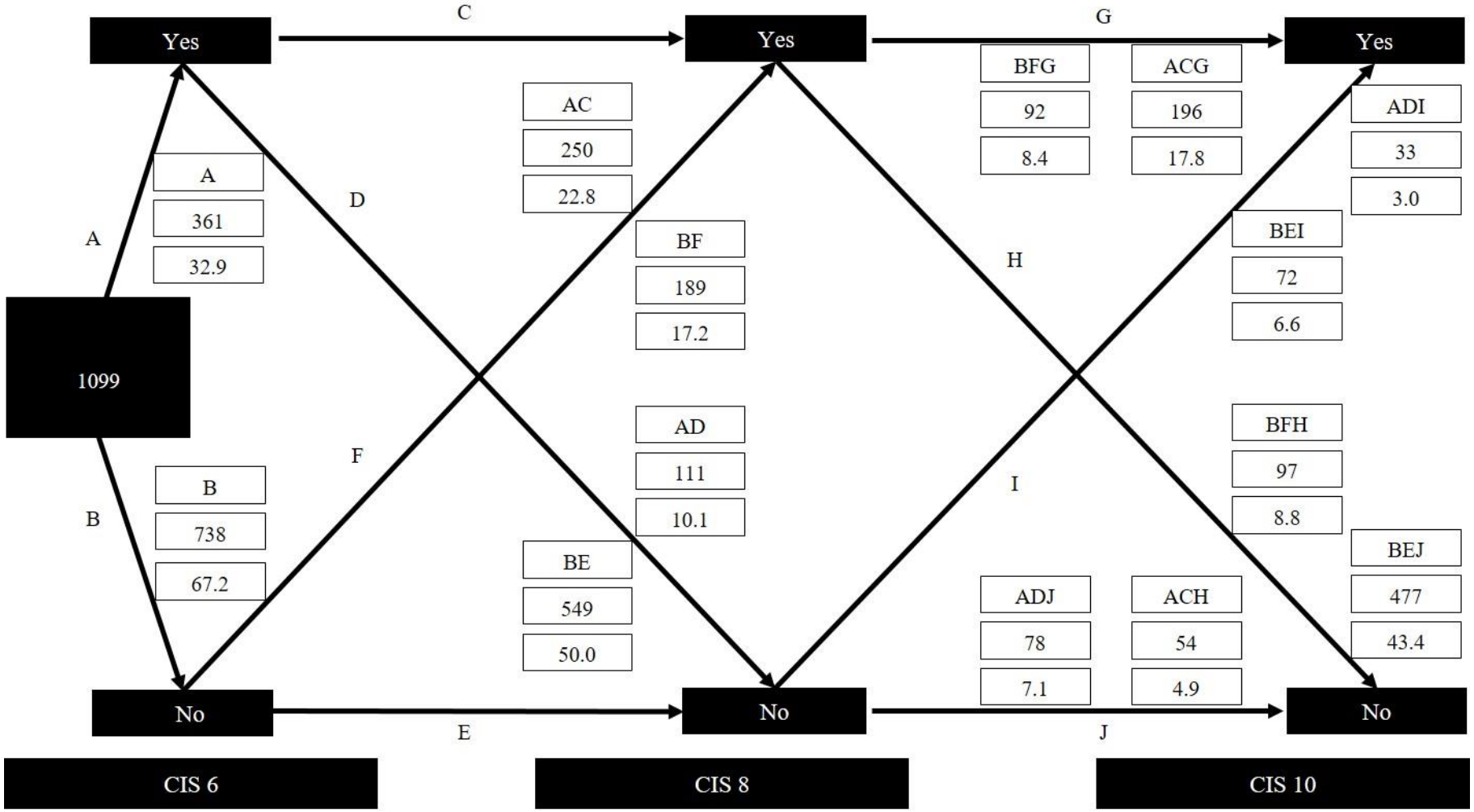
The innovative behaviour of the firm is observed over three periods of time, each one comprises one biennium.

Figure 2 - Transition frequencies: overall innovation



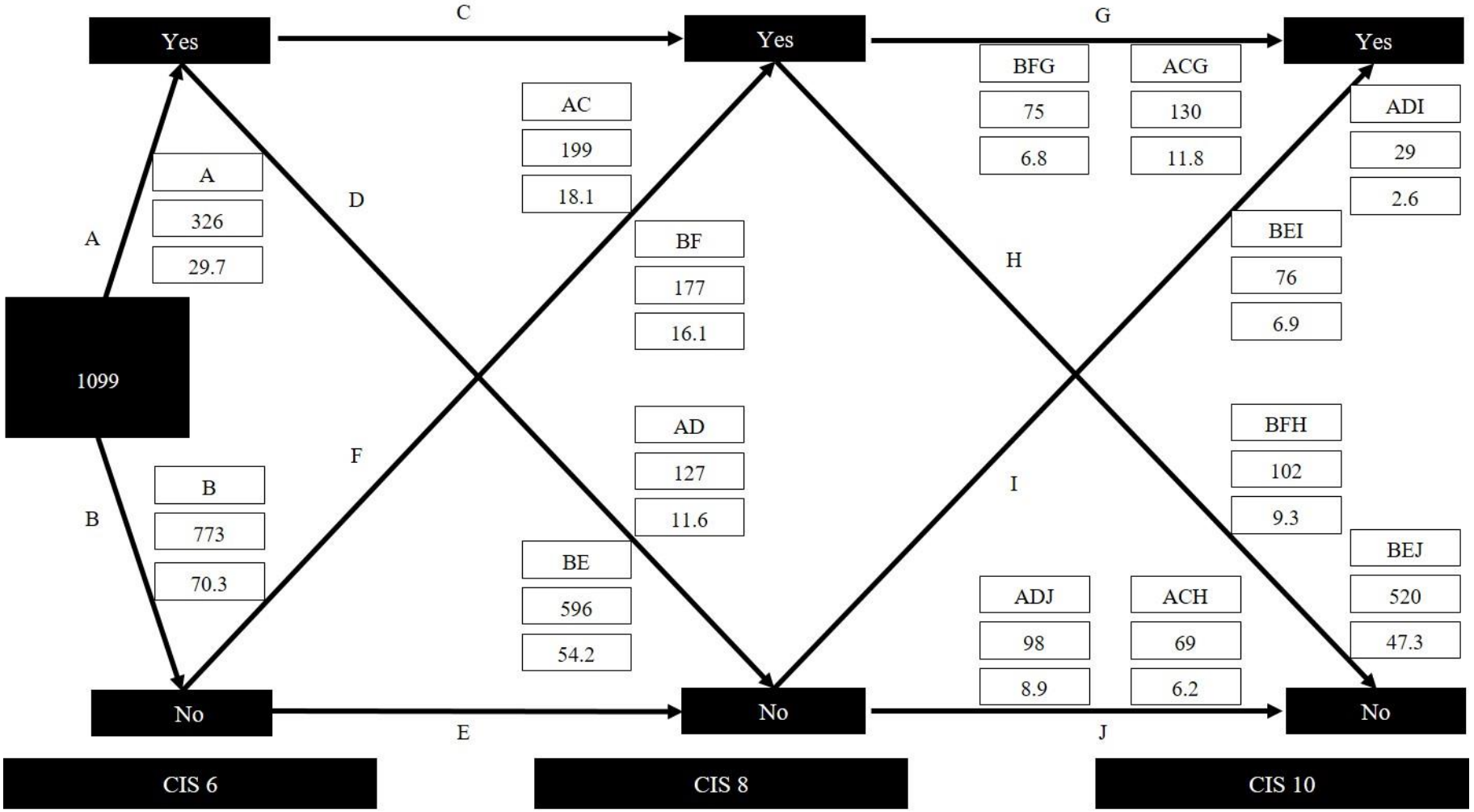
Source: Author's computation based on CIS data

Figure 3 - Transition frequencies – product innovation



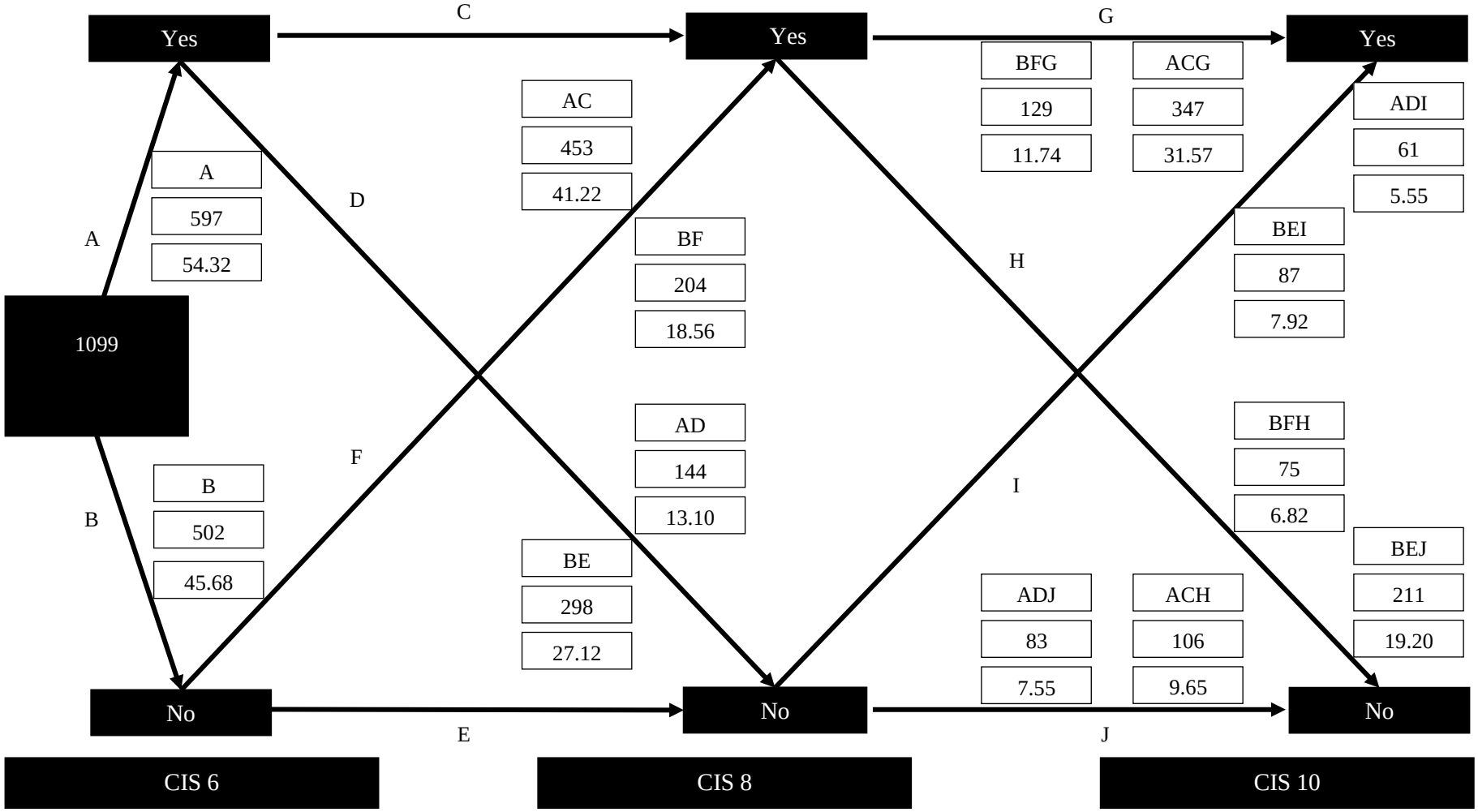
Source: Author's computation based on CIS data

Figure 4 - Transition frequencies – service innovation



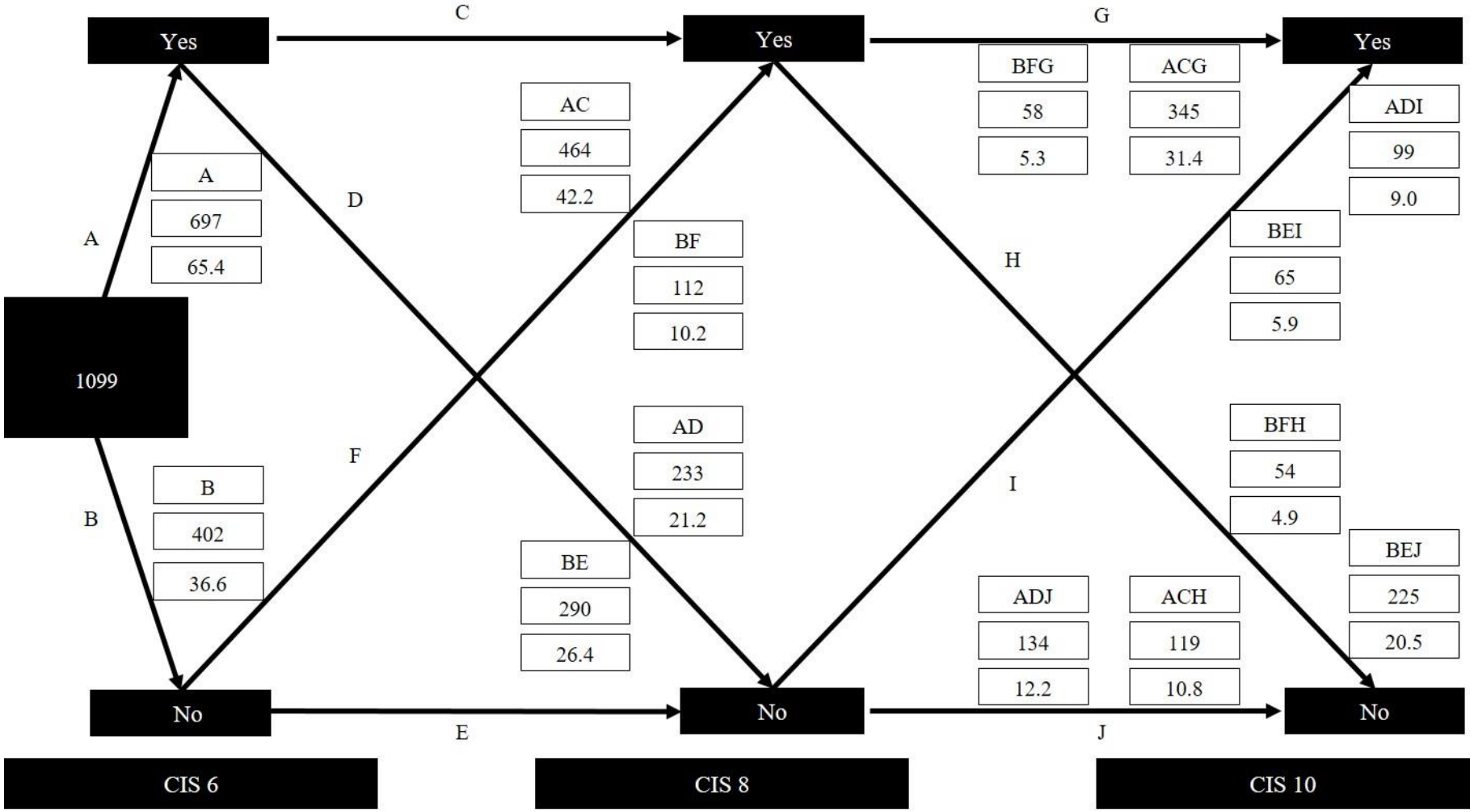
Source: Author's computation based on CIS data

Figure 5 - Transition frequencies – process innovation



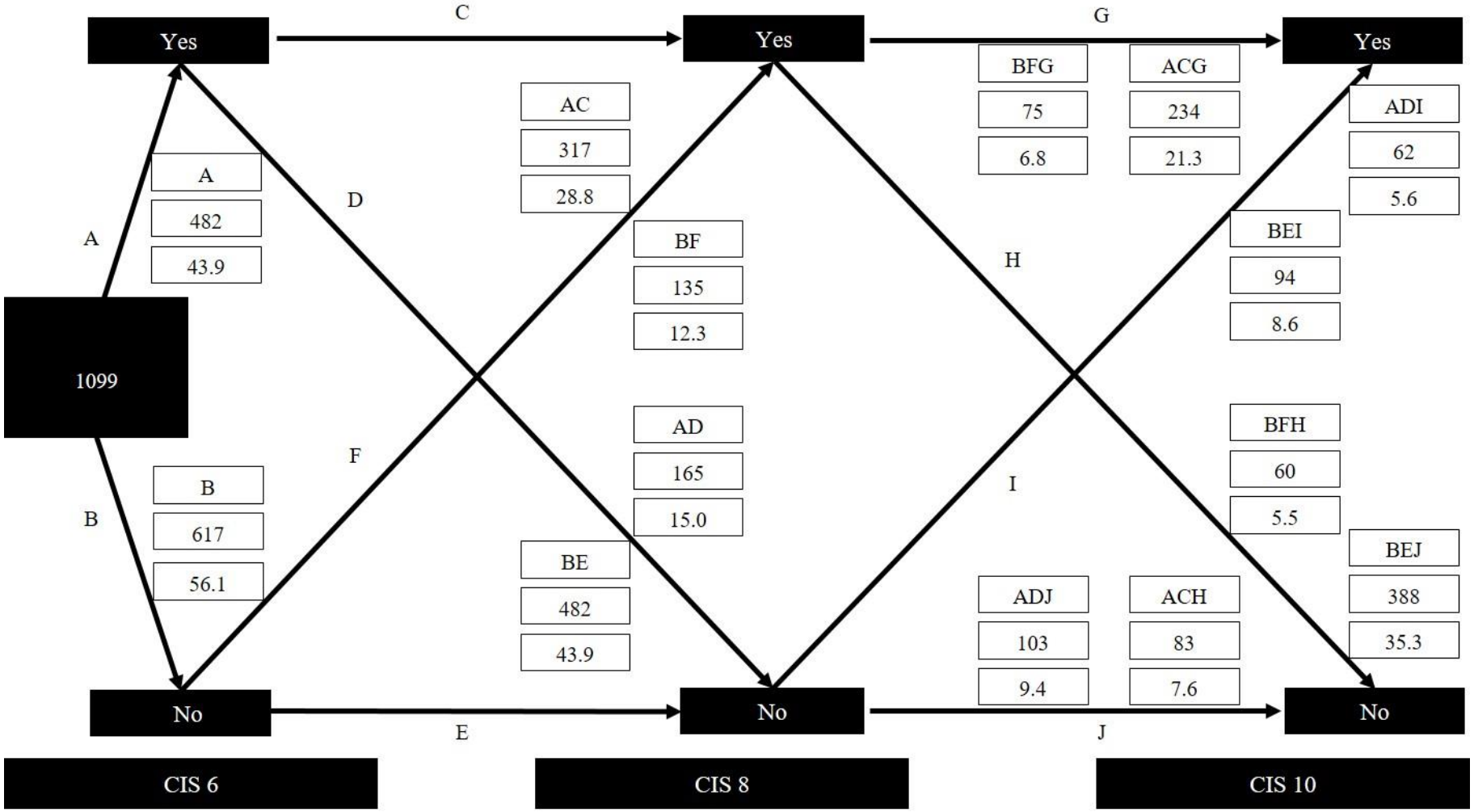
Source: Author's computation based on CIS data

Figure 6 - Transition frequencies – organisational innovation actions per CIS



Source: Author's computation based on CIS data

Figure 7 - Transition frequencies – marketing innovation actions per CIS



Source: Author's computation based on CIS data

Innovative strategies over time (summary)

Table 26 - Aggregation of the innovative strategies in the period of analysis

Innovative strategy		Type of innovation (nº of firms)					
		General	**Product**	**Service**	**Process**	**Organisational**	**Marketing**
ACG	Continuous	624	196	130	347	345	234
ACH	Continuous - Sporadic	101	54	69	106	119	83
ADI	Sporadic - New	77	33	29	61	99	62
ADJ	Sporadic - Non innovative	55	78	98	83	134	103
BFG	New - Continuous	74	92	75	129	58	75
BFH	New - Sporadic	26	97	102	75	54	60
BEI	Non - innovative - New	42	72	76	87	65	94
BEJ	Non - Innovative	100	477	520	211	225	388
	Total	**1099**	**1099**	**1099**	**1099**	**1099**	**1099**

Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The transition frequencies allow us to understand the innovation trajectories over time. The panel of firms is observed over three CIS waves, the CIS 6, the CIS 8 and the CIS 10. This diagram permits the understanding of the innovation strategies during the period of 2004-2010. Given the expected differences among innovation types, each one is made in separate: the first is for innovation in general (regardless the type), the second for product, the third for service, the fourth for process, and the fifth for organisational and the sixth for marketing.

When analysing the innovation in general, in the CIS6, 857 firms have reported having performed at least one type of innovation, which is 78% of the panel. When moving to the second period, the CIS8, one could report as persistent innovators 725 firms, meaning that 132 firms failed to continue their innovative path. Continuing to the CIS10, the number of persistent innovators felt to 624. On the contrary, 100 firms reported no innovation activities over the three consecutive periods.

No significant changes are found, from the first to the third period if we observe innovative firms at the aggregate level, 857 firms in the CIS6, and 817 in the CIS10. This

preliminary analysis illustrates that when considering innovation in general, no significant changes were reported even though, the type of innovation may have changed from one moment to the other.

Concerning product innovation, the portion of firms reporting an affirmative answer is small, 361, which is one third of the firms contained in the panel. When observing innovation persistence in product innovation, 196 firms reported product innovation in all of the periods. Conversely, 477 firms did not innovate in any of the periods.

For the CIS6 738 firms mentioned not having performed product innovation; the number of non innovative firms in the CIS10 rose to 783. Discontinuous behaviours are also frequent, in the first threshold 189 were new to innovation, and 111 stopped innovating. The panel contains clear evidence that the firms punctually innovate when needed.

Service innovation is not pursued by most of the firms, 773 in the CIS6, 723 and 789 in the CIS10, this means that during the period of analysis no significant changes were found in terms of firm options; however we can observe intermittences, as only 130 firms were persistent service innovators in the three periods. Stopping and starting innovative actions may be a strategic option for these firms given the unnecessary expenditure in continuous actions.

Process innovation is pursued by an important number of firms in the panel, 597, which represents more than 54% of the total. This innovation strategy is expectable, considering the fact that Portugal is a moderate innovator. Continuous improvements to generate cost reductions are frequent under these circumstances.

Two thirds of the firms included in the panel, affirmatively responded to the development of organisational innovations in the CIS6. This number fell to 567 in the last period. Only one third remained as persistent organisational innovators in the three biennia.

Marketing innovation is not an option for almost a half of the firms in the panel; one third was continuously non-innovative in the three waves; on the contrary, one fifth of the panel were persistent innovators.

4. Econometric Analysis

4.1. Initial considerations

Following the OECD and Eurostat (2005), innovation is the process that develops new or significantly improved products, processes, organisational or commercial techniques. An enlarged overview, presents innovation as part of a general behaviour, in which is found complementarity between product and process innovations Martinez-Ros and Labeaga (2009).

The firm is considered innovative if reporting innovations in terms of product, service, process, organisation or marketing. It is classified as an innovator, in general, if mentioning, at least, one of the possible types.

According to Mohnen and Hall (2013) product innovation consists in the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This type of innovation also includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.

Process innovation consists in implementing new or significantly improved production or delivery methods. Significant changes in techniques, equipments and/or softwares are also considered as being process innovations.

An organizational innovation involves the development of new organizational methods in the firm's internal or external business practices, workplace organization, communication and hierarchical layouts.

Marketing innovation is based on the implementation of a new marketing-mix and the development new its methods which will involve significant changes in product design or packaging, product placement, product promotion or pricing (the four P's).

The first moment will be considered as being of normal innovative behaviour, the second will capture the immediate effects of the crisis and the final will allow for adjustments to the new adverse environment.

The following table illustrates the total number of firms reporting innovation activities in the different types of innovation considered in the present analysis. This will provide an understanding of the entire picture of innovative activities compared to the constructed panel.

4.2. Measures and methodology

The dependent variable in both of these equations is binary: it takes the value of 1 if the firm *i* innovates at time *t* and the value of 0 otherwise. As is well-known, the nature of the dependent variable dictates that these models are best estimated using a probit (or logit) specification.

Given the panel structure of the data, a choice must be made concerning estimation through fixed-effects or random-effects. Because some of the explanatory variables of interest are time-invariant, the use of fixed effects is unfeasible, pointing to the use of random-effects. However, the use of random effects is only valid if the unobserved time invariant firm effects are uncorrelated to the explanatory variables, which is impossible given that the lagged value of the dependent variable is an explanatory variable.

Fortunately, Wooldridge (2005) developed a solution to relax the independence assumption in random effects dynamic probit models. This solution amounts to replace the α_i in the equations above by a linear function of the firm's observable characteristic's (i.e. the average values of the time-variant exogenous characteristics) plus the value of the so-called "initial condition", i.e., the innovative or non-innovative state of the firm at the start of the period under observation.

Therefore, the estimation of either the model presented in the following equations (equation (1) and equation (2)) will be completed using a dynamic random effects probit model.

Table 27 – Variable description

Variable	Type	Description
RD_intensity	Count	Ratio comparing the expenditures in R&D compared to the total turnover
Mid_tech	Binary	1 if the firm belongs to a SIC code classified as being mid tech [1]
High_tech	Binary	1 if the firm belongs to a SIC code classified as being high tech [1]
Balance	Binary	1 if the firm combines investments in endogenous and exogenous knowledge
Education_intensity	Count	Ratio comparing the number of top educated workers to the total
Openness	Count	Counts for the number of sources of innovation the firm uses
Funds	Binary	1 if the firm uses public funds
Medium_size	Binary	1 if the firm in medium
Large_size	Binary	1 if the firm in large

Variable	Type	Description
Group	Binary	1 if the firm belongs to an economic group
Industry	Binary	1 if the firm belongs to the industrial sector
Services	Binary	1 if the firm belongs to the services

[1] Technological intensity defined according to the Pavitt taxonomy in what concerns the manufacturing sector and expended to the other activities as seen in diffused literature from the OECD and the European Commission (exhaustive classification in appendix 6).

4.3. Descriptive statistics

The following table presents the descriptive statistics of the explanatory variables.

Table 28 – Descriptive statistics of the variables in analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
SIC_code	3297			7	74
tech_intensity	3297	2.298	0.778	1	3
sector	3297	2.329	0.517	1	3
size	3297	2.868	0.748	2	4
group	3297	0.485	0.500	0	1
product_innovation	3297	0.362	0.481	0	1
service_innovation	3297	0.307	0.461	0	1
process_innovation	3297	0.570	0.495	0	1
process_innov_production	3297	0.393	0.488	0	1
process_innov_logistic	3297	0.244	0.430	0	1
process_innov_support	3297	0.439	0.496	0	1
organisational_innov	3297	0.558	0.497	0	1
org_innov_procedure	3297	0.451	0.498	0	1
org_innov_responsibility	3297	0.442	0.497	0	1
org_innov_external_rel	3297	0.288	0.453	0	1
marketing_innovation	3297	0.424	0.494	0	1
mkting_innov_package	3297	0.258	0.438	0	1
mkting_innov_promotion	3297	0.290	0.454	0	1
mkting_innov_distribution	3297	0.159	0.365	0	1
mkting_innov_price_pol	3297	0.205	0.404	0	1
innovation_in_general	3297	0.758	0.428	0	1
Funds_general	3297	0.189	0.392	0	1
Openess	3297	4.914	4.081	0	10
R&D_intensity	3297	4.533	115.682	0	6615.23
Education intensity	3297	2.521	1.557	0	6

Source: Author's own computation based on CIS 6, 8 and 10

4.4. Econometric Model

As mentioned in the previous section, the conventional hypothesis of persistence does not comprise the alternative choices in terms of innovation strategy in the past. Therefore, this model will illustrate pure past dependence, having innovated in the past will positively influence the innovative behaviour in the present. Moreover, a set of explanatory variables are included, comprising the firm's structural traits and illustrating innovation efforts.

Following a similar procedure than what can be found in Suaréz (2014), we have drawn an econometric model allowing us to test the conventional persistence hypothesis, which is specified as follows:

$$INNOV_{it} = \beta_1 + \beta_2\, INNOV_{it-1} + \boldsymbol{\beta} W_{it} + \boldsymbol{\delta} V_i + \alpha_i + \varepsilon_{it} \qquad (1)$$

Where innovations at time *t* by firm *i* ($Innov_{it}$) depend on innovations at time *t-1*, a set of time-variant (W_{it}) and time-invariant (V_i) observable characteristics of the firm, and an unobservable firm-specific characteristic (α_i). The variables included in the vectors of control variables will be detailed in the following table.

Evidence in favour of the conventional persistence hypothesis is found if present innovations are positively influenced by past innovations, in other words, a significant and positive coefficient for the lagged dependent variable in the vein for serial correlation. Accordingly, having innovated in the past positively influences the odds of innovating in the present.

However, as previously mentioned, this model may be inadequate to test the persistence hypothesis in variable innovation strategies whose circumstance makes the firm opt for discontinuity in the innovative practices.

Following the taxonomy proposed in the European Innovation Scoreboard 2004, also adopted by Suaréz (2014), firms may be broken down in different sub-groups: continuous innovative firms if there is an affirmative answer to innovation in two consecutive time periods (Continuous_Innov); sporadically innovative firms, if one innovative period is followed by a non-innovative (Sporadic_Innov); new innovative firms

are those that started performing innovative activities after a period of no innovation (New_Innov); or non-innovative firms if in two periods the firm did not perform innovation.

In this context, the model in equation (1) must be updated as follows:

$$INNOV_{it} = \beta_1 + \beta_2 CONTINUOUS\_INNOV_{it-1}$$

$$+ \beta_3 SPORADIC\_INNOV_{it-1} + \beta_4 NEW\_INNOV_{it-1} + \boldsymbol{\beta} W_{it} + \boldsymbol{\delta} V_i + \alpha_i + \varepsilon_{it} \qquad (2)$$

In this case, evidence in favour of the persistence hypotheses could come from a positive coefficient on the Continuous_Innov$_{it-1}$ variable or from a positive coefficient of the New_Innov$_{it-1}$ variable. Concerning Sporadic_Innov$_{it-1}$, one would expect a negative effect in the probability.

Concerning the set of other explanatory variables, the operationalisation has been previously detailed, detailed information about the variables and their codification can be found in appendix 1.

4.5. Estimation results

The objective of analysis is to understand persistency in the innovative activities, which means, the relation between being an innovator in former time periods and being an innovator in the present. In order to capture the time effects of the endogenous variable (binary), we have opted for a dynamic probit random effects estimation.

Firm characteristics such as size, economic group, economic sector, use of funds, R&D intensity, technological intensity, intramural R&D activities, performing Innovation in general (independent on the type), among others were included to control for their effects (this vector of variables is chosen according to the findings of former studies (e.g Peters, 2009; Raymond et al. 2010; Frenz and Pevezer 2012; Ganter and Hecker 2013; Le Bas and Poussing, 2014)

The option to estimate the different types of innovation in separate, as well as the inclusion of all economic sectors rather than simply the manufacturing industry separates the present research from the existing literature. In consequence, there is no direct evidence

to establish the direct connection. Hence, previous exploratory analysis allowed for the understanding that the innovative strategy of firms importantly differs according to the type of innovation being performed, we expect differences in terms of the magnitude and similar patterns in terms if direction.

The following table shows twelve alternative models organised in pairs. The first pair analyses innovation in general, this means that we consider the firm as being innovative if one type of innovation has been performed in the period independent on its nature, this allows for being innovative in one type during one period and other type in another and still being classified as persistent innovator.

Table 29 – Estimation Results (alternative models of persistence)

	Innovation		Product		Service		Process		Organisational		Marketing	
	Model A1	Model A2	Model B1	Model B2	Model C1	Model C2	Model D1	Model D2	Model E1	Model E2	Model F1	Model F2
Innovation $_{t-1}$	0.025		0.025		**0.076***		**0.057****		0.030		**0.125*****	
	(0.026)		(0.034)		(0.040)		(0.026)		(0.039)		(0.041)	
Persistent_gen_lag 1		0.001		**-0.050*****		**-0.061*****		**-0.051*****		0.011		**-0.037****
		(0.012)		(0.017)		(0.019)		(0.015)		(0.018)		(0.017)
Sporadic_gen_lag1		**-0.035***		**-0.172*****		**-0.176*****		**-0.121*****		**-0.123*****		**-0.163*****
		(0.018)		(0.019)		(0.020)		(0.018)		(0.019)		(0.020)
New_gen_lag1		**0.102*****		**0.112*****		**0.116*****		**0.090*****		**0.167*****		**0.161*****
		(0.017)		(0.018)		(0.020)		(0.017)		(0.022)		(0.019)
R&D_intensity	**0.013****	-6.940×10^{-5}	0.002	1.590×10^{-5}	0.001	-1.130×10^{-5}	0.004	7.880×10^{-4}	**0.004****	9.867×10^{-4}	0.002	6.278×10^{-4}
	(0.006)	(1.861×10^{-4})	(0.001)	(3.900×10^{-5})	(0.001)	(2.190×10^{-5})	(0.003)	(7.446×10^{-4})	(0.002)	(8.530×10^{-4})	(0.002)	(7.886×10^{-3})
Mid_tech	0.014	0.014	**0.173*****	**0.108*****	0.038	0.019	-0.006	-0.006	**0.060***	**0.037****	-0.030	-0.013
	(0.019)	(0.013)	(0.029)	(0.017)	(0.031)	(0.019)	(0.021)	(0.015)	(0.031)	(0.018)	(0.030)	(0.019)
High_tech	-0.025	-0.006	**0.070****	**0.044****	**0.064****	**0.040****	-0.002	-0.002	0.038	**0.030***	**-0.109*****	**-0.062*****
	(0.021)	(0.014)	(0.029)	(0.017)	(0.030)	(0.018)	(0.022)	(0.016)	(0.030)	(0.018)	(0.030)	(0.018)
Balance	0.033	0.049	**0.065*****	**0.029***	**0.121*****	**0.073*****	**0.083*****	**0.067*****	**0.142*****	**0.111*****	**0.130*****	**0.090*****
	(0.059)	(0.049)	(0.024)	(0.015)	(0.022)	(0.015)	(0.028)	(0.018)	(0.031)	(0.021)	(0.027)	(0.018)
Education_intensity	0.012	0.001	-0.007	-0.002	**-0.031***	-0.006	0.007	0.007	0.003	-0.009	-0.007	-0.007
	(0.01)	(0.008)	(0.016)	(0.011)	(0.016)	(0.011)	(0.012)	(0.009)	(0.017)	(0.012)	(0.016)	(0.011)
Openness	**0.056*****	**0.049*****	**0.043*****	**0.037*****	**0.046*****	**0.039*****	**0.054*****	**0.052*****	**0.039*****	**0.030*****	**0.034*****	**0.025*****
	(0.004)	(0.004)	(0.003)	(0.002)	(0.004)	(0.002)	(0.003)	(0.002)	(0.004)	(0.003)	(0.004)	(0.003)
Funds	-0.036	-0.019	0.036	**0.037****	0.009	0.006	**0.061****	**0.048****	-0.002	-0.019	0.022	0.019
	(0.04)	(0.032)	(0.023)	(0.016)	(0.023)	(0.015)	(0.024)	(0.019)	(0.027)	(0.020)	(0.026)	(0.018)
Medium_size	-0.013	-0.009	-0.004	-0.007	**-0.047****	**-0.033****	0.026	0.016	-0.014	-0.012	**-0.067*****	**-0.044*****
	(0.014)	(0.010)	(0.024)	(0.014)	(0.023)	(0.014)	(0.017)	(0.012)	(0.024)	(0.015)	(0.024)	(0.015)
Large_size	0.035	**0.031****	0.012	-7.647×10^{-4}	-0.028	**-0.030***	**0.066*****	**0.038****	0.015	0.007	-0.045	-0.028
	(0.022)	(0.014)	(0.030)	(0.018)	(0.028)	(0.017)	(0.022)	(0.016)	(0.031)	(0.019)	(0.030)	(0.019)
Group	0.003	-0.008	-0.008	-0.007	-0.008	-0.001	-0.002	-0.003	-0.002	-0.011	**-0.038***	**-0.034****
	(0.016)	(0.011)	(0.023)	(0.014)	(0.021)	(0.013)	(0.018)	(0.013)	(0.023)	(0.014)	(0.022)	(0.014)
Industry	0.009	-0.001	**0.117****	**0.061***	0.060	0.032	0.034	0.024	3.080×10^{-5}	-0.010	-0.043	-0.035
	(0.036)	(0.026)	(0.051)	(0.032)	(0.099)	(0.057)	(0.048)	(0.035)	(0.070)	(0.040)	(0.067)	(0.042)
Services	0.025	0.002	-0.002	-0.012	**0.233****	**0.140****	0.001	-7.451×10^{-4}	0.043	0.008	0.079	0.037
	(0.038)	(0.027)	(0.055)	(0.034)	(0.100)	(0.058)	(0.050)	(0.036)	(0.072)	(0.041)	(0.069)	(0.043)
$Inno_0$	**0.066*****	**0.190*****	**0.191*****	**0.358*****	**0.115*****	**0.337*****	**0.054****	**0.268*****	**0.153*****	**0.359*****	**0.157*****	**0.408*****
	(0.021)	80.010)	(0.031)	(0.009)	(0.035)	(0.009)	(0.022)	(0.011)	(0.034)	(0.011)	(0.038)	(0.009)
mean_rd_intensity	5.903×10^{-4}	2.446×10^{-4}	-2.730×10^{-4}	-8.470×10^{-5}	$\mathbf{-1.788 \times 10^{-4}}$ **	$\mathbf{-1.016 \times 10^{-4}}$ *	$\mathbf{1.930 \times 10^{-4}}$ ***	$\mathbf{1.206 \times 10^{-4}}$ **	3.842×10^{-4}	2.123×10^{-4}	**-0.005***	**-0.003***
	(8.510×10^{-4})	(0.001)	(0.001)	(1.115×10^{-4})	(7.270×10^{-5})	(5.610×10^{-5})	(5.690×10^{-5})	(5.380×10^{-5})	(2.829×10^{-4})	(1.362×10^{-4})	(0.003)	(0.002)
mean_educ_intensity	-0.008	0.003	-0.004	-0.003	**0.036****	0.009	-0.017	-0.013	0.012	0.021	0.025	0.021
	(0.011)	(0.009)	(0.017)	(0.012)	(0.018)	(0.012)	(0.013)	(0.010)	(0.019)	(0.013)	(0.018)	(0.013)
mean_openness	4.432×10^{-4}	-0.003	**0.011***	-0.005	-0.009	**-0.014*****	**-0.011****	**-0.020*****	0.008	-0.002	0.005	-5.360×10^{-4}
	(0.005)	(0.003)	(0.006)	(0.003)	(0.006)	(0.003)	(0.005)	(0.003)	(0.006)	(0.003)	(0.006)	(0.003)
No. observations	2198	3296	2198	3296	2198	3296	2198	3296	2198	3296	2198	3296
No. of groups	1099	1098	1099	1098	1099	1098	1099	1098	1099	1098	1099	1098
Wald test (p-value)	160.63	750.14	273.4	1202.76	301.12	1071.1	344.24	1365.99	349.43	1187.57	386.67	1231.88
	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)	(<0.001)

Source: author's computation based on the constructed panel

4.5.1. Innovation in general

The first attempt to measure persistence was done by means of running dynamic probit random effects and considering innovation in general (with no separation among the different innovation types). This variable tries to empirically approach the concept of complex innovators discussed by Le Bas and Poussing, (2014). To them, these firms develop more than one type of innovation, normally product and process or organizational. They tend to be more persistent as there is a development of complementarities.

Concerning the traditional hypothesis of persistence (illustrated in model 1) being innovative in the past does not influence the probability of being innovative in the present. In other words, the hypothesis fails to be proved for innovation in general. Our empirical evidence does no support pure innovation persistence. Our result cannot be directly compared to those in the literature as the composite variable we have built is not analysed elsewhere, but, given the construction premises (any type of innovation), pure persistence should hold, still, the result is not statistically significant.

The controls for openness and initial innovation appear as being statistically significant, with positive effects on the probability to innovate. This fact highlights the importance of the sources of innovation to develop different innovative strategies and adapt to the changing environment. Relying on different sources of innovation, either internal or external to the firm will require lower levels of finance and may be crucial to the maintenance of a persistence innovation strategy.

Model A2, accepts the possibility of changing the innovative strategy over time, which means that the firm can start, stop or continue innovation in each period of time. Concerning innovation in general, the hypothesis formulated for dynamic innovative strategies, appear as being significant for new and sporadic innovators.

Being a sporadic innovator in the former period reduces the probability of innovation at present by 3.5 percentage points, compared to the non-innovative firms. On the contrary, being a new innovator in the previous period raises the probability of innovating in the present by 10.2 pp compared to the benchmark. Openness continues significant and positive. Large sized firms also have an increased probability to innovate by 3.1 pp, compared to the small.

When breaking down innovation into different types, past innovations seem to be useful to continue developing the present. In the case of service, process and marketing innovations different results appear, persistence hypothesis in the conventional manner is proved as being significant

When analysing conventional persistence in product innovation, Peters (2009) has found that German firms are persistent innovators, there is also finding statistical significance for size and the use of funds, going along with the present results. The Dutch case explored by Raymond et al. (2010), evidences persistence among mid-high and high tech and firms; still, in the case of mid-low and low tech firms persistence does not hold; our results go in a similar direction as the marginal effects of technological intensive are positive. Frenz and Prevezer (2012), exploring the British evidence confirm the conventional persistence hypothesis, also supporting the significance of size and sector.

4.5.2. Product innovation

Within the present panel, finding persistent innovators in terms of product or service component is far more difficult than in terms of processes or organisational. The complexity and the requirements of these processes are very different from the other dimensions mostly in terms of financial requirements.

Model B1 evidences that in the case of product innovation pure persistence does not hold. This result is different from those achieved in the studies performed in innovation leaders (e.g. Germany – Peters, 2009) and also followers (e.g. UK – Frenz and Prevezer 2012), and goes along with the Argentinean results of Suárez (2014).

The control variables such as technological intensity, openness and sector appear as being significant and the direction of the effects is as expected; innovation dynamics positively influences pursuing innovative activities in the present. Still, variables such as size, funds and group fail to be statistically significant.

In the same vein, Model B2 permits transitions in terms of the innovative strategies of firms. Being a persistent innovator in the past, decreases the probability of continuing innovative activities at present by 5 pp.; this result evidences that firms that were product innovative in the past are prone to stop, which goes in the opposite direction from the existing literature (e.g. Peters, 2009, Frenz and Prevezer 2012, Suárez 2014).

If in the former period the firm was a sporadic innovator, in other words, it did innovate in t-2 and stopped innovating in t-1, the probability to perform innovation in t falls by 17.2 pp. In the evidence of Suárez (2014) this trend failed to be significant.

Firms that are new to innovation in t-1 will have an increased probability to innovate in t of 11.2 pp; the results go along with those of Suárez (2014).

The control variables still hold with similar results than those commented on model B1. It is of worth underlining that size continues to be statistically insignificant.

These findings are, to us, of major relevance, as, concerning product innovation, intermittence in terms of innovation strategy appears as being strongly significant. Persistent innovators will have a reduced probability of continuing with innovation; firms that dumped innovation in the former period will continue as non-innovative and those who are new to innovation will continue, perhaps finishing the innovative wave. In sum, this may draw some cycle in the innovative strategy rather than the linear continuity described in the literature.

4.5.3. Service innovation

The classical hypothesis of persistence appears as significant for service innovation (Model C1); former persistent innovators have an increased probability to perform service innovation by 7.6 pp. The control variable behave in a similar mode as in the former models. It is reinforced the existence of different innovation patterns in the different economic sectors when observing that firms operating in the tertiary sector have an increased probability of performing service innovation of 23.3 pp.

Again, solid statistical significance is found for the alternating innovative strategies (Model C2). The results for persistent, sporadic and new innovator go along with those described in the former model. The controls also present the expected signs, and no surprisingly, belonging to the service sector increases the probability of service innovation by 14 pp.

4.5.4. Process innovation

Concerning process innovation, the hypothesis of pure persistence strategy, appears as statistically significant. Having performed innovation in the past raises the probability of continuing to innovate by 5.7 percentage points.

When considering dynamic innovative strategies, the three hypotheses are proved statistically significant. The persistence hypothesis is significant, despite with the opposite sign, from the former model. Hence, being an innovative firm in the past will decrease the probability of continuity at present. Being a sporadic innovator in the past will also decrease the probability of innovating at present. New innovators in the former period have an increased probability to continue innovating of 9 percentage points.

In the case of Spain, classified as a moderate innovator likewise Portugal, complementarities between product and process innovation are found (Martínez-Ros and Labeaga, 2009); these results approach from those found in our model. This may reinforce the existence of an eventual pattern among moderate innovators.

4.5.5. Organisational innovation

Organisational innovation has been scantily exploited in persistence literature apart from the recent works of Ganter and Hecker (2013) Haned et al. (2014) and Le Bas et al. (2015). In the context of a moderate innovator, this type of innovation bridges innovative opportunities from one period to the other. The financial and bureaucratic requirements of organizational innovation are far lower than other type of innovation; so, small firms with severe financial constraints may find in this procedure a smart way to perform innovation and operate cost reduction.

For organisational innovation the conventional hypothesis of persistence fails to be statistically significant. Moving to model E2, to illustrate innovative behaviour considering dynamic innovation strategies, only the sporadic and the new innovator hypothesis are presented as significant. Being a sporadic innovator in the past will decrease the probability of innovating at present by 12.3 percentage points. New innovators in the former period, have an increased probability to continue innovating of 16.7 percentage points.

Concerning the control variables, openness appears as having a positive effect in the probability to innovate, as well as belonging to a high tech sector. Firm sizes as well as belonging to an economic group and the use of public funds fail to be statistically significant. This innovation type is perhaps more close to the use of innovation sources rather than to some structural characteristics of the firm.

4.5.6. Marketing innovation

The evaluation of persistence in terms of marketing innovation is somehow unexploited in the existing literature. One of the few works devoted attention to this innovation type and its influence on persistence (e.g. Lhuillery, 2014).

For marketing innovation, the conventional hypothesis of innovation persistence is proved as being statistically significant. Having performed innovation in the past will increase the probability of innovating at present by 12.5 percentage points.

The hypotheses formulated for dynamic innovative strategies are proved as being significant. Persistent and sporadic innovators have a decreased probability to innovate compared to the default group; for new innovators the effect goes in the opposite direction. New innovators in the former period have an increased probability to innovate by 16 percentage points. Some of the control variables appear as significant for the usual levels reinforcing the importance of the structural traits.

6. Conclusion

The traditional hypothesis in terms of innovation persistence, in which it is considered pure serial correlation, appears as being significant to service, process and marketing innovation and fails to be significant to innovation in general, product innovation and organisational innovation. The existence of diverse results when breaking down innovation in different types reinforces the need for a deeper understanding of the nature of each innovative action as they appear as being different.

Moving to the analysis of discontinuous innovative strategies (models 2) we observe that the pure persistence hypothesis fails to be significant for innovation in general as well as organisational innovation, for the other innovation types it appears as statistically significant. The negative sign found on persistence may be due to the fact that past innovations are irrelevant in the new environment. Path dependence is limiting the range of possible responses of the firm; the former learning and accumulation id forcing the firm to postpone the present innovative activities. These firms may not yet be adapted to the new environment. Moreover they can be experiencing lock-in, being stuck in former innovation projects and being incapable to move forward. Invariably, firms with a high dynamic profile have a higher propensity to perform innovative activities.

The hypothesis of sporadic innovation fits those firms that have stopped their innovative activities; in this case, innovation can be interpreted as a single action, serving the purpose a particular problem with no intent in terms of continuity, innovative activities are punctual actions with very specific targets. There is evidence of persistence among new innovative firms, these firms are completely free to decide in terms of their innovative projects, they are not sticky to lock-in or path dependence, so they continue innovation perhaps to fully exploit an innovation cycle.

Present public policy actions do not accommodate heterogeneity; they rely on the theoretical assumptions of pure persistence, the existing evidence based of the orthodox frameworks which are perhaps not suitable for weaker innovators. Strategically, our firms decide to interrupt their innovative actions may be due to the unprofitableness of pure persistence. Under a public policy perspective, the evaluation of persistence is of major importance as the support of start-ups, the enrolment with the National System of Innovation as well as the establishment of strong connections among agents must be taken

into consideration to guarantee that the policy instruments reach the correct individuals. Secondly, the understanding of the specific needs of firms will raise the efficiency of public support, therefore improving the quality of the innovation process. A deeper understanding of the real causes of intermittence and its rationale is required as it can be either intentional or caused be exogenous constraints. Public policy is especially useful if the case is the second, as if the cause of intermittence is the existence of barriers or the excessive costs of innovation one must define the role of Governance and the Universities in overcoming this drawbacks.

These findings shed important light to the understanding of the huge difference among the empirical results of moderate innovators compared to the existing literature. The previous studies are mostly developed analysing innovation leaders, this points to the inadequacy of the perception of "one size fits all" in terms of persistence. Innovation policy is a major issue to be dealt by the Triple Helix. The role of the Government and the Universities is considered as strategic to boost economic growth, sustainability and convergence among countries. Given the asymmetries found among leaders and moderate innovators smart policy needs to be implemented, otherwise the policy design will be unsuitable for those who need the most. Existing actions seem therefore to work as "picking winners" destroying any possibility of cohesion and convergence among the European regions.

Table 30 – Hypotheses in test compared to the empirical results

Hypothesis	Description	Results
[H1]	The probability of innovating at present positively depends on past innovation (ignoring the possibility of discontinuous innovation)	Partially Supported
[H2]	Being a continuous innovator in the past, considering the possibility of intermittence rises the probability of continuous innovation	Not Supported
[H3]	Sporadic innovators will have a reduced probability to pursuit innovators at present	Supported
[H4]	Among firms that are new to innovation, the probability of continuous innovative activities is higher	Supported

Source: Author's own computation based on CIS data

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HINDERING FACTORS TO INNOVATION. DOES THE INNOVATION TYPE MATTER? A PANEL DATA ANALYSIS

Abstract

The existence of companies developing innovative activities is a key factor for a competitive economy. Firms recognize the importance of these actions to raise their productivity and create an advantage towards their competitors, consolidate their position in the market and gain extra profits (Geroski et al., 1997).

Innovation projects have a very uncertain outcome, thus exposing the firm to additional managerial risks. When the economic environment is adverse, firms tend to reduce the amount spent in R&D and deleverage innovative activities. The propensity of success of the innovative projects is very limited, many innovation projects fail. Very often, firms decide to abandon their innovative projects to avoid eventual failures or, in other cases due to the existence of exogenous hampering factors.

The perception of the obstacles to innovation depend on the firm's particular characteristics. One would expect similar firms to behave in the same manner, although there are important cleavages, and there is a certain uniqueness in each innovative process. Financial constraints are mentioned as the most common hampering factor to innovation (e.g Mohnen et al., 2008; Landry, 2008; Canepa and Stoneman 2002). Other factors are highlighted, such as knowledge and markets, even though they are complementary to finance.

Dependent on the type of innovation performed, the variety and amount of resources devoted to innovation will change. The stage of the process will also require different endowments of resources, consequently changing the effort demanded to the firm, therefore the importance of eventual barriers will change depending on the stage of innovation.

Given the importance of the financial constraints, it is expectable to find volatility in the efforts devoted to innovation in an adverse economic context. Therefore, the economic crisis, expectably caused an important rise in the number of firms forced to abandon their innovative activities due to financial constraints. Surprisingly in our panel, 278 firms mentioned having abandoned the innovative activities in the CIS 6 and few, 178, in the CIS 10.

These findings do illustrate that the lack of finance does hamper the innovative activities, but, there are, for certain other reasons influencing the abandon of the innovative activities. The identification of the determinants of failure will be of major importance to design the public policies, to redirect the financial support as well as the entrepreneurial practices to avoid withdrawing innovation due to the existence of constraints.

1. Introduction

Successful innovation is determinant to the economic performance of firms. The engagement of innovative activities by developing new products or processes will raise the efficiency level, productivity, minimisation of the cost structure, thus generating an advantage towards their competitors. Firms' and industry specific characteristics may speed up the pace of achieving innovations (Acs and Audretsch, 1987). Innovative firms grow more rapidly in terms of employment and profitability (Geroski et al., 1993), as a consequence, innovation policies may boost economic growth and convergence. Achieving innovation will depend on the ability to combine internal capabilities to the financial resources, get a clear picture about the market and its evolution as well as establishing fruitful links with external actors.

Firms need to tackle important contests to achieve successful innovation. The economic crisis that started in 2008 seriously affected innovation and R&D in Portugal likewise other countries. Furthermore, the existing weaknesses in the National System of Innovation (NSI) became wider (according to the results of the IUS). Further developments in the innovation policy are unclear, as new frameworks are designed and implemented, such as the RIS3, given former policy failures to address demand uncertainties, redeployment of both human and physical capital (OECD, 2012).

Irreversible damage was generated due to the erosion of credibility of the financial system, exponential growth of firm insolvency, long term skilled unemployment, emigration, insufficient demand caused by negative expectations about the future as well as dramatic cuts in innovation policies as a result of budgetary constraints.

Governments continue to allocate sums of money and resources in policy actions to promote R&D activities to heighten innovation, in the belief that these actions will boost economic growth and prosperity. The Lisbon Strategy designed in 2000, aimed at transforming the European Union into one of the innovation leaders' worldwide, therefore generating economic growth and social cohesion. The failure of these policies forced the European Commission to develop new policy instruments to improve the efficiency of the R&D; the RIS3 is expectably the solution towards cohesion and expectably it will overcome the drawbacks of the less favoured regions, approaching the most developed (CEC, 2012).

Innovation failure is an issue neglected by the literature, even though it is a natural condition of the process. Innovative activities are highly risky, due to the uncertainty regarding their outcomes: future earnings, scheduling, feasibility and market penetration are unpredictable; furthermore, and even with reliable forecasts unexpected drawbacks may happen.

When severe constraints, regardless of their nature, jeopardise the research projects, firms must abandon the innovative activities targeted to the development of new products or processes. Despite the eventual uniqueness or randomness of innovation failure we aim at finding some patterns concerning the determinants of abandon to anticipate failure or even to create theoretical and political contexts to reduce uncertainty, thus minimising losses. The study aims at systematizing the determinants of the abandon of innovative activities, understanding the eventual change it their structures caused by adverse economic environments and offering policy recommendations to hopefully put back innovation in the policy agenda.

Among the obstacles to innovation discussed in the literature, the most important are the financial constraints (e.g. Canepa and Stoneman (2002), Savignac (2008), Tiwari et al. (2008)) however they are not the single explanation for the weakening innovative activities. Currently, venture capital investments must reconsider participation in innovative activities; but policy-makers will play a determinant role in the design of accurate actions improving innovation and growth. Modern markets face global competition standards, products and technologies are rapidly declining, consumer demand suffers constant variations; independent on their size, firms must be flexible enough to adapt to the new environment. Non-innovative markets will perish.

Understanding the full dimension of innovation and its hindering factors may help entrepreneurs, managers and financial investors to avoid several miscalculations. Approaching the framework proposed by the CIS, three major types of barriers will influence the abandon probability: lack of finance (internal or external), knowledge factors and market conditions.

Firms that perceive a favourable environment with reduced barriers to innovation will be more prone to perform innovative activities. Accordingly, policy makers must create the confidence conditions.

As the firm is an open system, the exogenous economic and knowledge circumstance will determine the attitude of firms towards innovation; efforts should be made to nourish this milieu. Perception of obstacles from innovators varies across countries; consequently, policy makers should conceive a country specific innovation policy to overcome the limitations (Galia et al. 2012).

A particularly singular feature of this paper is that it compiles two CIS waves, to be exact the CIS 6 and the CIS 10 creating a panel of firms, gathering firms from all sectors, all technological intensities and all sizes, in sum, a broad sample of almost all SIC codes. The panel comprises 1496 firms, observed during the 2004-2006 and the 2008-2010 biennia. An analysis of the obstacles perceived by the Portuguese firms over the two CIS waves will be performed to shed some light into the hindering factors of innovation and produce some policy recommendations in order to incentive and finance the innovative activities of firms.

The perception of financial constraints strongly influences the probability of abandon, along with sources such as the existence of trained workers or the uncertainty in terms of the demand. Considering that financial constraints are of major importance, the change in the economic environment caused by an economic crisis will eventually change the firm perspective towards innovation, if so, the empirical evidence will illustrate higher rates of abandon in the second period of the panel.

Previous econometric results reinforce the fact that intermittence in innovative strategies is part of the managerial conduct of firms. Former persistent innovators are less prone to continue innovation as well as sporadic innovators; consequently, the abandon of the innovative activities seem to be part of the managerial rationality.

The remainder of the paper is structured as follows: Section 2 presents the theoretical background, of barriers to innovation and their complementarity. It also discusses the role of barriers to innovation concerning different economic contexts. In Section 3 database, hypothesis, methodology and econometric modelling are defined. Hereinafter, Section 4 presents the econometric results, and the discussion. Lastly, Section 5 concludes and addresses some policy recommendations.

2. Critical literature review

Due to the uncertainties involved in innovative activities, many firms opt for not engaging innovation activities at all. The negative impact of the potential risk can be a significant obstacle to innovation within firms (Borgelt and Falk, 2007).

Most of the literature is committed to explaining innovation success and its factors, very few has been done addressing what determines the failure of the innovation projects, if there is a possible systematisation, and what can policy makers do to minimise the negative consequences of this phenomenon.

Theoretical and empirical evidence about the determinants of innovation failures is scant; the financial crisis as along with the failure of several policy frameworks made it a recent point of interest among researchers. The literature presents different strands to addressing the issue of innovation failure and the barriers to innovation, and some bridging results concerning innovation activities over the business cycle. The most representative papers in this area are the works of Galia and Legros (2004), Landry et al. (2008), Mohnen et al. (2008), Savignac (2008), Tiwari et al. (2008), García-Vega and López (2010) and Madrid-Guijarro et al. (2009). In this section highlights concerning theoretical and empirical findings are presented.

This paper aims at addressing the influence of the barriers to innovation (economic factors, knowledge factors and market factors) in the probability of abandoning the innovative activities; additionally if these barriers affect differently the aspects of innovation (product, process, service, organizational and marketing innovation) and if the adverse economic environment changes the perception about the barriers and their importance.

The determinants of the innovation failure will be empirically tested by means of the construction of several models. In the first case, the probability of abandon will be tested in general, without any sectorial or innovative segmentation. The second model separates de firms according to their economic activity; the third, uses each of the innovation vectors illustrating the differences in their requirements and the fourth combines both.

2.1. Determinants of innovation failure

The existence of companies pursuing innovative activities is a key factor for a competitive economy; yet innovation exposes firms to additional risks. In the innovation process, failure can be inevitable; the outcome of innovation projects is uncertain, thus risky. Consequently, the prize to be paid to investors must be higher independent on relying on internal or external sources.

When firms launch new research projects they can make forecasts, but they do not know, for certain, if the project will succeed, its profitability and the difficulties they will find while pursuing these actions.

Projects concerning innovative activities are unattractive to external investors as they cannot control the outcome of the firm's actions nor the evolution of the process; information asymmetries will disincentive venture capital due to the lack of warrantees, as the use of intangible assets as collateral is not commonly accepted.

Besides, firms fear delivering much information due to appropriability problems. Signalling the viability of innovative projects is costly Bhattacharya and Ritter (1985). Due to all these constraints, external sources of finance are often unavailable; firms prefer the use of internal rather than external funds, fostering their innovative activities based on internal liquidity (Myers and Majluf, 1984).

The existence of financial constraints or restricted endowments forces firms to postpone their innovation activities; investments in innovation become even more unappealing due to risk aversion. There is an inverse correlation between innovation intensity and risk aversion of managers (Souitaris, 2001). Taking more risks raises the financial exposure; this may disincentive internal and external financing.

Barriers affect in a different way the different types of innovations such as product innovation, service innovation, process innovation, organizational innovation, and marketing innovation. Better understanding of barriers to innovation can assist firms to foster development of an environment that supports innovation (Hadjimanolis, 1999).

According to Asplund and Sandin (1999) and Cozijnsen et al. (2000) there is an obvious need to systematically assess factors decisive for success and failure of innovation.

To van der Panne et al., (2003). innovation success is determined by positive impact of the firm culture; experience in innovation projects; availability of a variety of

skills among the R&D team; coherent innovation strategy; managerial coherence with the innovative strategy; compatibility of the research with firm competences; matrix organization; competitive price and quantity compared to its substitutes; market opportunity. The viability of a certain product depends on Firm related factors; Project related factors; Product related factors; and Market related factors, firms lacking the accurate characteristics will be more prone to fail. The relation between R&D intensity and innovative output is moderated by such factors as regional knowledge spillovers, demand-pull effects or differences in technological opportunity. Mohnen et al. (2008) mainly analyzes the impact of financial constraints on firm decisions to abandon, prematurely stop, slow down or not start innovation projects; financial obstacles and others related to innovation development are the most important (Landry et al. (2008) and Canepa and Stoneman (2002)), even though there are additional determinants affecting the failure of innovation projects, such as the creation of knowledge, firm strategies, external sources of knowledge, funding, vulnerability and degree of novelty.

Experience enables the firm to capitalize upon learning-by-doing and learning-by-failing effects. Whereas the first improves the firm's R&D efficiency, the latter exposes the firm's weaknesses (Zirger, 1997). Failure is a natural component of the innovation process.

2.2. Innovation Barriers and firm characteristics

Successful firms are engaged in innovative activities to improve their performance in what concerns the cost structure and the advantage of their products. Sectoral and firm characteristics are established as determinants and advantages to produce innovation and patent licensing (Acs and Audretsch 1987, 1988).

The relationship between obstacles to innovation and firms' characteristics are studied in works such as Baldwin and Lin (2002), Galia and Legros (2004), Mohnen and Rosa (2002) and Tourigny and Le (2004), D'Este et al. (2012). These studies consider two major vectors of characteristics, the first related to intrinsic features of the firm (such as size, sector, age, competitive environment, group membership, among others), and the second connected to the firm attitude towards innovation activity (such as technological intensity, financial support for innovation, of sources of knowledge for innovation activities, R&D intensity, introduction of technological innovations and novelty of

innovation, among others). Firms' heterogeneity has to be taken into account to evaluate the firms´ perception of obstacles to innovation and their degree of importance.

There is a general belief that innovation barriers may differ according to firm size, dimension seems to be a hampering factor as small firms tend to find more difficult to pursuit innovative activities than large firms. Small firms have lesser availability of finance being more constrained towards innovation, meaning a broader perception of barriers and their importance. Among SME's there is increased probability in finding difficult pursuing innovative actions (Hadjimanolis, 1999). Despite their difficulty in finding finance, small firms also have absorptive capacity, and flexibility which can work as an innovative advantage compared to large firms. Large firms are threatened by innovation barriers in a different manner.

Increased productivity, growth potential and likelihood of survival will be enhanced in small firms that successfully pursue innovation as a core business strategy (Cefis and Marsili, 2006; Heunks, 1998; Geroski et al., 1993). Those who opt for not embracing these actions are highly prone to become uncompetitive because of the obsolescence of their products and processes. Companies operate under volatile environments facing global competition standards, shorted product and technology lifecycles; and unstable consumer demand. Regardless of their size, firms must achieve the benchmark otherwise being excluded from the market.

Young and small and medium sized firms pursuing these risky actions may fall in severe financial problems (Hadjimanolis, 1999). Creating the accurate policy framework to incentive and finance the innovative activities of firms, mainly among SME's which tend to find more difficult to innovate is determinant for overcoming severe crisis and huge unemployment figures. Teece (1996) emphasized the need to understand and clarify how SMEs can overcome barriers to innovation. Public policies encouraging innovative attitudes, providing funds to SME's in their innovation will allow the start-up, the growth or even the survival of many entrepreneurial initiatives.

Innovating means doing something new, or doing the same in a different manner (Garcia and Calantone, 2002). Being able to introduce innovations in the market depends on the small firm characteristics. Firms down weighting bureaucracy, with managerial expertise, and strong linkages in their productive chain will increase the probability if introducing successful innovations. Small firms achieve advantages in terms of flexibility

and adaptability to compensate the disadvantage of resource constraints when attempting to become more innovative (Freel, 2000).

2.3. Multiplicity of innovation barriers and their complementarity

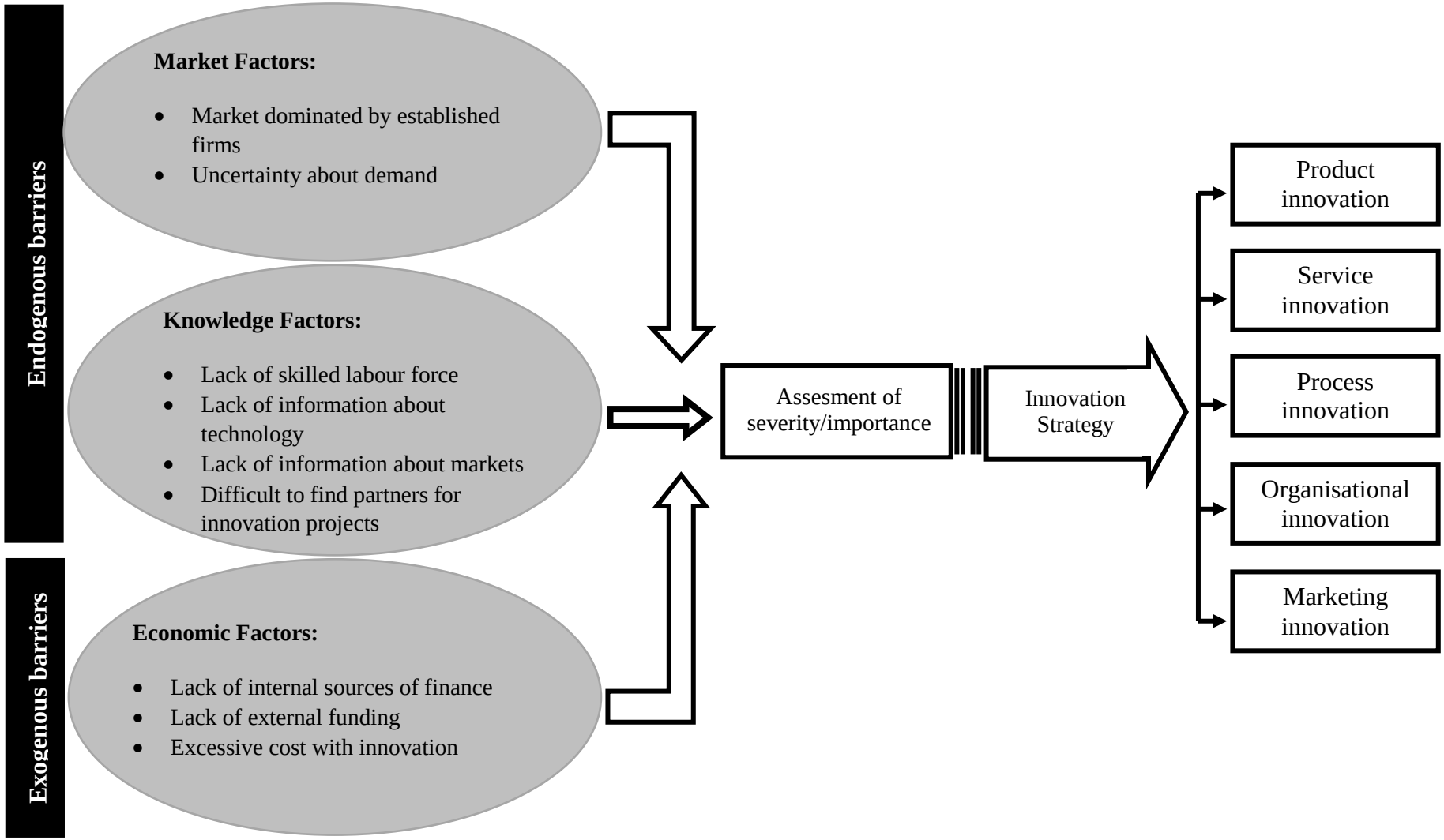
Firms have a different perception to the barriers to innovation, according to their structural traits. Moreover, the perception of the weight of the innovation costs, the institutional constraints, the firm culture, the skills of the labour force are also of major importance (Mohnen and Röölller (2005) and Baldwin and Lin (2002).

A comprehensive knowledge about the barriers to innovation perceived interpreted by the entrepreneurs, the clients, the suppliers and other stakeholders may influence the innovative strategies as well as the positioning towards the market. (Hadjimanolis 1999).

Complementarities between obstacles to innovation constitute a relevant branch of the literature, in this vein Mohnen and Rosa (2002) find cost factors and risk seem to go together; as well as problems of internal and external governance. On the other hand Galia and Legros (2004; 2012) find evidence pointing to the existence of important complementarities between obstacles to innovation in postponed projects, which decay of importance when analyzing abandoned projects. Mohnen and Röölller (2005) propose a different approach to studying complementarities using a discrete test of supermodularity. García-Vega and López, (2010) find all obstacles have a positive effect on the probability of abandoning innovative activities, moreover, the fearing eventual barriers will also work as an hampering factor.

The complementarity of the existing barriers will be, at first verified, as in the preliminary analysis of their correlations there are positive and statistically significant. These results hold in the different time observations, therefore the evidence of our panel seem to go along with the arguments presented in the literature (details from the correlations are presented in the section 4.3.2).

Figure 8 - Innovation barriers and their impact



Source: Author's organisation based on the CIS questionnaire

2.4. Effects of the barriers to innovation and the innovative activity

Economic downturns jeopardize innovation performance. According to Schumpeter's process of *creative destruction*, recessive phases are a pool of opportunities for the agents improving the NSI. Three major factors can be outlined to explain poor performance during the crises: a) uncertainty in demand; b) availability of finance to develop R&D and innovative activities; c) readjustments in terms of the Governmental innovation policy. Under uncertainty, agents contract their willingness to develop risky projects such as innovation. Downturns make agents opt for the reduced exposition to activities generating uncertain pay-offs. Crises generally reduce the demand for products; reduce the liquidity, raise uncertainty, change the innovation policy.

According to the empirical evidence previously discussed, the firm innovative strategy comprises continuing, commencing or stopping the innovative activities, this option is perhaps due to the perceived barriers. So, the probability to abandon the innovative activities will, to some extent be based on the existence of barriers.

Although, not all non-innovative firms face the constraints of barriers, in some cases this behaviour is a simple strategical option. Not engaging new innovative projects may have different reasons, and, sometimes, under a managerial point of view, suspend innovation may seem the best option.

Firms may survive or even grow with no innovation due to product characteristics. Innovation is not as determinant in all sectors. Some firms opt not to innovate at all, other firms prefer to imitate innovators. In the Portuguese case, independent on the CIS session, in almost all economic sectors, nearly half of the firms refer not having performed innovative activities.

Market related factors are pointed as an important abandon due to competition of established firms and market uncertainty. Large firms tend to abandon due the lack of skills (qualified personnel) and availability of external finance. Also, public funding will help firms in supporting the costs and reducing the risk in fostering innovation projects.

The effect of the barriers to innovation in the probability of abandon has been scarcely exploited and the results are to some extent dissimilar in some cases, the barriers reduce the probability to abandon, in other studies the results go in the opposite direction (e.g Mohnen and Röller (2005) and Lööf and Heshmati (2006)).This diversity can be caused by a problem of endogeneity of hampering factors, as there are common factors

affecting both innovation and perception of obstacles. Savignac (2008), Hajivassiliou and Savignac (2008) and Tiwari et al. (2008) analyse the role of endogeneity in innovation barriers, underlining the effect of financial constraints.

2.5. Description of the Barriers to innovation

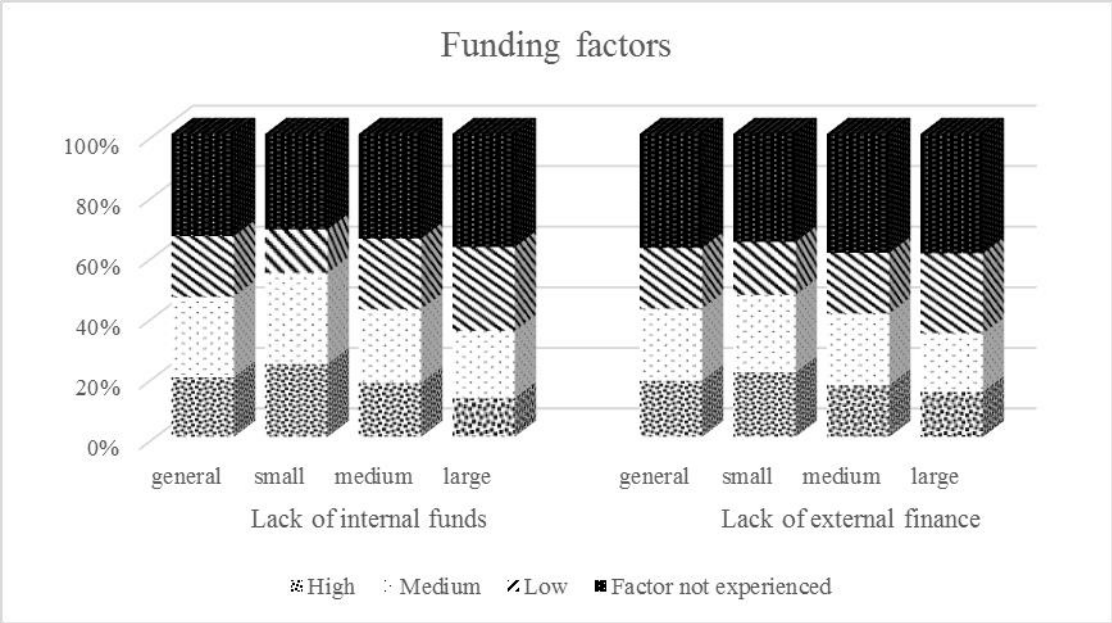
The literature is consensual in terms of enouncing the barriers to innovation, the CIS goes in the same direction asking the firms about the importance of funding factors, market factors and knowledge factors in hampering their innovative activities.

To draw a preliminary picture of the firms' responses to these factors and comprising all the respondents of the CIS 6 and CIS 10 editions some descriptive statistics were performed (appendix 10). The results are very similar for the two waves, albeit a noticeable increase in the mention of the barriers as being of high importance

2.5.1. Barriers to innovation in the sample

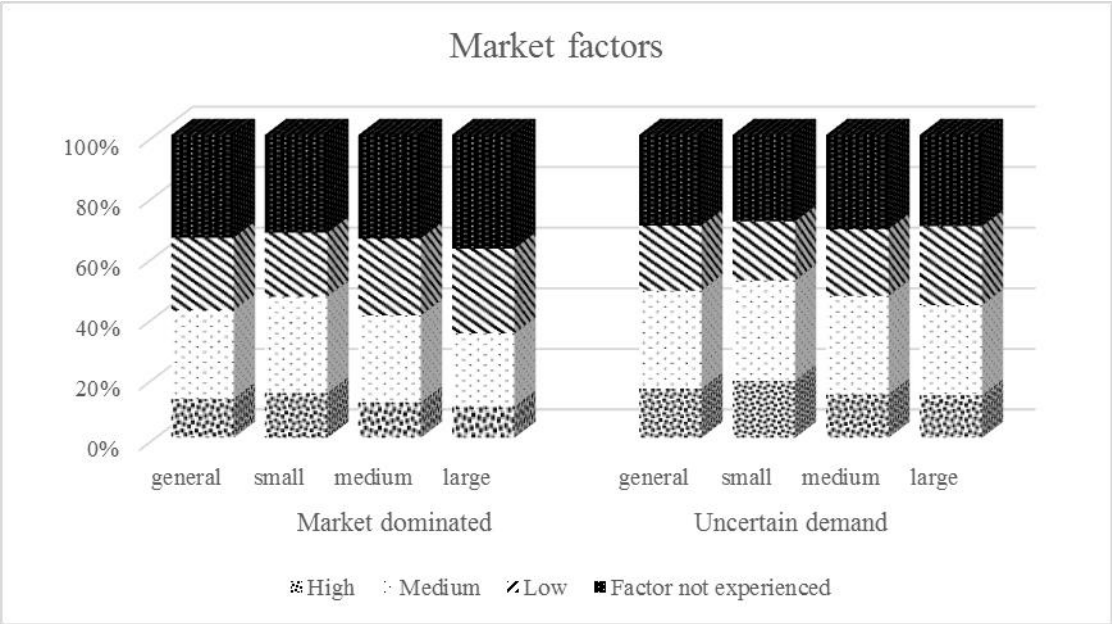
The following graphics illustrate the relevance of the innovation barriers for the entire CIS, this analysis aims at understanding the intensity of the constraint perceived by the firm. The information if divided accordingly to the groups of barriers and the CIS waves.

Graphic 38 - Funding factors – division per size



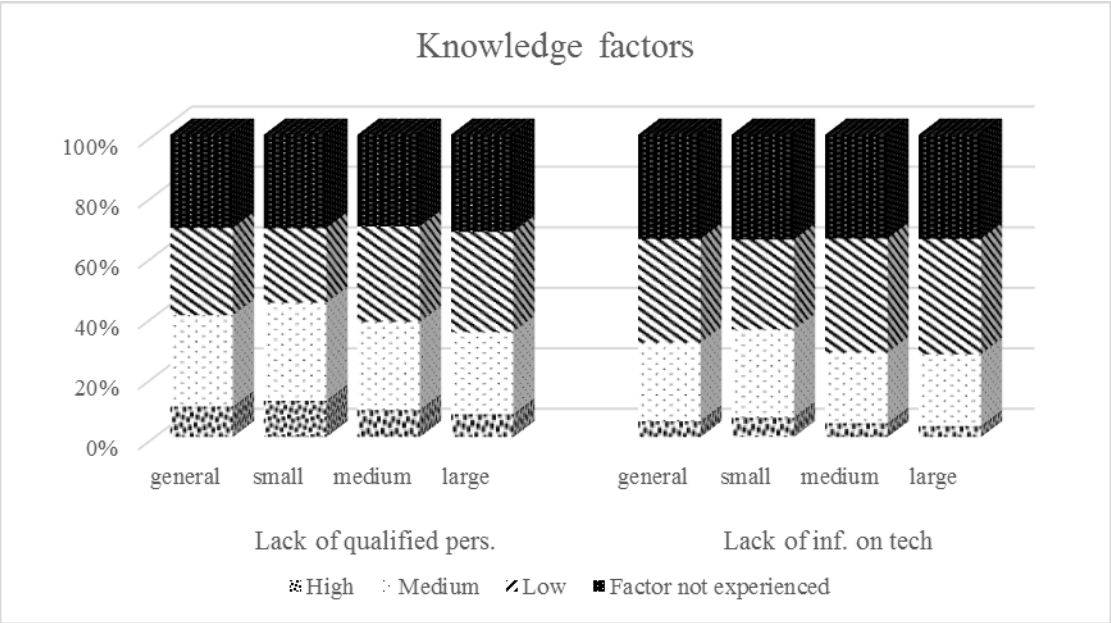
Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 39 - Market factors - division per size



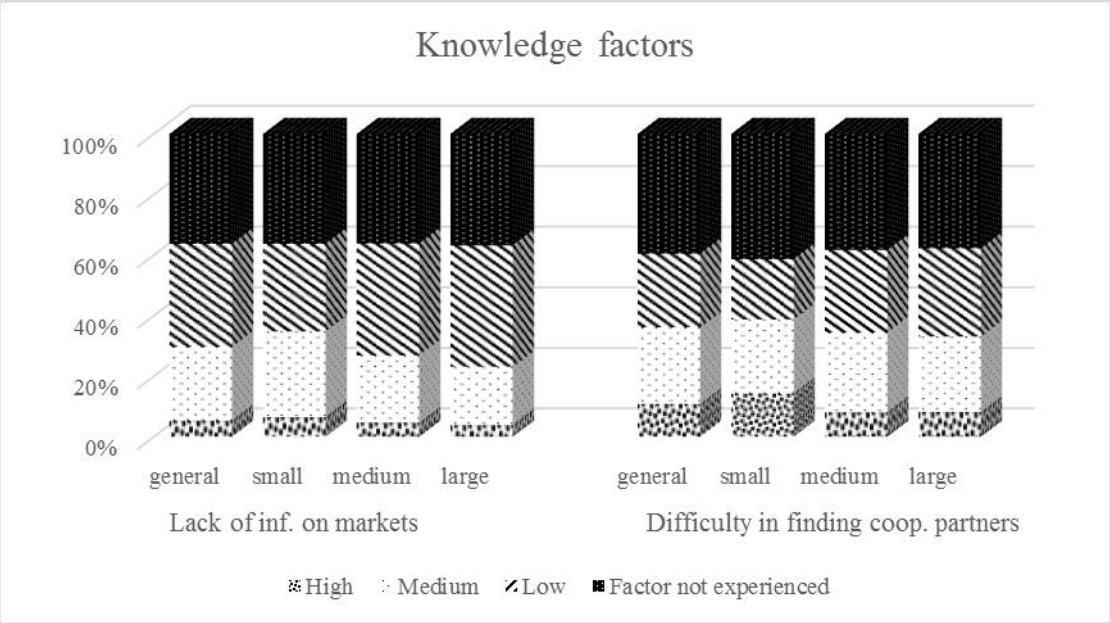
Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 40 - Knowledge factors – division per size



Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

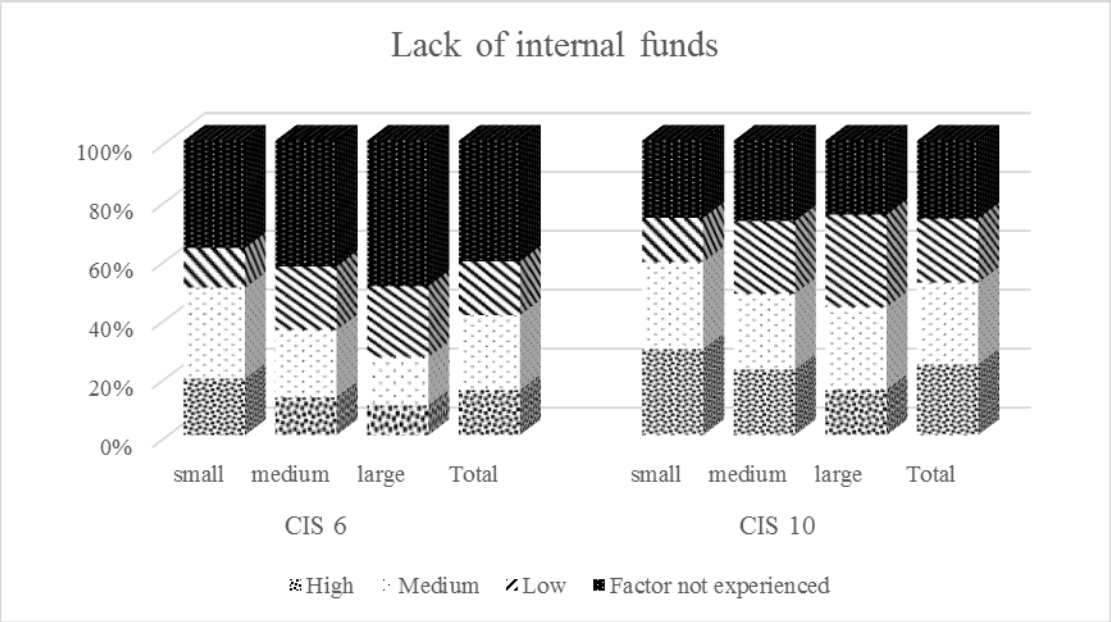
Graphic 41- Knowledge factors (continued) – division per size



Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

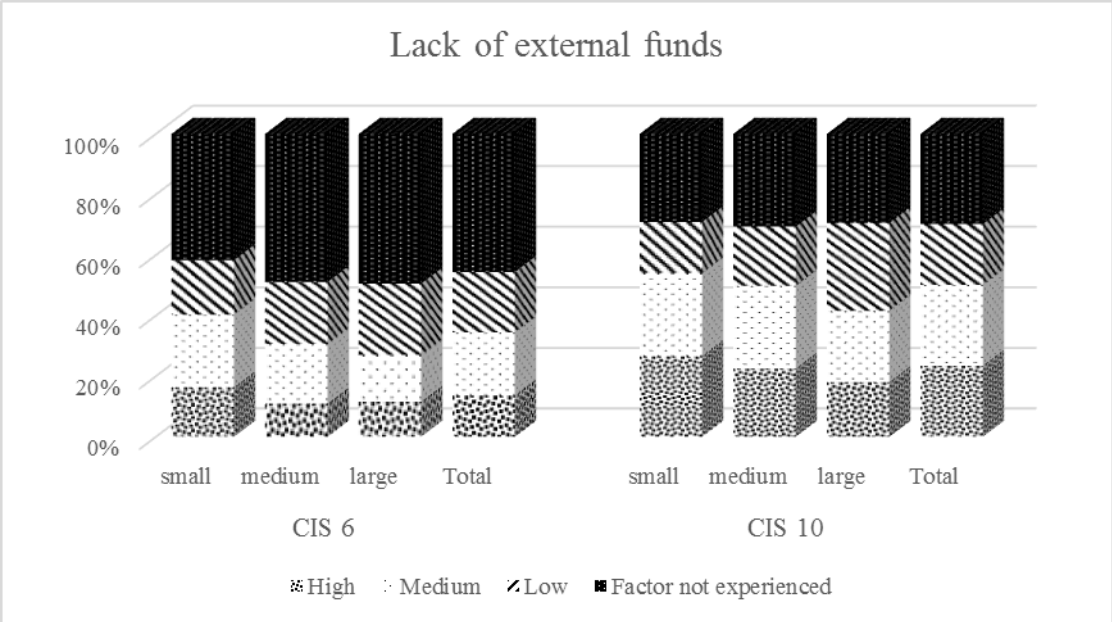
Evolution of the different barriers over time

Graphic 42 – Lack of internal finance – time series analysis



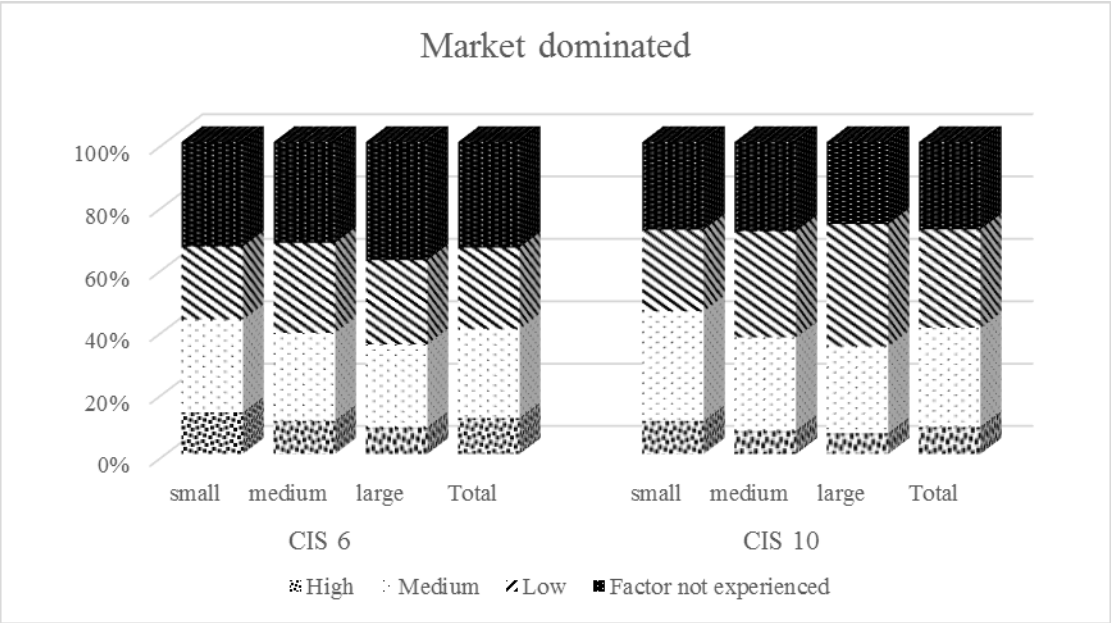
Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 43 – Lack of external finance – time series analysis



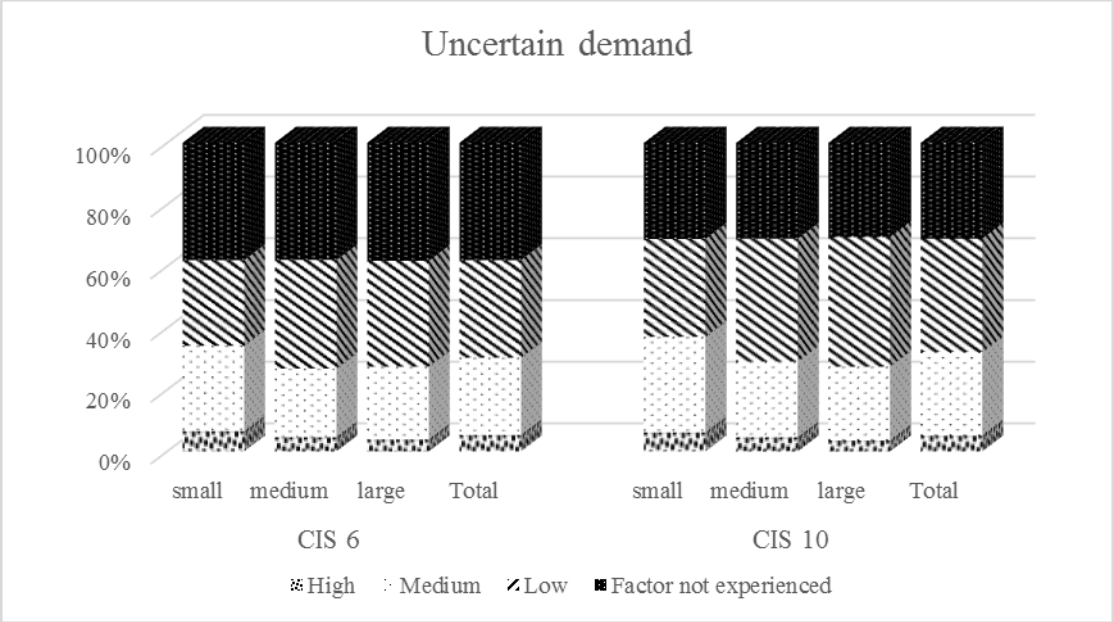
Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 44 – Presence in markets dominated by large firms – time series analysis



Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 45 - Perception about volatility in demand – time series analysis

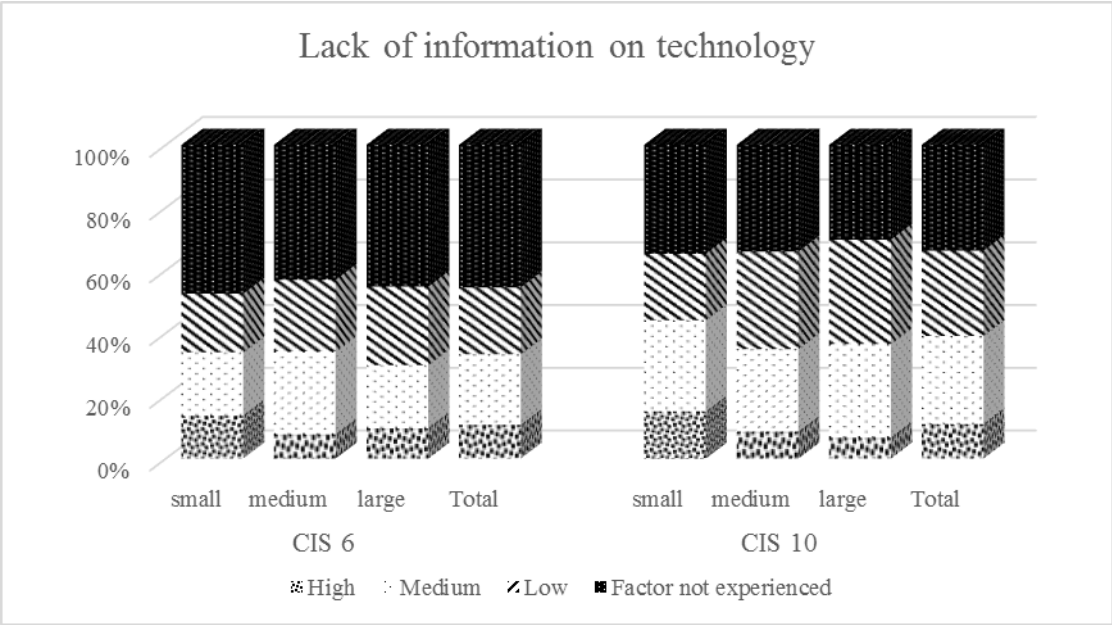


Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 46 – Lack of qualified personnel – time series analysis

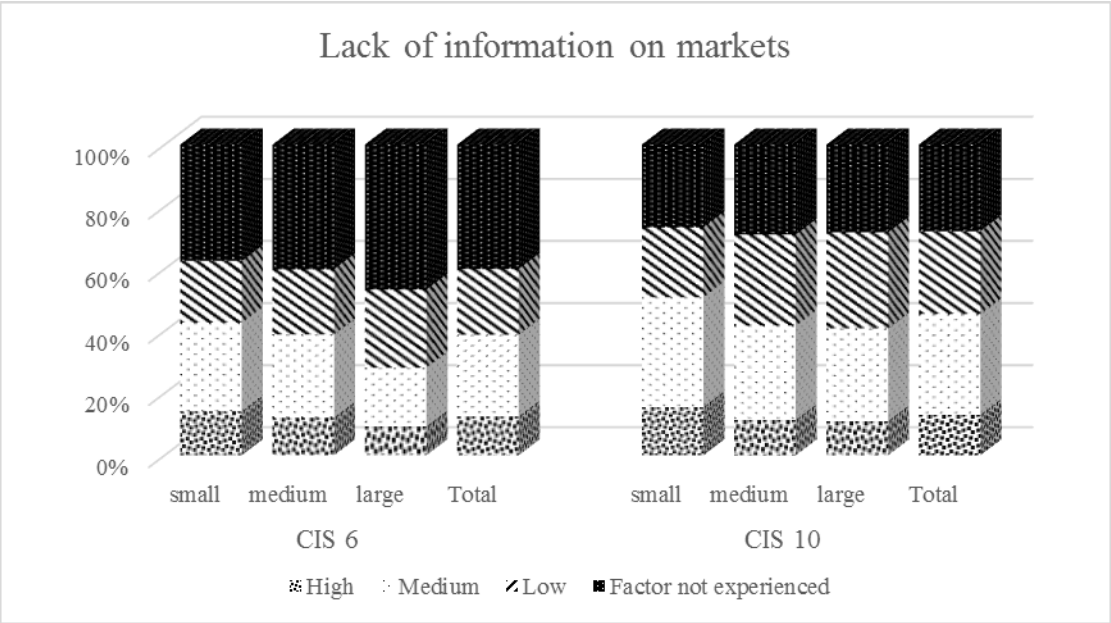
Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 47 - Lack of information about technology – time series analysis



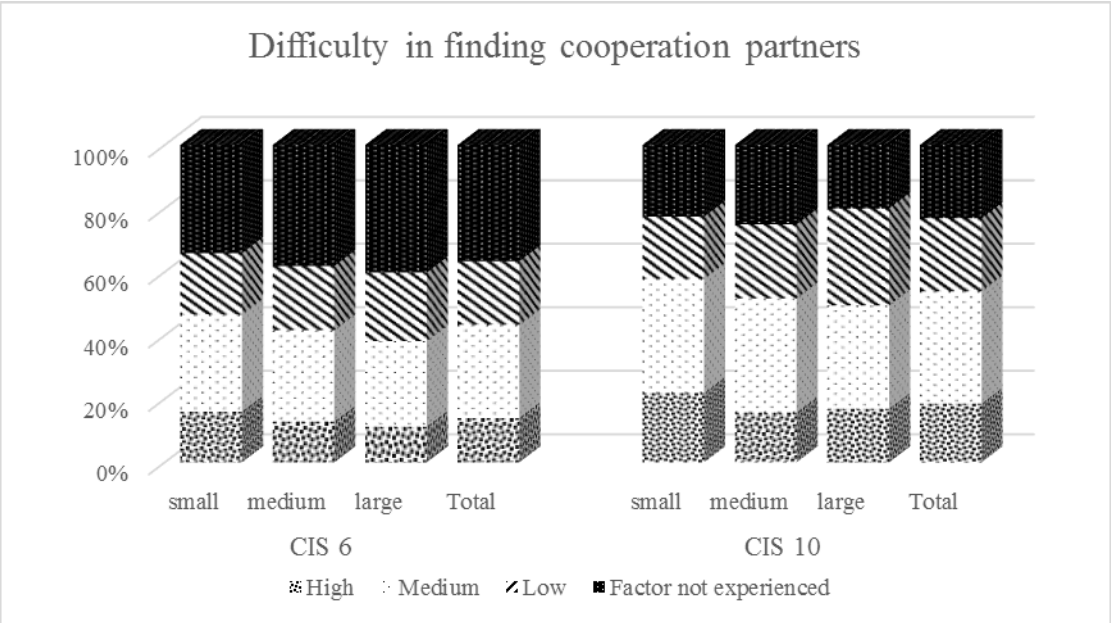
Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 48 – Lack of information on markets – time series analysis



Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Graphic 49 – Difficulties in finding cooperation partners – time series analysis



Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

2.5.2. Importance of the barriers to innovation for the panel of firms

Graphic 50 - Barriers' to innovation importance reported by firms

	Barriers		CIS 6				CIS 10			
			Not used	Low or very low	Medium	High and very high	Not used	Low or very low	Medium	High and very high
Economic Factors	Insufficiency of equity (internal finance)	n	613	273	382	228	396	325	416	359
		%	41.0	18.2	25.5	15.2	26.5	21.7	27.8	24.0
	Lack of external sources of finance	n	683	297	313	203	445	300	400	351
		%	45.7	19.9	20.9	13.6	29.7	20.1	26.7	23.5
Knowledge Factors	Lack of skilled labour force	n	506	389	429	172	419	472	476	129
		%	33.8	26.0	28.7	11.5	28.0	31.6	31.8	8.6
	Lack of information about technology	n	569	473	374	80	464	550	406	76
		%	38.0	31.6	25.0	5.3	31.0	36.8	27.1	5.1
	Lack of information about markets	n	615	469	329	83	472	546	401	77
		%	41.1	31.4	22.0	5.5	31.6	36.5	26.8	5.1
	Difficulty in finding innovation partners	n	680	319	336	161	504	408	420	164
		%	45.5	21.3	22.5	10.8	33.7	27.3	28.1	11.0
Market factors	Market dominated by established firms	n	599	317	393	187	417	399	485	195
		%	40.0	21.2	26.3	12.5	27.9	26.7	32.4	13.0
	Uncertainty about the demand	n	548	300	439	209	346	344	530	276
		%	36.6	20.1	29.3	14.0	23.1	23.0	35.4	18.4

Source: Author's computation based on the panel (CIS 6 and CIS 10)

2.6. Hypothesis of the research

The analysis of the negative responses given to performing innovative activities is normally followed by questioning the reason. Negative answers rely on some constraint. Hence, there is rationality in deciding not to innovate in the period, not to innovate at all, or to abandon the innovative activities (Blanchard et al., 2009).

The managerial strategy of the firm towards innovation is normally constrained to a binary response: firms must be willing to innovate or not. Here, the focus is placed on those firms that do want to perform innovative activities despite not being capable to complete these actions due to the presence of obstacles (Blanchard et al., 2012). Former evidence refers that the negative effects of the obstacles are only effective for those firms willing to innovate.

Based on the CIS data, one can only observe the effective innovative action, rather the firm intention, as the data provides a binary classification of being innovative or not in the period.

Multiple innovative projects in different innovation vectors may coexist. Some of them will be completed others abandoned. Thus innovators will potentially abandon their innovative activities for several reasons: rationality or hampering factors.

Furthermore, among non-innovative firms two types of possible strategies emerge: firms that spontaneously opted for not innovating at all, therefore not being influenced by the barrier; firms that did not perform innovation in the period for strategical reasons, such as huge barriers to such an extent that these actions not even started and those that were not fortunate to conclude innovation due to the complete abandon of the projects in course. So, we have opted to consider the nil responses to the innovation question as it is important seizing the heterogeneity in this category. Exploratory analysis of the correlations allows decisions to be made.

Very often the underlying reason to abandon the innovative activities is connected to the existence of financial constraints. Larger firms are expected to have an easier access to different financing sources either internal or external.

The access to public grants, bank overdrafts, venture capital or other credit and event to internal equity is easier in larger firms. With lower constraints in financing these actions large organizations are expected to have a simplified journey in pursuing

innovative activities. Consequently is expectable that size negatively influences the abandon of innovative activities.

Hypothesis 1: larger firms will have a lower probability of abandoning their innovative activities.

If firms perform successful innovation, accumulation and feedback will be generated; the literature uses the expression "virtuous cycles". In consequence, firms perceive the advantages of introducing these novelties to the market and develop innovation in a continuous base, discouraging these organisations will be tougher as they understand the advantages and abandon only those projects which are economically unfeasible. Thus, innovative firms tend to be embedded in the innovation cycle and present a lower probability of abandon.

Hypothesis 2: Firms performing, at least, one innovation vector during the biennium will have a lower probability of abandoning their innovative activities.

Top educated workers will enhance the development of innovations and boosting the absorptive capacity. The human resources by using their skills with allow the firm to behave as an innovator or as an adopter. These human means will solve the problems in a daily basis, so the innovative processes have no reason to be delayed or postponed.

More educated workers will rise the probability of success, therefore, the probability of abandon will follow; moreover, when the firms do not possess these employees they will probably perceive the lack of qualified personnel; the effects of these vectors on the probability to abandon will go in an opposite direction.

Hypothesis 3: The availability of top educated workers will reduce the probability of abandoning innovative activities. This hypothesis, will be analysed by two vectors: in one side, by means of the analysis of the education intensity; on the other hand, the perception about the lack of qualified personnel (which operates as a barrier to the innovative projects).

Innovation activities are, by nature, highly risky. When successful, these actions will produce high pay offs, generate abnormal profits, conquer market share, in sum

depassing the competitors. Under adverse economic contexts managers tend to increase risk aversion, postponing risky actions, independent of their nature.

The absence of financing options will force in concentrating in routinely actions rather than in activities with uncertain results. Financial constraints are expected to positively influence the abandon of innovative activities.

Hypothesis 4: financial constraints will act as hampering factors in the development of innovative activities.

Due to information asymmetry and other failures, seizing external financing is a complex task. Hence, firms normally have insufficient internal finance to develop these actions; public financing will fulfill the gap of private investors, boosting innovative actions. Public funds will act as substitutes to private investors, thus reducing the probability of abandon the innovative activities.

Hypothesis 5: public financing to develop innovative activities will reduce the probability of abandoning the innovative activities.

The development of innovative activities face two major hurdles, the first being the feasibility of the project and the second its performance in the market (success towards the demand). Fearing a poor reception in the market may disincentive pursuing innovative actions. As a consequence, the uncertainty about the demand behavior is expected to rise the probability of abandoning the innovative activities.

Hypothesis 6: the uncertainty about the demand will raise the probability of abandoning the innovative activities.

3. Database, model and methodology

The panel of firms used for this analysis is extracted from the CIS. Firms were asked about their structural characteristics, their perception of the innovation barriers and about abandoning their innovative activities; this data will be used to highlight the systematization of abandoning firms, their individual heterogeneity, their perception about barriers and the effect of the crisis in these decisions observed by time variability.

3.1 Database

The analysis will comprise a panel of Portuguese firms constructed using data from the CIS 2006 and the CIS 2010 as firms are asked about innovation barriers each four years The two CIS waves include a total number of observations 10881 firms, (4721 firms in the CIS 6 and 6160 firms in the CIS 10) however, when building the panel we get 1496 firms observed in both periods.

A general overview will be produced, a segmentation through size, economic activity and technological intensity in order to understand what hampers innovation activities and to understand if the determinants are the same among sectors. Following the procedure of the survey, barriers to innovation will be grouped, when needed, into funding factors, knowledge factors and market factors.

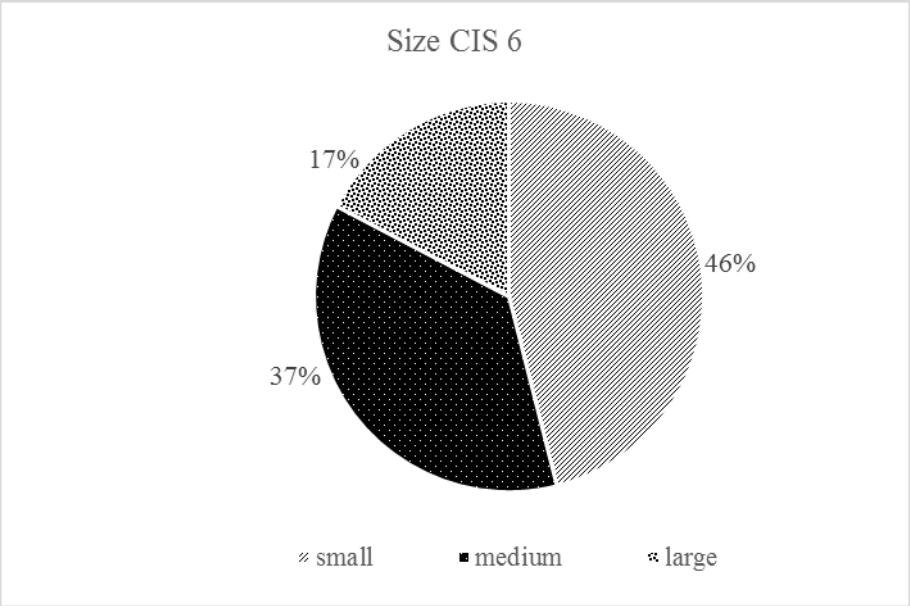
The database provides direct information about the abandon of innovative activities; perception about the different barriers to innovation and a set of firm structural characteristics such as size, SIC code, economic sector, technological intensity, sources of innovation, education intensity, R&D intensity, among others.

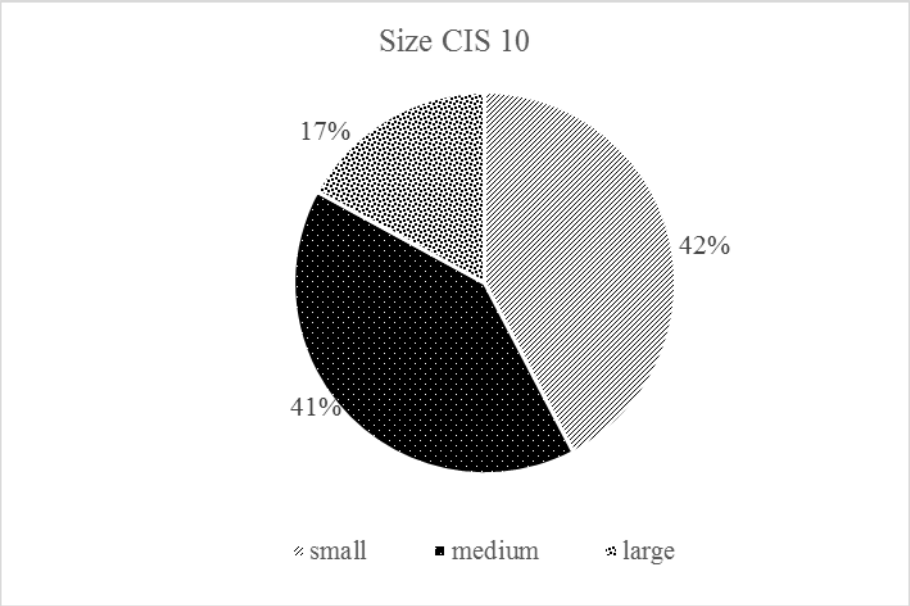
Structural trait of the entire sample in appendix 10.

3.2. Structural traits

3.2.1. Size

Graphic 51- Proportion of firms in the panel per size



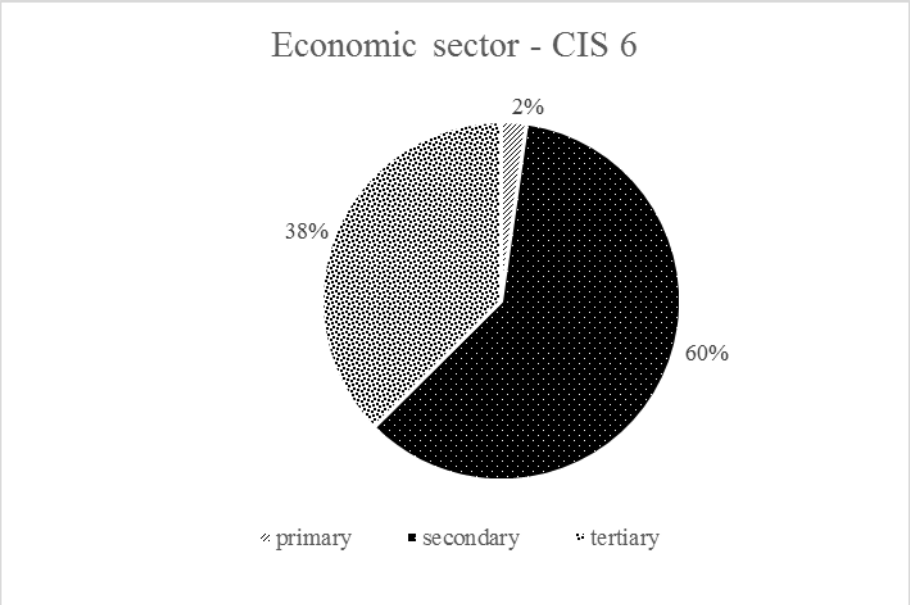


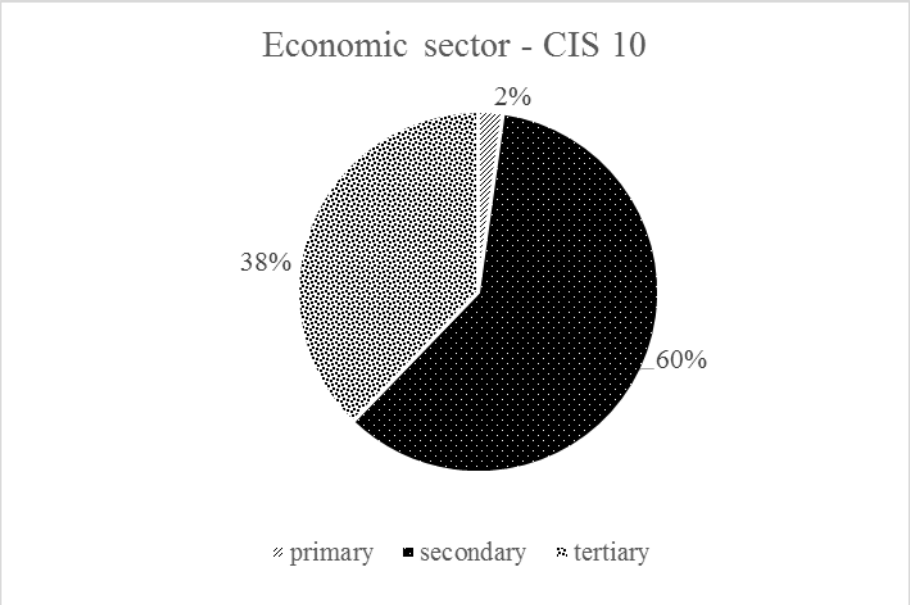
Source: Author's computation based on the panel (CIS 6 and 10)

The questions about innovation barriers are posed each four years, the periods of analysis are the CIS 6 and the CIS 10. The structural traits of the constructed panel, in what concerns the size, remain almost unchanged. Small and medium sized firms comprise nearly four fifths of the panel, achieving similar proportions, and around one fifth includes large firms. The literature mentions the fact the small firms face increased barriers to innovation as they need to tackle financial constraints and risk aversion, whereas large firms will overcome eventual constraints based on internal equity or credibility towards creditors.

3.2.2. Economic sector

Graphic 52 - Proportion of firms in the panel per economic sector



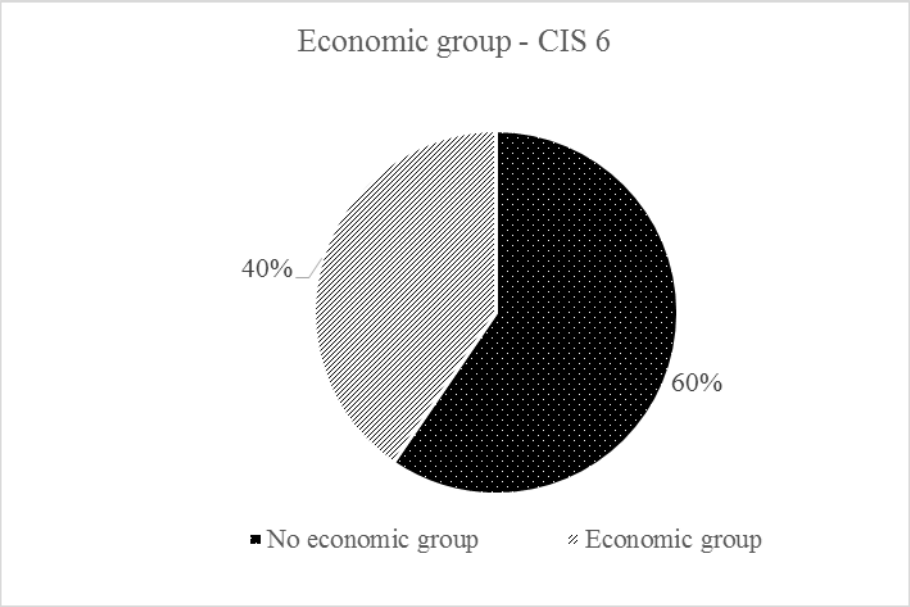


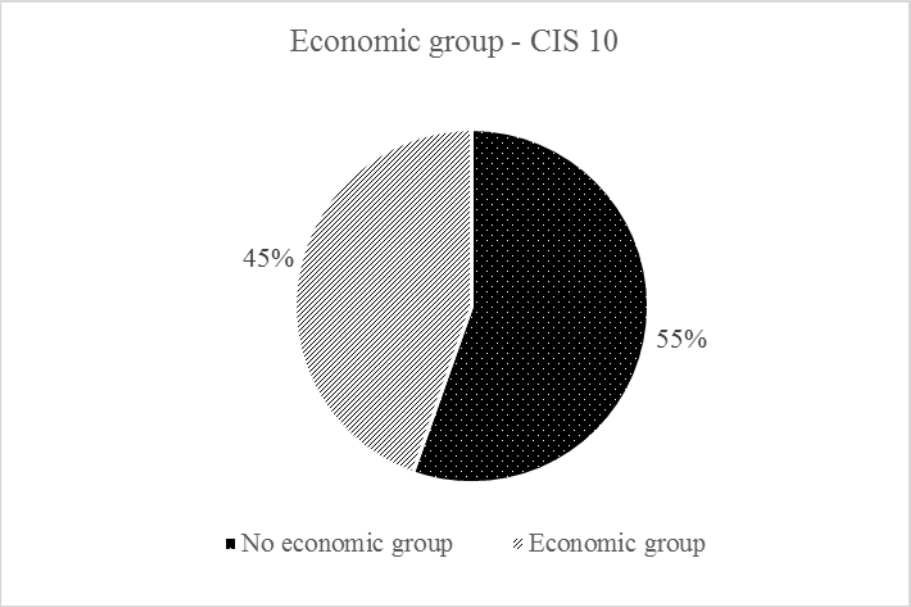
Source: Author's computation based on the panel (CIS 6 and 10)

No changes are found in the two time periods respectively to the economic sector, the proportion of firms is exactly the same. This result was absolutely predictable as the firm economic sector is a time invariant individual characteristic, considering that we are observing exactly the same firms no changes were expected to happen. The panel includes 60% of firms operating in the secondary sector, 38% in the tertiary and 2% in the primary. This portrait is illustrative of the aggregate Portuguese reality. The intense representation of industrial activities will allow for the conventional analysis in terms of innovation activities, even though this study is comprehensive.

3.2.3. Economic group

Graphic 53 - Proportion of firms in the panel per economic group



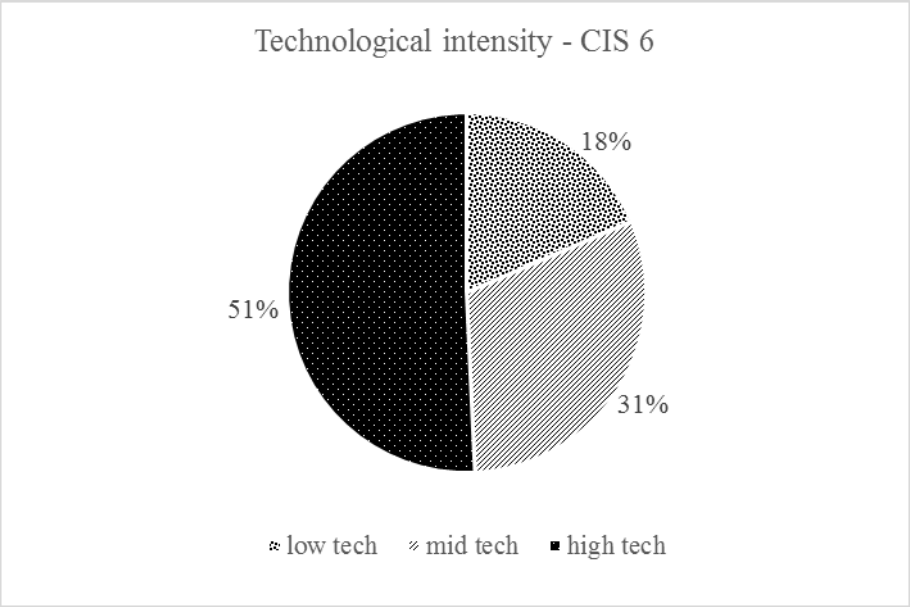


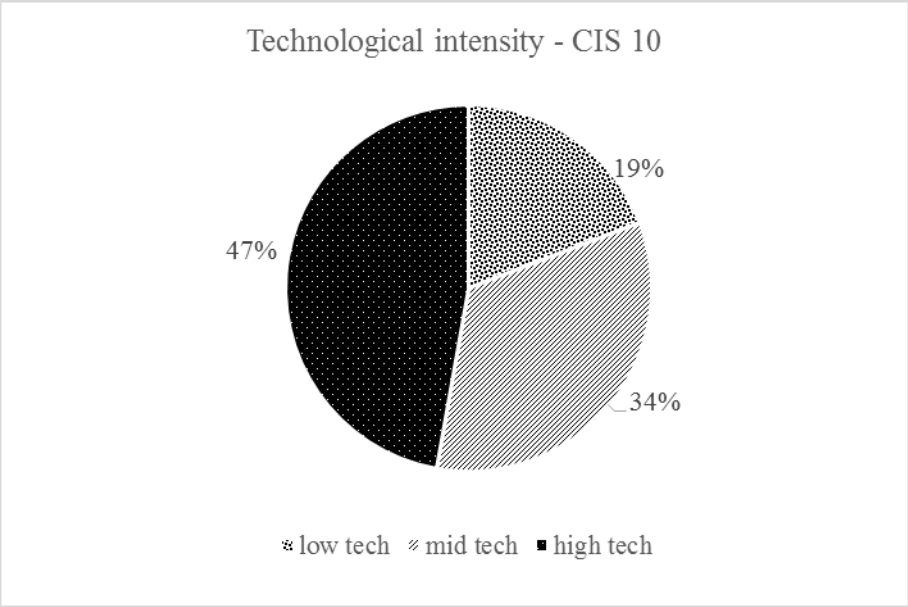
Source: Author's computation based on the panel (CIS 6 and 10)

The majority of the firms in the panel belongs to an economic group. The fact of integrating a group will enhance the endowments of financial and human resources, therefore the perception in terms of the barriers is expected to decrease. In the firm waves of the panel 60% of the firms belong to a group, and societal changes were operated in such a way that in the CIS 10 this percentage went to 55%.

3.2.4. Technological intensity

Graphic 54 - Proportion of firms in the panel per technological intensity



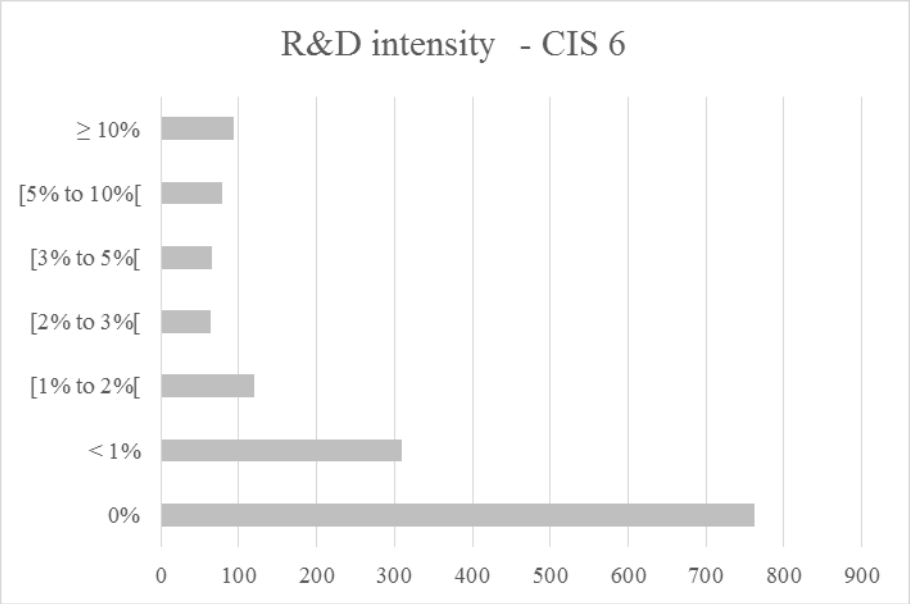


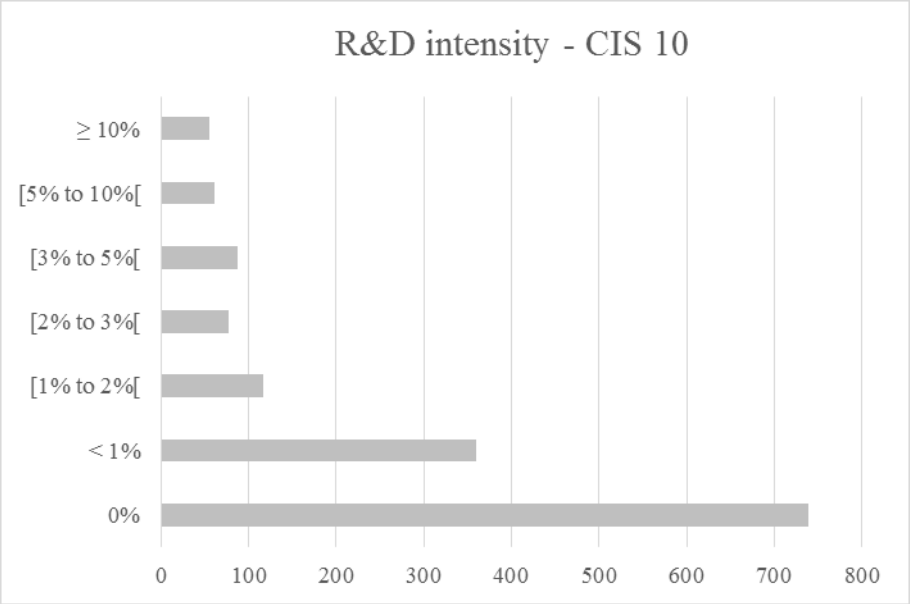
Source: Author's computation based on the panel (CIS 6 and 10)

Nearly a half of the firms belongs to a high tech sector, the expectable dynamism in terms of innovative activities is high, forcing the firms to overcome the difficulties in terms of innovation. In the first wave the proportion of high tech firms was 51% moving to 47% in the second wave; in the mid tech 31% in the first and 34% in the second. Low tech firms represented 18% in the first wave, 19% in the second. The explanation for this result relies on the fact that Portuguese firms have two alternative SIC codes and the one that absorbs the higher percentage of the turnover is reported to the questionnaire.

3.2.5. R&D intensity

Graphic 55 - Proportion of firms in the panel per R&D intensity





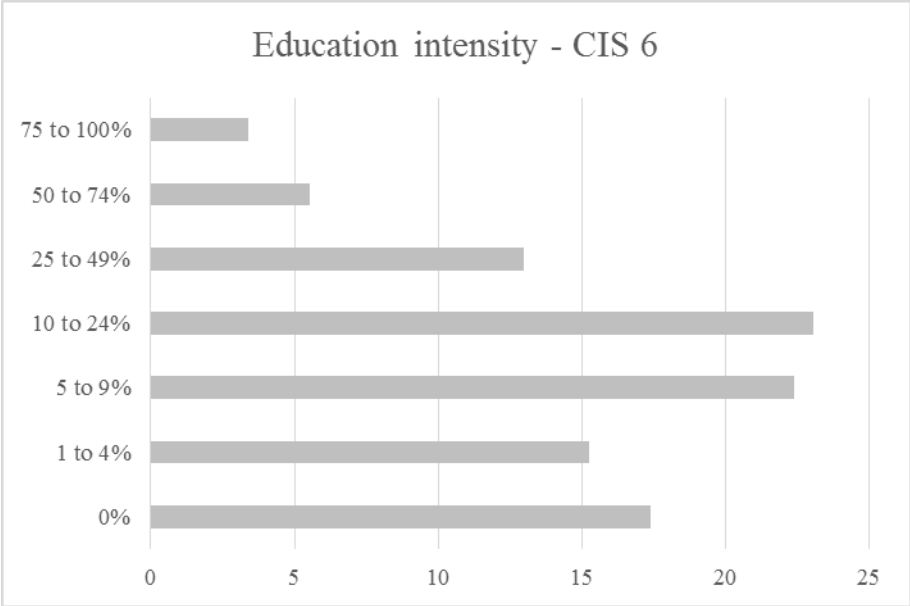
Source: Author's computation based on the panel (CIS 6 and 10)

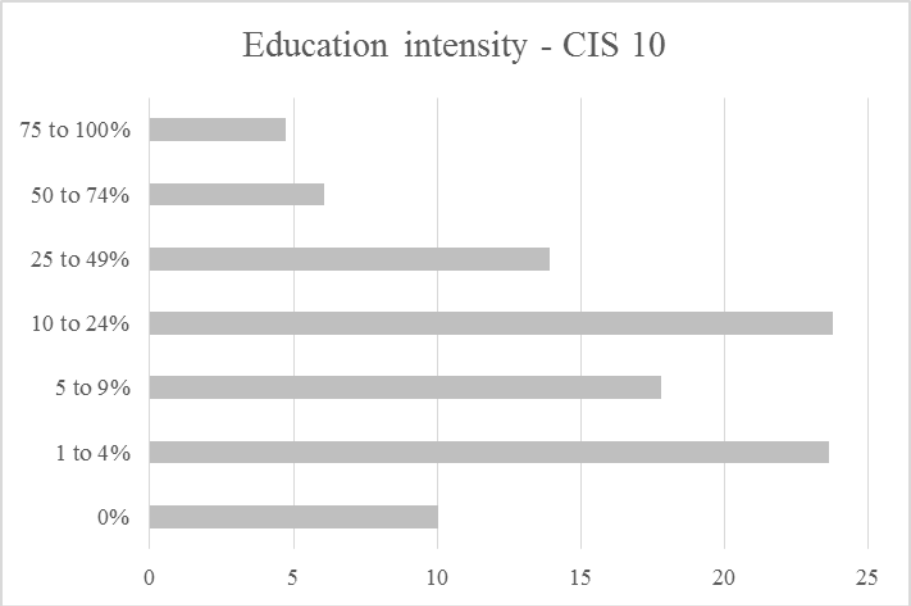
Most of the firms in the panel reported not devoting any financial resources to R&D activities. The total number of firms was 763 for the CIS 6 and 739 in the CIS 10.

The pattern remained almost unchanged in both periods, a remarkable proportion of firms mentioned R&D intensities above the European target of 3% in both cases. The economic effects of the crisis were expected to decrease the firms' propensity to pursuit these actions, the changes are not noticeable. Indeed, the top intensities grasp a smaller proportion of firms but on average the results are similar.

3.2.6. Education intensity

Graphic 56 - Proportion of firms in the panel per education intensity



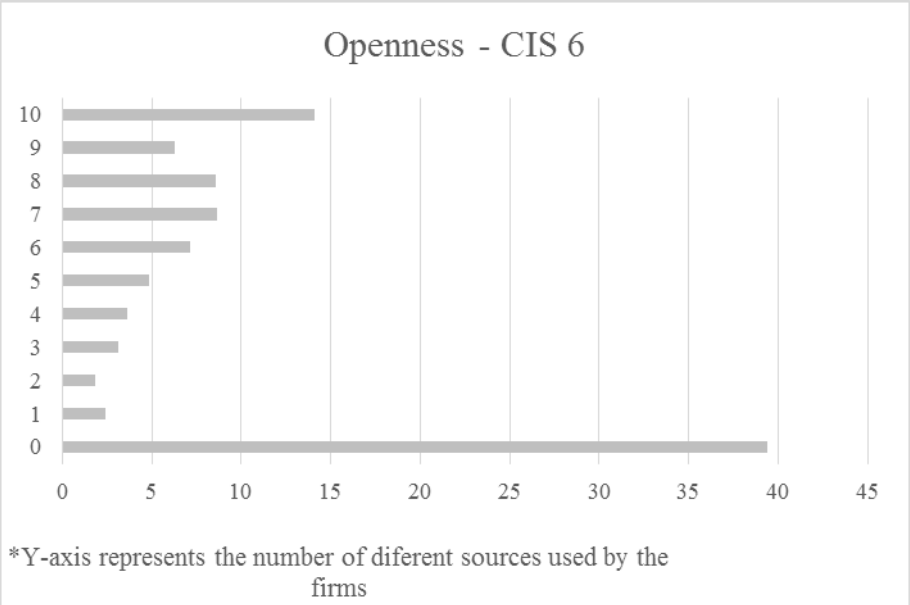


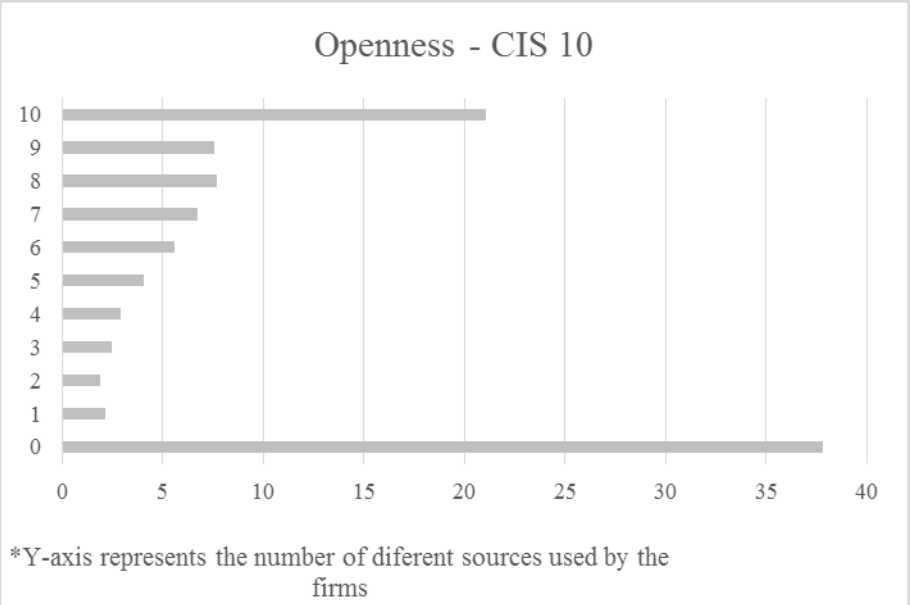
Source: Author's computation based on the panel (CIS 6 and 10)

An important evolution in terms of the education intensity is noticed among the respondent firms. The proportion of firms with no top educated workers felt significantly from 17.4% to 10%. Contrarily, the proportion of firms mentioning having 1 to 4% of the labour force highly educated rose from 15.2% to 23.7%. In the extreme scales the proportion remained almost unchanged. This evidence unveils the policy efforts developed to provide the working population with higher schooling degrees. This effort aims to furnish the entrepreneurs the human capital required to develop innovative actions thus raising productivity levels.

3.2.7. Openness

Graphic 57- Proportion of firms in the panel per openness





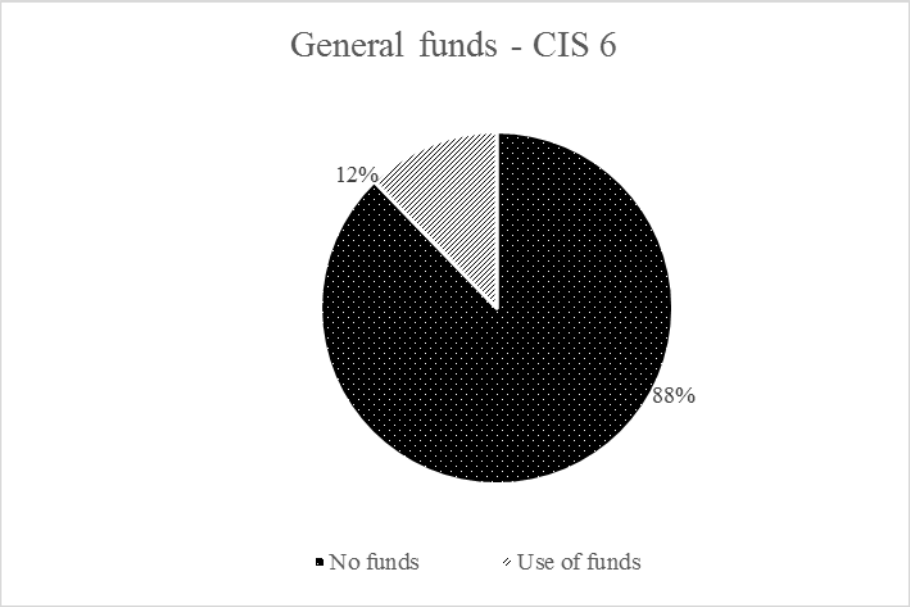
Source: Author's computation based on the panel (CIS 6 and 10)

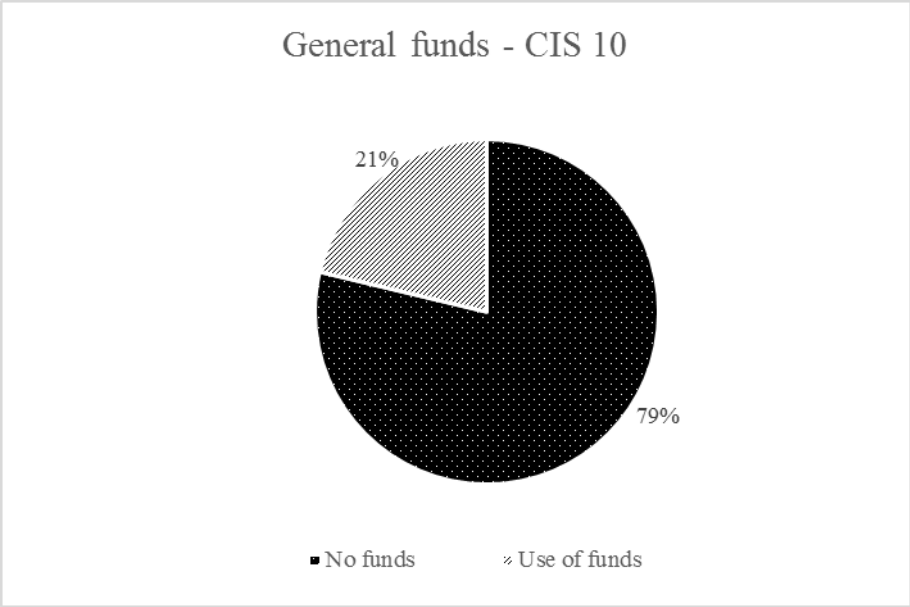
Firms are expected to rely on the sources to overcome eventual barriers in their individual endowments of resources. The development of networks will enhance the construction of innovative projects in cooperation with other institutions while overcoming the eventual barriers. Still any internal constraints may act as barriers themselves, such as the poor absorptive capacity.

Not using any of the possible sources was 39.4% in the CIS 6 and 37.8% in the CIS 10, no remarkable changes were presented. The highest score reaches 14.1% in the CIS 6 and 21.1% in this CIS 10. This suggests economic environment influenced the second.

3.2.8. Funds

Graphic 58 - Proportion of firms in the panel per general funds





Source: Author's computation based on the panel (CIS 6 and 10)

A frequent handicap towards innovative activities is the lack of finance. Policy makers actively seek to provide the firms the possibility to use public finance to support their innovative activities. Public funding is a strong policy recommendation in the present economic environment, whereas its full extent has not yet been quantified. In the panel we observed that in the first wave 88% of the firms did not rely on public funning to develop their innovative activities, and this proportion decreased in the second wave, being 79%,. Desirably, public funding will allow overcoming the internal scarcity on finance, illustrated by means of the financial barriers.

4. Empirical investigation and econometric estimation

4.1 Initial considerations

The empirical analysis performed in this chapter will be organised as follows: in the following section describes the measurements (Section 4.2), then (Section 4.3) presents the descriptive statistics and the correlation. Section 4.4 discusses the econometric modelling and the respective framework. Finally (Section 4.5) presents the estimation results and compared them to hypotheses in test.

4.2 Measurements

To examine the determinants of abandoning the innovative activities at the firm level the endogenous variable (abandon), will be binary. It will take the value 1 if the firms did mention having abandoned innovative activities in the period, zero otherwise.

As explanatory variables, the models include firms's structural traits, innovative performance in the different innovation vectors, the use of some sources of innovation and the different barriers.

It is worth mentioning that the CIS collects information about barriers to innovation in a multinomial scale: the barrier can be considered as not being experienced (0), experienced but with a low impact (1), medium (2) or high (3). Consequently, dummy variables are generated to capture the marginal impact of the different intensities perceived.

The measurements in terms of the sources of innovation are implemented in a similar vein, and the structural traits in the conventional manner. Further details about the proxies and measurement scales are presented in the codebook (appendix 1).

4.3. Descriptive statistics and correlations

4.3.1 Descriptive statistics

Table 31- Descriptive statistics

Variable	Description	N	Mean	Std. Dev.	Minimum	Maximum
tech_intensity	Technological intensity	2992	2.301	0.767	1	3
sector	Economic Sector (agregation)	2992	2.354	0.523	1	3
size	Firm size	2992	2.730	0.735	2	4
group	Economic Group	2992	0.425	0.494	0	1
prod_innov	Product Innovation	2992	0.321	0.467	0	1
serv_innov	Service Innovation	2992	0.272	0.445	0	1
process_innov	Process Innovation in general	2992	0.522	0.500	0	1
org_innov	Organisational Innovation_procedures	2992	0.550	0.498	0	1
mkting_innov	Marketing Innovation	2992	0.421	0.494	0	1
innov_geral	Innovation in one vector	2992	0.741	0.438	0	1
expenditures_rd_total	Expenditures RD Total (€)	2992	812175	4511950	0	8.09×10^7
funds_general	Use of funds to innovate	2992	0.167	0.373	0	1
ppenness	Openness to sources of innovation	2992	4.451	4.079	0	10
barr_internal_finance	Barriers to innovation_internal_fianace	2992	1.322	1.134	0	3
barr_external_equity	Barriers to innovation lack of external equity	2992	1.232	1.141	0	3
barr_inov_expensive	Barriers to innovation_too_expensive	2992	1.672	1.132	0	3
barr_qualified_personel	Barriers to innovation qualified personnel	2992	1.195	0.988	0	3
barr_inform_tecnol	Barriers to innovation_lack_ information_technology	2992	1.020	0.902	0	3
barr_inform_mkt	Barriers to innovation_info_markets	2992	0.988	0.906	0	3
barr_partners	Barriers to innovation_lack_info_markets	2992	1.074	1.038	0	3
barr_market_dominated	Barriers to innovation_market dominted	2992	1.209	1.049	0	3
barr_uncertainty	Barriers to innovation_market_uncertainty	2992	1.349	1.072	0	3
turnover_growth_rate	Turnover Growth Rate - percentage (%)	2992	18.192	200.963	-100	8246.67
rd_intensity	R&D expenditures to Turnover Ratio	2992	4.553	121.384	0	6615.23
education_intensity	Percentage of the labour force with undergraduate trainig or more	2992	2.372	1.598	0	6

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

4.3.2. Correlations among barriers to innovation

Table 32 - Innovation barriers correlation - entire panel data (n=1496)

		Correlations among innovation barriers (overall panel - CIS 6 and CIS 10)								
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Economic Factors	**Insufficiency of equity (internal finance) (1)**		0.756**	0.670**	0.415**	0.413**	0.433**	0.401**	0.403**	0.401**
	Lack of external sources of finance (2)			0.669**	0.419**	0.415**	0.445**	0.443**	0.388**	0.401**
	Innovation costs excessively high (3)				0.479**	0.467**	0.466**	0.456**	0.415**	0.453**
Knowledge Factors	**Lack of skilled labour force (4)**					0.741**	0.655**	0.538**	0.419**	0.448**
	Lack of information about technology (5)						0.782**	0.597**	0.439**	0.452**
	Lack of information about markets (6)							0.614**	0.481**	0.512**
	Difficulty in finding innovation partners (7)								0.438**	0.489**
Market Factors	**Market dominated by established firms (8)**									0.663**
	Uncertainty about the demand (9)									

** Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 6 and CIS 10

Table 33 - Innovation barriers correlation – small firms panel data (n=661)

		Correlations among innovation barriers (small firms - CIS 6 and CIS 10)								
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Economic Factors	**Insufficiency of equity (internal finance) (1)**		0.797**	0.714**	0.446**	0.464**	0.453**	0.427**	0.457**	0.454**
	Lack of external sources of finance (2)			0.686**	0.465**	0.463**	0.476**	0.474**	0.455**	0.454**
	Innovation costs excessively high (3)				0.501**	0.492**	0.482**	0.466**	0.469**	0.495**
Knowledge Factors	**Lack of skilled labour force (4)**					0.720**	0.647**	0.515**	0.468**	0.501**
	Lack of information about technology (5)						0.793**	0.567**	0.466**	0.494**
	Lack of information about markets (6)							0.611**	0.504**	0.530**
	Difficulty in finding innovation partners (7)								0.478**	0.539**
Market Factors	**Market dominated by established firms (8)**									0.673**
	Uncertainty about the demand (9)									

** Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 6 and CIS 10

Table 34 - Innovation barriers correlation –medium firms panel data (n=578)

		Correlations among innovation barriers (medium firms - CIS 6 and CIS 10)								
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Economic Factors	**Insufficiency of equity (internal finance) (1)**		0.712**	0.631**	0.391**	0.372**	0.417**	0.380**	0.353**	0.335**
	Lack of external sources of finance (2)			0.657**	0.384**	0.385**	0.429**	0.433**	0.314**	0.334**
	Innovation costs excessively high (3)				0.468**	0.461**	0.475**	0.479**	0.361**	0.421**
Knowledge Factors	**Lack of skilled labour force (4)**					0.748**	0.657**	0.552**	0.364**	0.400**
	Lack of information about technology (5)						0.773**	0.623**	0.424**	0.431**
	Lack of information about markets (6)							0.629**	0.454**	0.499**
	Difficulty in finding innovation partners (7)								0.409**	0.451**
Market Factors	**Market dominated by established firms (8)**									0.648**
	Uncertainty about the demand (9)									

** Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 6 and CIS 10

Table 35 - Innovation barriers correlation – large firms panel data (n=257)

		Correlations among innovation barriers (large firms - CIS 6 and CIS 10)								
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Economic Factors	**Insufficiency of equity (internal finance) (1)**		0.729**	0.612**	0.353**	0.335**	0.383**	0.365**	0.325**	0.382**
	Lack of external sources of finance (2)			0.639**	0.351**	0.330**	0.367**	0.365**	0.343**	0.391**
	Innovation costs excessively high (3)				0.427**	0.391**	0.375**	0.362**	0.362**	0.394**
Knowledge Factors	**Lack of skilled labour force (4)**					0.781**	0.669**	0.572**	0.384**	0.390**
	Lack of information about technology (5)						0.763**	0.625**	0.382**	0.365**
	Lack of information about markets (6)							0.588**	0.460**	0.480**
	Difficulty in finding innovation partners (7)								0.379**	0.423**
Market Factors	**Market dominated by established firms (8)**									0.661**
	Uncertainty about the demand (9)									

** Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 6 and CIS 10

4.4. Theoretical model specification

The analysis of the probability of abandoning the innovative activities will be modelled by means of a panel comprising two time periods. The objective is to get a full understanding about the role of the obstacles to innovation in the abandon of the innovative activities. Due to self-selection, firms which start an innovation activity are very prone to succeed. If firms perceive important obstacles they will naturally tend to postpone or even to abandon their innovative activities.

Relevant aspects of the empirical analysis will be presented using the descriptive statistics, which immediately follows, the analysis of correlations among the different barriers to innovation, then, the random effects probit model to explain the determinants of the abandon of the innovative activities are run the different models. The estimations were produced based on stata version 13.

In the descriptive statistics, the variables behave in a similar pattern than in the former analyses. The different barriers to innovation are positively correlated with a high degree of significance.

The abandon of the innovative activities will be determined by the firm structural traits, some innovation determinants and the innovation barriers. Firms are asked about innovation barriers each four years; this means that to construct the panel we have taken into account the CIS 6 and the CIS 10.

Despite the awareness of the aggregation made in the CIS, the models include each innovation barrier in separate as well as a dummy variable to capture the marginal effect of the intensity to capture the detailed effect of each hampering factor in the different degrees.

4.5. Estimations results[2]

The panel is strongly balanced as only firms responding to the two CIS waves were taken into account. Thus the structure comprises 1496 firms observed in the two biennia. A random effects probit model is run having the abandon of the innovative activities as endogenous variable and different combinations of explanatory variables in the different models.

[2] Details in appendix 11, 12, 13, 14 and 15

Model 1 illustrates the general model of innovation abandon considering structural traits and innovative variables; Model 2 controls per economic sector, being the benchmark the primary sector; Model 3 separates the different innovation vectors and Model 4 puts together sectorial control and the innovative type.

Table 36 – Average marginal effects **-** Model 1

	Probit									
	Variable Prob.		**Variable Prob.**		**Variable Prob.**		**Variable Prob.**		**Variable Prob.**
size_medium	0.010 (0.025)	sou_inter_medium	0.003 (0.049)	education_intensity	-0.003 (0.008)	Innov_too_expensive_low	0.066* (0.038)	lack_info_mkt_medium	-0.055 (0.043)
size_large	0.037 (0.030)	sou_inter_high	0.008 (0.048)	occasional	0.120*** (0.027)	Innov_too_expensive_medium	0.067* (0.037)	lack_info_mkt_high	-0.103 (0.064)
group	-0.027 (0.025	sou_univ_low	-0.049 (0.035)	persistent	0.214*** (0.027)	Innov_too_expensive_high	0.050 (0.042)	lack_info_ partners _low	0.046 (0.033)
tech_inte_medium	-0.024 (0.029)	sou_univ_medium	-0.024 (0.036)	act_innov_external_know	0.057*** (0.022)	lack_qualified_personel_low	0.008 (0.039)	lack_info_ partners _medium	0.031 (0.035)
tech_inte_large	-0.012 (0.028)	sou_univ_high	0.061 (0.044)	internal_fin_low	0.083** (0.036)	lack_qualified_personel_medium	0.039 (0.041)	lack_info_ partners _high	0.107** (0.043)
innov_geral	-0.224** (0.095)	sou_pub_labs_low	0.017 (0.033)	internal_fin_medium	0.002 (0.037)	lack_qualified_personel_high	0.100** (0.048)	mkt_dominated_low	-0.036 (0.035)
expenditures_rd_total	1.950×10^{-9} $(1.800 \times 10^{-9}$	sou_publ_medium	0.061 (0.038)	internal_fin_high	0.106** (0.042)	lack_info_tech_low	0.019 (0.041)	mkt_dominated_medium	0.004 (0.035)
funds_general	0.017 (0.023)	sou_publ_high	0.012 (0.053)	lack_external_equity_low	-0.128*** (0.035)	lack_info_tech_medium	-0.007 (0.048)	mkt_dominated_high	0.090** (0.039)
openness	0.005 (0.007)	rd_intensity	0.00 (0.001)	lack_external_equity_medium	-0.106*** (0.036)	lack_info_tech_high	-0.021 (0.068)	mkt_uncert_low	-0.086** (0.034)
sou_inter_low	-0.001 (0.065)	turnover_growth_rate	1.547×10^{-4} (1.145×10^{-4})	lack_external_equity_high	-0.129*** (0.041)	lack_info_mkt_low	-0.040 (0.035)	mkt_uncert_medium	-0.051 (0.034)
								mkt_uncert_high	-0.048 (0.041)

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

The random effects probit regression constructed to capture the general effects of the structural traits, the innovation strategies and the barriers to innovation produced the following general results: structural traits, with the exception of being an innovator fail to be statistically significant, the perception of the barriers increases the probability of abandoning the innovative activities as expected.

Model 1 illustrates the first attempt to estimate the random effects probit model. In this version of the model there is no segmentation by economic sector or innovation type. In this model, size appears as being statistically insignificant, this means that firm dimension does not influence the probability of abandoning the innovative activities.

If the firm is to some extent innovative, performing at least one type of innovation, its probability to abandon the innovative activities is smaller; innovators have a lower probability to abandon their innovative activities of 22.4 percentage points, compared to the non-innovative firms.

The use of the different institutional sources of innovation such as the Universities appear as being statistically insignificant; relying on these sources will not affect the probability of abandon.

Considering the intermittent innovative strategies interesting results are found as, firms that are former sporadic innovators will have a higher probability to abandon their innovative activities at present of 12 pp. Moreover being a former persistent innovator also rises the probability of abandon by 21.4 pp. These results reinforce the importance of the innovative strategies of firms to explain the abandon of the innovative activities; furthermore the positive signs also evidence the intermittence of the strategies; the results of this model also go along with the fact that firms who did innovate in the past will stop their innovative actions.

The perceived difficulty in gathering internal and external finance rises the probability to abandon the innovative activities, independent of being internal finance or external equity.

Finding innovation as being too expensive also works as a hindering factor to innovation; the perceived excessive costs of these activities rises the probability to abandon of 6.6 pp.

Availability of qualified personnel will decrease the probability of abandon; in the model, lacking top educated workers or qualified personnel rises the probability to abandon by 10 pp.

Inexistence of partners and the information flows among them also rises the probability to abandon by 10.7 pp. This result reinforces the importance of innovation networks and the existence of knowledge flows to mutually support the innovative action and to diffuse the costs and risks involved in the innovative actions.

Market risks, and the lack of information about the market conditions will increase the probability of abandon by 9 pp. The effect of uncertainty about the market condition decreases the probability of abandon, perhaps fearing future developments in terms of sales forces the firms to continue innovating.

Table 37 – Average marginal effects – Model 2

Probit									
	Variable Pr(Use)		**Variable Prob.**		**Variable Prob.**		**Variable Prob.**		**Variable Prob.**
size_medium	0.009 (0.025)	sou_inter_high	0.007 (0.048)	persistent	0.212*** (0.027)	lack_qualified_personel_low	0.008 (0.039)	lack_info_partners_medium	0.031 (0.035)
size_large	0.035 (0.030)	sou_univ_low	-0.051 (0.035)	act_innov_ external_know	0.058*** (0.022)	lack_qualified_personel_medium	0.039 (0.041)	lack_info_partners_high	0.107** (0.043)
group	-0.025 (0.024)	sou_univ_medium	-0.026 (0.036)	internal_fin_low	0.085** (0.036)	lack_qualified_personel_high	0.097*** (0.048)	mkt_dominated_low	-0.036 (0.035)
tech_inte_medium	-0.016 (0.030)	sou_univ_high	-0.026 (0.036)	internal_fin_medium	0.003 (0.037)	lack_info_tech_low	0.017 (0.041)	mkt_dominated_medium	0.004 (0.035)
tech_inte_high	-0.007 (00.029)	sou_publ_low	0.059 (0.044)	internal_fin_high	0.106** (0.042)	lack_info_tech_medium	-0.008 (0.048)	mkt_dominated_high	0.089** (0.039)
innov_geral	-0.225** (0.095)	sou_publ_medium	0.061 (0.039)	lack_external_equity_low	-0.129*** (0.035)	lack_info_tech_high	-0.022 (0.068)	mkt_uncert_low	-0.086** (0.034)
expenditures_rd_total	2.000×10^{-9} (1.810×10^{-9})	sou_publ_high	0.011 (0.053)	lack_external_equity_medium	-0.107*** (0.036)	lack_info_mkt_low	-0.040 (0.035)	mkt_uncert_medium	-0.051 (0.034)
funds_general	0.016 (0.023	rd_intensity	0.001 (0.001)	lack_external_equity_high	-0.131*** (0.041)	lack_info_mkt_medium	-0.055 (0.043)	mkt_uncert_high	-0.048 (0.041)
openness	0.005 (0.006)	turnover_growth_rate	1.554×10^{-4} (1.151×10^{-4})	innov_too_expensive_low	0.067* (0.038)	lack_info_mkt_high	-0.102 (0.064)	industry	0.114 (0.087)
sou_inter_low	1.540×10^{-5} (0.065)	education_intensity	-0.002 (0.008)	innov_too_expensive_ medium	0.068* (0.037)	lack_info_partners_low	0.046 (0.033)	services	0.101 (0.089)
sou_inter_medium	3.822×10^{-4} (0.049)	occasional	0.121*** (0.027)	innov_too_expensive_high	0.050 (0.042)				

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

When controlling for the economic sector, similar results hold; model 2 includes sectorial segmentation to perceive if the nature of the economic activity does influence the probability of abandon. Still, sectorial discrimination appears as being statistically insignificant either in the case of the secondary and the tertiary sector.

In model 2, innovative firms, independent on the vector have a lower probability to abandon the innovative activities. The cleavage is 22.5 pp.

In the same vein than in the former model, technological intensity, the use of public funds, the openness strategy or even drawing upon external sources of knowledge appear as statistically insignificant.

Innovative intermittence also affects the probability of abandon, the results are similar from model 1. Which means that occasional innovators will have a higher probability to abandon of 12.1 pp and persistent innovators 21.2.

Regarding innovation barriers the results hold the findings of the previous model, lack of internal finance will increase the probabilities of abandoning the innovative activities. External finance is another significant barrier, finding the absence of external equity as being of high importance reduces the probability of abandon by 13.1 pp, so firms consider the existence of this type of supports very relevant

The consideration of innovation to be too expensive is also statistically significant. Firms that did find innovative activities as being too expensive at a low or moderate degree have an increased probability to abandon the innovative activities of 6.7 and 6.8 percentage points compared to those who found it irrelevant.

The lack of trained personnel is a significant barrier to innovative activities. Firms that perceive the lack of qualified personnel with a high degree of importance raise the probability of abandoning the innovative activities; therefore, once top educated personnel is available, the probability of abandon is lower.

Table 38 - Average marginal effects – Model 3

Probit									
	Variable Prob.		**Variable Prob**		**Variable Prob.**		**Variable Prob.**		**Variable Prob.**
size_medium	0.016 (0.026)	funds_general	0.020 (0.023)	rd_intensity	0.001 (0.001)	lack_external_equity_high	-0.120*** (0.040)	lack_info_mkt_medium	-0.057 (0.042)
size_large	0.040 (0.030)	openness	-0.001 (0.007)	turnover_growth_rate	1.31×10^{-4} (1.025×10^{-4})	innov_too_expensive_low	0.068* (0.038)	lack_info_mkt_high	-0.113* (0.064)
group	-0.025 (0.024)	sou_inter_low	-0.004 (0.065)	education_intensity	-0.007 (0.008)	innov_too_expensive_medium	0.071* (0.037)	lack_info_partners_low	0.050 (0.032)
tech_inte_medium	-0.032 (0.030)	sou_inter_medium	-0.004 (0.049)	occasional	0.114*** (0.027)	innov_too_expensive_high	0.048 (0.041)	lack_info_partners_medium	0.029 (0.035)
tech_inte_high	-0.017 (0.028)	sou_inter_high	0.001 (0.048)	persistent	0.205*** (0.028)	lack_quailified_personel_low	0.003 (0.039)	lack_info_partners_high	0.099** (0.043)
prod_innov	0.009 (0.022)	sou_univ_low	-0.036 (0.035)	act_innov_external_ know	0.053** (0.022)	lack_quailified_personel_medium	0.029 (0.040)	mkt_dominated_low	-0.035 (0.035)
serv_innov	0.007 (0.022)	sou_univ_medium	-0.017 (0.036)	internal_fin_low	0.078** (0.035)	lack_quailified_personel_high	0.099** (0.047)	mkt_dominated_medium	0.005 (0.034)
process_innov	-0.071** (0.028)	sou_univ_high	0.081* (0.044)	internal_fin_medium	-0.005 (0.037)	lack_info_tech_low	0.025 (0.041)	mkt_dominated_high	0.080** (0.040)
org_innov	0.061** (0.026)	sou_pub_labs_low	0.019 (0.033)	internal_fin_high	0.099** (0.072)	lack_info_tech_medium	0.003 (0.047)	mkt_uncert_low	-0.090*** (0.034)
mkting_innov	0.038* (0.022)	sou_pub_labs_medium	0.064* (0.038)	lack_external_equity_low	-0.123*** (0.035)	lack_info_tech_high	0.004 (0.068)	mkt_uncert_medium	-0.054 (0.034)
expenditures_rd_total	1.73×10^{-9} (1.8×10^{-9})	sou_pub_labs_high	0.010 (0.053)	lack_external_equity_medium	-0.098*** (0.035)	lack_info_mkt_low	-0.039 (0.034)	mkt_uncert_high	-0.052 (0.041)

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Model 3 operated a segmentation of the innovation types to understand if the pattern of abandon will differ according to the innovation type. Sectorial segmentation is not included.

As in the previous models, structural characteristics such as the size, being part of an economic group, technological intensity the use of funds and the openness structure fail to be statistically significant.

The use of institutional sources of knowledge, namely Universities have poor significance and when significant, go in the opposite direction from what was expected as the firms that find the University as being of high importance have an increased probability of abandon.

Concerning innovative strategies similar results hold as well as the importance of the barriers and their effect on the probability to abandon.

Interesting findings are observed regarding innovation types, as performing product or service innovation appear as statistically insignificant to explain the abandon, contrarily to process, organizational and marketing.

Firms that perform process innovation have a lower probability to abandon their innovative activities, the marginal effect is 7.1 pp. This points towards an interesting pattern, process innovators are less prone to interrupt their innovative efforts as their target is to enhance productivity, decrease their cost structure boosting their competitiveness. Vert often operating innovation in the productive process is associated with TRIZ (technology research in innovation based on problem solving) seems to be an action which is less prone to be abandoned, due to the imminence of the need to solve any problem independent of its cause.

Being an organizational innovator rises the probability to abandon the innovative activities compared to non-innovative firms by 6.1 pp; this result may illustrate that organisational changes are by nature intermittent and firms operating these actions will withdraw them every time they feel necessary.

Marketing innovators also have an increased probability to abandon their innovative activities of 3.8 pp. similarly from the previous finding, these action may not be central to the firm core activities consequently being abandoned when needed. Additionally, most of the firms may not feel the need of continuous innovation in this field only performing these actions sporadically or when there is finance available.

Table 39 – Average marginal effects – Model 4

Probit									
	Variable Prob.		**Variable Prob.**		**Variable Prob.**		**Variable Prob.**		**Variable Prob.**
size_medium	0.015 (0.025)	openness	4.894×10^{-4} (0.007)	education_intensity	-0.006 (0.008)	innov_too_expensive_high	0.049 (0.041)	lack_info_partners_high	0.099** (0.043)
size_large	0.038 (0.030)	sou_inter_low	-0.001 (0.065)	occasional	0.115*** (0.027)	lack_qualified_personel_low	0.003 (0.039)	mkt_dominated_low	-0.036 (0.034)
group	-0.023 (0.024)	sou_inter_medium	-0.007 (0.049)	persistent	0.203*** (0.028)	lack_qualified_personel_medium	0.029 (0.040)	mkt_dominated_medium	0.004 (0.034)
tech_inte_medium	-0.019 (0.031)	sou_inter_high	0.001 (0.048)	act_innov_external_know	0.054** (0.022)	lack_qualified_personel_high	0.096** (0.047)	mkt_dominated_high	0.078** (0.040)
tech_inte_large	-0.009 (0.030)	sou_univ_low	-0.038 (0.035)	internal_fin_low	0.080** (0.035)	lack_info_tech_low	0.023 (0.041)	mkt_uncert_low	-0.090*** (0.034)
prod_innov	0.003 (0.023)	sou_univ_medium	-0.020 (0.036)	internal_fin_medium	-0.003 (0.037)	lack_info_tech_medium	0.002 (0.047)	mkt_uncert_medium	-0.054 (0.034)
serv_innov	0.011 (0.023)	sou_univ_high	0.077* (0.044)	internal_fin_high	0.100** (0.042)	lack_info_tech_high	0.003 (0.068)	mkt_uncert_high	-0.052 (0.041)
process_innov	-0.073*** (0.028)	sou_pub_labs_low	0.020 (0.033)	lack_external_equity_low	-0.124*** (0.034)	lack_info_mkt_low	-0.038 (0.034)	industry	0.126 (0.087)
org_innov	0.062** (0.026)	sou_pub_labs_medium	0.064* (0.038)	lack_external_equity_medium	-0.100*** (0.035)	lack_info_mkt_medium	-0.056 (0.042)	services	0.102 (0.089)
mkting_innov	0.040* (0.022)	sou_pub_labs_high	0.009 (0.052)	lack_external_equity_high	-0.121*** (0.040)	lack_info_mkt_high	-0.113* (0.064)		
expenditures_rd_total	1.83×10^{-9} (1.81×10^{-9})	rd_intensity	0.001 (0.001)	innov_too_expensive_low	0.070* (0.038)	lack_info_partners_low	0.049 (0.032)		
funds_general	0.018 (0.023)	turnover_growth_rate	1.317×10^{-4} $(1.047 \times 10^{-4}$	innov_too_expensive_medium	0.072* (0.037)	lack_info_partners_medium	0.029 (0.035)		

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Model 4 controls for the economic sector of the firm and for the different innovation vectors performed and the structural traits. The estimation results are very similar from those found in the previous models.

In terms of the firms' structural traits, the results do hold as in the former models, being mostly insignificant. The different innovation barriers affect the probability to innovate in a similar manner than in Model 3, the cleavage by economic sector also fails to be statistically significant. Concerning the barriers to innovation, the effects are similar from the previous models.

In sum, there is an increased probability to abandon the innovative activities in the case of organisational and marketing innovators and a decreased probability to abandon of the process innovators.

The perception and effect of the barriers is similar from previous models which means that the lack of finance will rise the probability of abandon, as well as the absence of qualified personnel. The excessive costs of innovation will put firms far away from the innovative activities and the uncertainty about the future will decrease the odds of abandon.

5. Conclusion

Academics, entrepreneurs and policy makers are focused in innovation and its success; worldwide the Governments are concerned about the creation and development of the underlying conditions to promote innovation given its importance in the promotion of growth. Very few has been done to understand the causes of innovation failure, in concrete the abandon of the innovative activities.

Adverse economic contexts are believed to endorse a deceleration of the promotion of innovative actions, given that most of the literature points the lack of finance as being the major hampering factor towards the innovative activities (e.g; Galia and Legros, 2004; Savignac, 2008 ; García-Vega and López, 2010; Galia et al., 2012). The evident argument for the abandon of innovative activities is connected to finance, either internal or external.

Our evidence shows that finance is indeed an important barrier to innovation as it rises the probability of abandon. Albeit one would expect that the use of public funds could overcome this constraint. Furthermore, relying upon other sources of knowledge could solve the drawbacks caused by the lack of finance, but to us, these sources appear as being statistically insignificant.

These results may help policy makers in understanding that the jigsaw has some loose links as firms do need finance to perform innovation, and in the absence of those they stop them being incapable to use instead Universities or public funds. This may show that policy actions even in the context of the RIS3 are failing to help firms in overcoming financial constraints and promote knowledge creation and diffusion drawing upon external sources.

Preconceived ideas would lead us believe that this phenomena will be more prone affecting small firms operating in low tech sectors, nevertheless, firm size and technological intensity appear as statistically insignificant to explain innovation abandon.

The innovation type performed, to us, should depict different patterns in terms of innovation abandon. The evidence shows that when we observe innovation in general terms, innovative firms are less prone to abandon innovative activities. Notwithstanding the insignificance of product and service innovation, process innovators have a lower probability to abandon these actions, contrarily to organisational and marketing. The results reinforce the differences in terms of the nature of innovation activities and the

centrality of these actions to the core business of the firm. Policy makers should consider these differences as funding must cover the specificity of each type, in addition, intermittence can be efficient in these vectors and the public funding will perhaps be of low importance.

Despite the existence of financial constraints, innovation actions central to the core business of the firm such as process innovation will not be dumped. Firms seem to have a clear picture of their priorities in terms of innovation activities. These results may go along with the policy recommendations presented in the different documents supporting the RIS3 (e.g. CEC, 2011; CEC 2012; Foray et al 2007; Foray et al 2009; Foray and Goenaga 2013 and Foray, 2015), which put a major emphasis in the creation of transversal knowledge in the academia rather than inside the firms. Pursuing product and service innovation in a smooth base must depend on the implementation of a functional and effective link among Universities and firms to promote a continuous channel with bidirectional communication, as these actions request important amounts of finance not persistently available inside the firms.

The significance found for the effects of former innovation strategies in the probability of abandon may also shed some light in the intentionality of the abandon. Due to their managerial strategies, these firms may find inefficient to continue innovation in a persistent base allocating their resources in other fields. Conceivably public policy may be designed in such way to substitute the internal resources and support the firms during the intermittence intervals.

As the traditional barriers to innovation appear as being significant, and, in most cases operate in the same direction from what was presented in the literature, policy instruments may target overstepping their drawbacks and helping firms in continuing their innovative activities. The availability of trained personnel is undeniably valuable to firms, this evidence reinforces the importance the role of the University in the supply of trained individuals and in the adjustment of the curricula to serve the needs of the productive sector. Again, this result reinforces the accuracy of the guidelines of the RIS3 in promoting the importance and the role of the Universities in promoting innovation and its criticality in the success of the innovation policy at a regional and national dimension.

Table 40 – Investigation Hypotheses

Hypothesis	Description	Results
[H1]	Larger firms will have a lower probability of abandoning their innovative activities.	Unsupported
[H2]	Firms performing at least on innovation vector in the period are less prone to abandon their innovative.	Supported
[H3]	Availability of top educated workers will reduce the innovation abandon (educations intensity and lack of qualified personnel).	Supported
[H4]	Financial constraints will force the firms to abandon their innovative activities: internal and external.	Supported
[H5]	Relying on public funds to develop the innovative activities will reduce the probability of abandoning the innovative activities	Unsupported
[H6]	Uncertainty about the demand will increase the probability of abandoning the innovative activities.	Supported (opposite direction of the effects)

Source: Author's composition according to the literature

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THE ROLE OF UNIVERSITIES AS SOURCES OF RELEVANT KNOWLEDGE FOR INNOVATION

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1. Introduction

The Science and Technology binomial is considered in the literature as an innovation system. Different theoretical frameworks were proposed over time such as the "National Systems" (Freeman, 1987; Lundvall, 1992; Nelson, 1993; Edquist, 1997), "Mode 2" (Gibbons et al., 1994), "Regional Innovation Systems" (Cooke et al., 1997) or the "Triple Helix" (Etzkowitz et al., 1998), conceptualising the role of the agents of the innovation processes of knowledge-based economies.

This system is composed by three major elements: the Government, the industry and the University; recently another element has been presented – the non-profit sector. It is a dynamic framework as its elements continuously interact boosting the development of new or significantly modified products or processes. The National System of Innovation is an acknowledged frame to describe the technological innovation process, with sequential improvements but invariably relying on the work of List (Freeman, 1982b; 1987; Lundvall; 1992, Nelson, 1993; Edquist, 1997, Lundvall, 2004).

Given the poor results in terms of employment growth and cohesive development of the European Union compared to the ambitious *Lisbon Strategy* settings, the "knowledge for growth group", created in 2005, justified the emergence of the smart specialisation. In addition, the financial crisis of 2008 forced the countries worldwide and, the European Union in particular to change their mindset in towards innovation. The RIS 3 (Research and Innovation Strategies for Smart Specialisation) has gained momentum to promote a place-based economic transformation relying on three foundations: smart, sustainable and inclusive growth.

The failure of the deterritorialised innovation policy addressing the regions based on the "one size fits all" policy making made the RIS3 become the Holy Grail of the

European cohesion. It is part of a multi level strategy, including both national and regional components and harmonising transversal strategies combining different aspects to generate a cohesive policy mix (Goddard et al. 2013) Smart growth will develop an economy based on knowledge and innovation, which is expected to improve welfare and transversally modernise the economic activities. Sustainable growth will optimise the use of resources, boost the efficiency levels, generate competitiveness and respect the environment. Inclusive growth will promote social and territorial cohesion which is vastly promoted in the convergence policies, which have slowed down their pace after the financial crisis.

Much has been said about smart specialisation, still there is a need for the operationalisation of the concept in terms of the regional development policies and the roles played by the different actors, in particular the Universities. With no exception, the existence of relevant connections between Universities and the other institutional elements is underlined. The evolutions in the proposed frameworks reinforce the importance of knowledge producers – Universities – reinforcing the production and diffusion of knowledge according to the regional competitive advantages (Foray and van Ark, 2007) creating an entrepreneurial dynamic in the emerging areas (McCann e Ortega Argilés, 2013a)

The linkage between Universities and firms is mediated by a set of other institutions and sets of parallel interactions, thus the direct effects of Knowledge production arising from Universities on industrial innovation are hardly quantified (Salter and Martin, 2001).

The theoretical debate puts ambitious challenges to the academia, although the most important one relies in the case of the less favoured regions, in which the Universities are expected to produce knowledge in alignment with the regional differentiating domains presented on the smart specialisation framework. Moreover, the transmission of the knowledge must be immediate and somehow automatic.

Evidence based on the CIS point to a weak importance of Universities as a source of information or knowledge for innovative activities amongst European firms (Laursen and Salter, 2004). This is a consideration to be taken into account (despite the vagueness of the joint analysis) as it may suggest that some adjustments need to be done in the policy actions.

A systematic empirical analysis of firm's perception of Universities as sources of information for innovation activities is critical to a complete understanding of the new alliances between industry and academia.

The goal of this research is to produce empirical evidence to support the importance of Universities as sources of knowledge for innovative activities, regardless firms' activities; moreover, to understand their role as determinants for innovation success.

By drawing an up to date outlook on the Portuguese situation, which has not yet been done, we attempt to provide some policy recommendations on the role of Universities in knowledge production and diffusion among firms as well as the importance of these institutions in the development of successful innovative activities.

The research will target at answering: 1) Which firms consider Universities as important sources of knowledge for their innovative activities?; 2) How far does the openness of firms influence their ability to draw upon the Universities?; 3) Do innovative firms use the Universities more than non-innovative?; 4) How can the policy design boost University-firm linkages?

The remainder of the paper is structured as follows: Section 2 includes a critical revision of the existing literature on the role of innovation sources, in particular Universities, in the production of knowledge for innovative activities; the role of firm openness as a leverage to innovation production, and the role of the NSI in overcoming potential hampering factor in innovation activities and finalises with the main hypothesis to be considered. Section 3 consists of methodological issues, database and sample, preliminary descriptive statistics. Section 4 reports the econometric estimation and the discussion of the model results. Section 5 concludes by systematising model outcomes and the validation of hypothesis and draws some policy recommendations.

2. Theoretical background

2.1. University-firm interactions - theoretical frameworks

Over the last decades, following different conceptual frameworks, Governments worldwide have made efforts to boost their National Systems of Innovation under the strong belief that the interaction among these elements would create "engines of growth". The development of strong connections between the Academia and firms will encourage

economic development, create job opportunities, promote sustainability and inclusive growth (e.g. CEC, 2011, 2012).

It is far consensual that Universities are instruments of knowledge-based economic development and change, acting as regional boosters and improving the quality of life and the cohesion among region, as a consequence, these institutions will be central in the context of either regional and innovation policies (Markusen et al.,1986; Mowery and Sampat, 2004; Etzkowitz and Leydesdorff, 2000; Rodrigues, 2011).

The CEC (2011), highlights the importance of the Academia in the RIS3, moving from the role of being located in regions towards being an active part of the region interacting with regional playiers in the conception and implementation of the "capacity building process"; therefore, the new policy reinforces the role of the Universities in the regional development and the creation of comparative advantages (Kempton, 2015).

Universities are believed to play a major role in terms of the RIS3, they are expected to produce and diffuse knowledge in alignment with the needs emerging from the differentiating domains defined in each region (McCann and Ortega-Argilés, 2013a). Despite the vagueness in terms of practicalities, in the context of smart specialisation Universities have a much wider role than in the former policy frameworks which consisted in generalised guidelines (Goddard et al. 2013). According to Foray et al., (2009), the Universities must receive incentives to discern and implement the differentiating domains of the regions.

This new approach to the public policy is expected to correct the former mistakes, enrol the other actors such as the firms and the Universities; still it will be built upon the existing projects and it will complement them. It will focus on the uniqueness if each region and the development of particular competences, by development entrepreneurial characteristics and competitive advantages, moreover, it will produce specialisation patterns based upon the discovery of new opportunities, concentration and agglomeration of resources, as well as the development of relevant knowledge and skills (Foray et al. 2009, Foray, 2015).

The development of the new opportunities will reinforce the interaction within the other institutions in the region, such as the University or even with other regions. At first, the conceptual framework pointed towards the development of high tech sectors, as it was the political response to the poor achievements of the former policy actions.

Notwithstanding, the need to boost competitiveness in the European regions emphasised the need to overcome weaknesses of the regional systems of innovation (McCann and Ortega-Argilés, 2013b).

The specific role of Universities is somehow multidimensional as they are expected to find specialisation patterns, stimulate entrepreneurship, provide consultancy, supply the labour market with educated labourforce, create the dynamics for start-ups, interaction with clusters and innovative networks, and adapt the curricula to the differentiating domains (CEC, 2011 and 2012).

It is of major importance to synchronise the knowledge produced in the Academia and the specific needs of the firms operating in the region, and the adjustment effort must be performed in the side of the University. The innovative potential of the territory will be based on the variety of productive sectors operating in the region, which does not collide with the need for specialisation tackling on the concept of "related variety". Under this concept there will be an increased probability to generate and benefit from the agglomeration of different sectors with complementary knowledge. This framework will rely upon the singular expertise of the Universities to promote longitudinal platforms of knowledge creation in diffusion being the cement of this concept (Goddard et al. 2013).

It is of worth mentioning that the coexistence of leader and follower regions is accepted as there is an odd distribution of endowments, creating natural distances among the regions. The Universities, due to their ability to deal with knowledge in a globalised manner, are also responsible for and efficient task distribution and for the connection of the territory using a supra-regional approach (Goddard et al., 2013).

Tougher challenge is the operationalisation of the role of Universities in less developed regions, as they are asked to mitigate the starting constraints to innovation. Kempton et al. (2013) reinforce the exiguity of absorptive capacity and the inexistent connection among the innovation actors, underlining the need for a deep understanding of the importance of each institution as well as a solid cooperation among them.

The University plays a vast and multidimensional role in the innovation process that leads to regional growth and sustainable cohesive development. To successfully implement the RIS3 process, the connections between the University, the Firms and the Governance must be based of trust, usefulness, proximity and interactive learning.

2.2. Innovation sources

In order to gather the knowledge required to perform innovative activities firms have two major choices: using internal or external knowledge. Very often, firms use the external sources to overcome their gaps thus exploiting the technological opportunities present in the market (Cohen and Levinthal, 1990; Rosenkopf and Nerkar, 2001).

There is a positive correlation between innovation success and the use of external sources of information (MacPherson, 1997). The higher the number of interactions (as well as the number of different connections) the more it will boost the propensity to successfully innovate (Laursen and Salter, 2004).

There are different possibilities to acquire external knowledge such as the acquisition of human capital by means of graduated workers, scientists or engineers (Zucker, 1998; Almeida and Kogut, 1999), the development of strategic alliances (Mowery et al., 1996; Rosenkopf and Almeida, 2003), or the membership in informal networks (Liebeskind et al., 1996; Almeida and Kogut, 1997; Rosenkopf and Tushman, 1998).

The development of connections inside and outside the productive chain (conventional sources of knowledge) is classified as being of particular importance. Suppliers, clients, competitors and other interveners of the informal networks provide relevant information to the development of innovative activities. Universities, public and private laboratories and government agencies also contribute the firms' relevant basic knowledge to develop their innovative activities (Jewkes et al., 1958).

Suppliers give major contributions to the improvements in terms of product design, as well as product development (Wasti and Liker, 1999; Nellore and Balachandra, 2001). Customers are the greatest source of new product ideas (Utterback, 1974; Gemunden et al., 1992). Conferences, firm associations and publications provide the firms with a set of important contributions (Mansfield, 1991; Cohen et al., 2002).

Among R&D intensive firms the major sources of information for innovation are internal sources, consumers, top management and marketing. Moreover, the establishment of strong ties with formal sources of knowledge such as Universities, public and private R&D laboratories will raise the propensity to develop successful innovations (Deiaco, 1992; Gemunden et al., 1992).

In the empirical analysis, the sources of information for innovative activities are organised in a similar structure to the one used in the CIS, henceforth, the tables will aggregate the data accordingly. The following table (table 1) describes the importance given to each innovation source by the respondent panel. It is worth mentioning that the same 1099 firms are observed in three biennia (the CIS 6, CIS 8 and the CIS 10), which may allow for some persistence of the response patterns. Further details in terms of the structural traits of the respondent panel are available in the appendix 8.

The use of internal sources of information for innovative activities is mentioned as being highly important for nearly a half of firms in the panel, moreover, less than 10% of the firms considered this source as irrelevant. Compared to the other innovation sources, this is the one who has a lower rate of "not used" and "low importance". The results were very similar in the three observed biennia, pointing to an unchanged trend.

Firms tend to establish vertical and horizontal connections inside their value chain to promote innovative activities. Sharing the same difficulties and problems to be solved reinforces the importance of these sources of knowledge; concerning competitors, the opinions are far more divided.

Suppliers are often considered as an important source of information for innovative activities. They are classified as a very important source by nearly 20% of the panel, in concrete, 208 firms in the CIS 6; 213 in the CIS 8 and 208 in the CIS 10. No significant changes are observed in the six year period. Concerning clients the results are similar, an important proportion of firms classify this source of information as being of high importance. There was an important increase from the CIS 6 to the CIS 8 which was maintained in the CIS 10, (248 to 316 and 319, respectively). These results reinforce the importance of the informal links established inside the value chain.

Traditionally, the connections inside the market are more complicated when established with competitors. Fighting for the same market, fearing the appropriation industrial secrecy or some intangible know-how may turn away firms from their competitors.

The number of firms that have mentioned the information produced by their competitors as "not used" goes up to 170, 180 and 140, respectively. On the other hand, this source is considered of high importance, for 94, 125 and 135 firms. These figures illustrate increased the cooperation inside the sector.

Among the market sources, consultants and private labs are the less used; 298 firms considered this source of information as being irrelevant in the CIS 6, 258 in the CIS 8 and 204 in the CIS 10. Conversely, this source is of high importance to 94, 102, and 119 firms, respectively.

Analysing the overall results, the use of institutional sources is less popular than the market sources, Universities and Government labs appear as an irrelevant source of information for a large proportion of firms.

Universities were mentioned as irrelevant sources of knowledge for the innovative activities for 385 firms in the CIS 6, 367 in the CIS 8 and 299 in the CIS 10. The time span depicts a decreasing trend, although the high proportion of firms that do not find any use in the knowledge produced by the academia. On the other hand, the University is seen as a very important source of information for innovation by 74 firms in the CIS 6; 69 in the CIS 8 and 82 in the CIS 10. Government labs present poorer results, compared to the Universities, being neglected by the firms as sources of knowledge. In general, the connection with the Institutional sources of knowledge across these years is very insignificant, which may illustrate the lack of communication for innovation between the academia and the entrepreneurial sector.

Besides the use of the internal, market and institutional sources firms can rely upon other sources of information for innovative activities such as Conferences, Journals and Firm Associations. These sources promote knowledge transmission in a sporadic and generalist base, which means that they will promote weak ties rather than a daily cooperation with deep knowledge share, but, they are accessible and not expensive. Not surprisingly, they appear as being irrelevant to approximately one fifth of the firms and the achievements did not change significantly over time. Very rarely they are considered of high importance by firms, and they seem to be of secondary importance during the time span in analysis.

Table 41 - Relative importance of the innovation sources for the observed panel

	Source		CIS 6				CIS 8				CIS 10			
			Not used	**Low or very low**	**Medium**	**High and very high**	**Not used**	**Low or very low**	**Medium**	**High and very high**	**Not used**	**Low or very low**	**Medium**	**High and very high**
Internal Sources	**Inside the firm**	n	40	28	206	434	47	38	228	449	38	45	208	439
		%	3.6	2.5	18.7	39.5	4.3	3.5	20.7	40.9	3.5	4.1	18.9	39.9
Market Sources	**Suppliers**	n	76	88	336	208	62	111	376	213	71	96	355	208
		%	6.9	8.0	30.6	18.9	5.6	10.1	34.2	19.4	6.5	8.7	32.3	18.9
	Clients	n	102	111	247	248	93	121	232	316	81	104	226	319
		%	9.3	10.1	22.5	22.6	8.5	11.0	21.1	28.8	7.4	9.5	20.6	29.0
	Competitors	n	170	178	266	94	180	175	282	125	140	189	266	135
		%	15.5	16.2	24.2	8.6	16.4	15.9	25.7	11.4	12.7	17.2	24.2	12.3
	Consultants & Private labs	n	298	151	165	94	258	179	223	102	204	205	202	119
		%	27.1	13.7	15.0	8.6	23.5	16.3	20.3	9.3	18.6	18.7	18.4	10.8
Institutional Sources	**Universities**	**n**	**385**	**132**	**117**	**74**	**367**	**164**	**162**	**69**	**299**	**182**	**167**	**82**
		%	**35.0**	**12.0**	**10.6**	**6.7**	**33.4**	**14.9**	**14.7**	**6.3**	**27.2**	**16.6**	**15.2**	**7.5**
	Government Labs	n	444	144	88	32	443	164	108	47	390	187	103	50
		%	40.4	13.1	8.0	2.9	40.3	14.9	9.8	4.3	35.5	17.0	9.4	4.5
Other Sources	**Conferences**	n	149	180	258	121	166	217	274	105	135	211	249	135
		%	13.6	16.4	23.5	11.0	15.1	19.7	24.9	9.6	12.3	19.2	22.7	12.3
	Scientific Journals	n	155	190	283	80	160	248	285	69	151	235	274	70
		%	14.1	17.3	25.8	7.3	14.6	22.6	25.9	6.3	13.7	21.4	24.9	6.4
	Firm associations	n	241	223	195	49	232	256	218	56	221	246	218	44
		%	21.9	20.3	17.7	4.5	21.1	23.3	19.8	5.1	20,1	22,4	19,8	4,0

Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

2.3. The role of universities within innovation processes

All firms are to a certain extent technology-based (Freeman, 1982a). The definition of knowledge industries addresses the generation, dissemination and the application of technology. However, the technological requirements of firms do differ, thus having some sectors classified as being low-tech, mid tech or high-tech. This separation among sectors relied on the taxonomy presented by Pavitt (1984).

Universities play a major role in knowledge production and diffusion which has been grown over time. The anchor of the institutional role of the University is more accurately designed by the National System of Innovation (NSI) framework. (Freeman, 1987 and Lundvall, 2007). Immediately followed by the "Research system in transition" (Cozzens et al, 1990; Ziman, 1998) the "Mode 2" (Gibbons et al. 1994), the "Post-modern research system" and the "Triple Helix" (Etzkowitz and Leydesdorff, 1997).

The following theoretical frameworks continued enhancing the role of knowledge production and diffusion, reinforcing its role on industrial innovation too (Mansfield and Lee, 1996).

One cannot understand the effective role of the Universities without getting a clearer picture of what involves the NSI involves. The original definition proposed by Freeman (1987) in that the NSI is the "the network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies ". To Lundvall (1992) the NSI comprises "elements and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge"; on the other hand, it is "set of institutions whose interaction determine the innovative performance of national firms." (Nelson and Rosenberg, 1993): later to Patel and Pavitt, (1994) it is the national institutions, their incentive structures and their competencies, that determine the rate and direction of technological learning.

To Metcalfe, (1995) the NSI is composed by a system of innovation which is that set of distinct institutions which jointly and individually contributes to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process. Therefore, it is a system of interconnected institutions to create, store and transfer the knowledge, skills and artefacts which define new technologies.

Innovation systems approaches view innovation in a more systemic, interactive and evolutionary way, whereby new products and processes are brought into economic and social use through the activities of networks of organisations mediated by various institutions and policies (Hall et al., 2003).

2.4. Hypothesis to be tested

The present research aims at understanding the relevance of the Universities as sources of information for the firms' innovative activities, moreover, another goal is to understand if the firms' organisational structure in terms of its human capital will determine the probability of relying on Universities. Additionally, there is an aim in the comprehension about the role of an open innovation strategy relying on Universities. The final target is the understanding of the changes in the role of Universities as sources of information for innovative activities in times of crisis. Therefore the major research questions are: 1) What is the role of Universities as sources of information for Portuguese firms?; 2) Does the structure of the human capital influence the connection with the University?; 3) Will having an open innovative strategy enhance the connection with the Universities?; 4) Did the role of Universities as sources of information change due to the financial crisis?

The role of Universities in innovation systems and as an engine of growth has been widely discussed in the works of Feller (1990), Henderson et al., (1998), Mohnen and Hoareau (2003), Van Looy (2009), Hausman (2012),Veugelers and Del Rey (2014).

Universities are thus considered as vital sources of information for innovative activities, in most cases it is connected to patent licensing or local spillovers (the cases of France, Spain or the UK among others have been presented in the works of Monjon and Waelbroeck (2003), Duch et al. (2008), Laursen and Salter (2004), Hughes and Kitson (2012), Mansfield and Lee, (1996).

In general, the literature point to the need for structural characteristics of firms influencing the probability to draw from Universities things such as the firm dimension, the R&D, the endowments of human capital, the openness in terms of innovative strategy, the use of public funds among others.

Firm size is consequently a relevant aspect, though with different interpretations: to Kogut and Zander (1993), Levinthal and March (1993), Almeida and Kogut (1999), Almeida et al., (2003). Larger firms will present a higher propensity to draw upon Universities as sources of information for their innovative activities due to the availability of a wide variety

of knowledge, skills, organisational structures which are more developed. Moreover, these companies will diffuse their research over their larger structure, place new products in the market more easily due to their efficient productive chain; influence the stakeholders backwards and forwards.

Contrarily, small firms will have weaknesses in these components, they may lack finance, human resources, and influential positions in the productive chain, however, they are flexible, non-bureaucratic, chameleonic, and efficient. Consequently, they may produce a rapid response to the changing environment.

The expected sign of the size is debatable as large firms have advantages in terms of physical resources, whereas the organizational flexibility of small firms may outweigh this advantage (Rothwell and Dodgson, 1994). Small firms have an increased willingness to take risks, they tend to be more innovative than larger firms, and present higher innovation rates and patent licencing per employee (Pavitt, 1987), and as a result they are more innovative and dynamic (Bommer and Jalajas, 2004).

Due to the constraints in terms of internal finance to develop innovative projects, and no external finance will be available to them firms may be forced rely upon other innovative sources (Hadjimanolis, 1999), small firms are prone to be strongly connected to external sources, in particular to Universities (Jones and Tang, 1996). According to Acs et al., (1994), small firms will benefit in a larger scale from the knowledge produced in the Universities.

Empirical evidence from the studies of Cohen et al., (2002), Salter and Martin (2001), Mohnen and Hoareau (2003), Laursen and Salter (2004) highlight the increased propensity of large firms to use Universities as sources of information and to the consequent establishment of close ties between Universities and firms. The underlying reason for stronger connections between large firms and Universities is the existence of R&D departments in these organisations with higher knowledge proximity to them with which they will establish closer links.

To us, firm size will positively influence the probability of drawing upon Universities and attributing and increased importance to this source of information.

Hypothesis 1: size will positively influence drawing upon Universities.

Innovative activities are the result of successful R&D; consequently, the expenditures in this vector are a good measure of the importance of these activities in the managerial

strategy. The use of the R&D intensity allows for the perception of the importance of the R&D activities controlled by the firm size.

The scientific and technological aptitude of the firms is proxied by R&D expenditures (Markusen et al., 1986), higher expenses in this component will raise the odds of relying on public R&D (Cohen and Levinthal, 1990).

The importance attributed to the Universities by the firms is controversial; very few tend to classify this source of information as being relevant to their innovative activities, hence there is sectoral heterogeneity in classifying the importance of this component (Klevorick et al., 1995).

The incentives to invest in technology and R&D and human capital are interdependent, hence, firms need to complement their technological investments with the proper endowments in terms of human capital (Senker and Brady, 1989).

The expected sign of this variable to Cohen and Levinthal (1990), Mohnen and Hoareau (2003) and Laursen and Salter (2004) is positive, which means that higher R&D intensities increase the probability of using Universities as sources of information for innovation. Nevertheless, Salter and Martin (2001) found an insignificant coefficient for this explanatory variable.

Hypothesis 2: R&D intensity positively influences drawing from Universities

The development of innovative activities strongly depends on the firms' absorptive capacity. The ability to seize the opportunities arising in the economic environment will depend on the availability of resources, namely human capital (Cohen and Levinthal, 1990).

Human capital investments, such as training, formal education, will generate technical superiority (Schultz, 1961). The provision of literacy, numeracy and general education will transform the workers in problem solvers due to their ability to learn, which is vital for the innovation process (Foster, 1987). High tech firms need to grasp skills amongst their staff to develop innovative activities, under rapid economic and technological change, the availability of top educated and skilled workers will be determinant (Teixeira, 2002).

Qualified workers are expected to behave as problem solvers, therefore the availability of skilled workers such as undergraduates, engineers, masters or doctorates will determine the potential of firms to develop their own innovative activities or to absorb the knowledge emerging from external sources.

The availability of human capital will enhance the probability of developing innovative activities as the firms will have the human endowments needed for the process. (Lopez-Garcia and Montero, 2012).

Education will leverage the problem solving competences, the pace of absorption, the accommodation of new techniques and the development of new solutions which will boost innovation and efficiency. It is determinant to the understanding and application of technical information embedded in the productive process (Gibbons and Johnston, 1974).

University education imparts the ability to accurately assess problems and the ability to solve them or to find the solution in searching for the relevant information. Skilled workers feed virtuous cycles of knowledge as they accumulate knowledge, experience and the networks to seek for new knowledge. Therefore the University is the major channel transferring knowledge to firms (Gibbons and Johnston, 1974; Rosenberg and Nelson, 1994; Schartinger et al., 2001).

Hypothesis 3: Education intensity positively influences the drawing from universities.

According to Pavitt's taxonomy (Pavitt, 1984), firms are classified concerning their technological intensity; each group is expected to behave in a different manner towards innovation. Technologically intensive firms are naturally expected to be more prone to develop innovative activities.

Firms in the same sector are expected to have a similar knowledge base; even though it can be enlarged by means of the exploitation of internal or external knowledge (Saviotti, 1998).

As a consequence, firms with higher technological intensity will rely on external sources to develop their innovative activities amongst whom Universities are included.

Hypothesis 4: Technological intensity positively influences the drawing from universities.

In fast progress industries, firms lacking qualified personnel may lose their share (Layard et al., 1971) as there is a constant demand for changing the design, the processes, or even the organization (Whiston et al., 1980); the lack of qualified personnel to

develop these actions will force them to postpone or even not to performs the requested evolution which will put in danger the future of the organisation (Booth and Snower, 1996).

Innovative firms develop a wide variety of competences to embed these processes; namely competencies that support the linkages with sources of innovation to absorb the external knowledge, to acquire the material and human capital (Morgan, 1997).

The development of innovative projects requires multiple interactions with other institutions, the use of different sources, amongst whom public institutions such as Universities and Research centres (Gibbons et al., 1994). Moreover, the links established with other external agents are also important to the daily actions as well as to develop innovations.

Cohen and Levinthal (1990) proposed the concept of absorptive capacity to describe the ability to exploit external knowledge, which is of vital importance to perform innovations.

Seizing innovative opportunities will depend on the ability to assimilate existing knowledge emerging from external interactions.

Innovative firms are able to grasp the existing knowledge and to transform it according to their needs. In doing so they will be connected to external source of knowledge. As a consequence, being an innovative firm increases the probability of using the University as a source of information for the innovative activities.

Hypothesis 5: Innovative firms are more likely to draw from universities.

The theoretical and empirical research has not yet proved effectiveness of the different policy instruments to subsidise R&D and to provide a full understanding of the role of Universities in this context. The attribution of financial support for collaborative research absorbs an important proportion of public funding given the importance attributed to the development of industry science links.

On the one hand, public funding is pointed out an effective measure to overcome the lack of internal finance of the insufficient venture capital, on the other hand it is argued that public funding crowds out the private (David et al., 2000). Even though, there is positive evidence on participating firm's R&D intensity or patent activity Cerulli (2010).

Therefore, it is expected that relying on funds will present more dynamic R&D departments which will draw on Universities to develop innovative projects.

Hypothesis 6: Firms that rely on funds are more prone to rely on Universities

The firm innovative strategy will define, among others, the firm positioning and interactions with the NSI. For strategical reasons some firms opt for a closed solution in terms of the use of external sources to develop innovative projects and as a result there will be a strong focus in the internal R&D department. In other cases, managers decide to develop connections with other stakeholders in the chain of production or the NSI, thus diversifying the provenience of the knowledge they use to develop their innovative activities. To von Hippel (1988) agents in the chain of production such as clients or suppliers determine the innovative activities. Clients are considered a very important source of new product ideas Gemunden et al., 1992 and Salter and Martin (2001).

Following a similar procedure to Laursen and Salter (2004) and Costa (2005), an "openness" variable was constructed; it is a count of different sources of innovation used by the firm to perform its innovative activities. Firms with an open innovative strategy will rely on a larger number of sources and will find them very important to their innovative activities. According their evidence, open firms will have a higher probability to draw upon Universities and find this source as being very important.

Hypothesis 7: Being more open positively influences drawing from Universities.

Being an innovative firm in the past increases the probability of continuity, which means that innovative actions generate virtuous cycles of innovation. The repeated actions to innovate are defined in the literature as innovation persistence. (e.g. Peters 2009). Different innovative strategies will conduct the firm to become a persistent innovator, sporadic innovator or non-innovator.

Being an R&D intensive firm or technological intensive will raise the odds of being a persistent innovator, in other words these firms will pursuit innovative actions with a persistence base being part of their daily routines, (Clausen et al., 2012).

Persistence of product and process innovations requires a dynamic R&D department, with absorptive capacity, connected to the different external sources of innovation to accelerate the pace of innovation. As a consequence, firms performing innovation in a persistence base are expected to heavily draw upon universities.

Hypothesis 8: Persistent innovators are more likely to draw from universities

3. Database and descriptive results

This section will detail the underlying methodology for the panel construction considering the three CIS waves. The exploratory analysis of the main characteristics of the panel will be performed afterwards, dividing the results into three major segments: the structural characteristics of firms, the characteristics of the labour force and their innovative strategy.

3.1. Database and sample

The analysis of the role of Universities as sources of relevant information for the development of innovative activities can be empirically tested by observing the importance attributed to this source by the firms in the sample. In order to understand the perception of the importance of the University as a source of knowledge to the innovative activities we have collected data from the Community Innovation Survey, henceforth CIS.

The present research aims at understanding the role of the Universities after the implementation of the RIS3, which theoretically reinforces the importance of this source of knowledge to the entrepreneurial sector. As a result, the data collection covers a six year period, drawing upon information from the CIS 6, the CIS 8 and the CIS 10.

The panel is strongly balanced as only firms responding to the three waves were kept; the non-matching observations were dropped. This procedure allowed gathering of 1099 firms observed over three biennia, which will permit the observation before and after the financial crisis to understand the extent of its effects.

3.2 Exploratory analysis of the panel - Structural traits

An exploratory analysis of the constructed panel was run to understand the distribution of the respondent firms according to their structural traits. This preliminary analysis will provide relevant information about what to expect by comparing to the literature as well as an understanding of how far it is connected to the Portuguese reality. Given the extension of the information and the fact that its interest is not central to the discussion, all the information is provided in the appendix 8.

3.3. Correlation among innovation sources

The different sources of information for the innovative activities offer the firms assorted features of the innovation process. The sources of information act as complements in the development of the innovative activities and serve different purposes and complexities of knowledge transmission. Each source will provide a different solution to integrate in the innovative process, such that the firms will ask for different collaborations according to their needs (Frenz and Letto-Gilles, 2009).

The innovative sources are positively correlated amongst themselves with a high degree of significance, for the three biennia, presenting similar degrees of intensity.

Table 42 - Correlation among innovation sources for the CIS 6 for the constructed panel

		Correlations among innovation sources (CIS 6)									
		Inside the firm	**Suppliers**	**Clients**	**Competitors**	**Consultants & Private**	**Universities**	**Government Labs**	**Conferences**	**Scientific Journals**	**Firm associations**
Internal Sources	**Inside the firm**		0.111**	0.297**	0.150**	0.180**	0.156**	0.138**	0.130**	0.184**	0.092*
	Suppliers			0.240**	0.297**	0.268**	0.137**	0.207**	0.322**	0.318**	0.25**[*]
Market Sources	**Clients**				0.513**	0.210**	0.213**	0.230**	0.320**	0.324**	0.289**
	Competitors					0.303**	0.287**	0.308**	0.382**	0.337**	0.322**
	Consultants & Private						0.369**	0.384**	0.232**	0.235**	0.329**
Institutional Sources	**Universities**							0.369**	0.384**	0.232**	0.235**
	Government Labs								0.339**	0.382**	0.353**
	Conferences									0.675**	0.482**
Other Sources	**Scientific Journals**										0.498**
	Firm associations										

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 6

Table 43 - Correlation among innovation sources for the CIS 8 for the constructed panel

		Correlations among innovation sources (CIS 8)									
		Inside the firm	**Suppliers**	**Clients**	**Competitors**	**Consultants & Private**	**Universities**	**Government Labs**	**Conferences**	**Scientific Journals**	**Firm associations**
Internal Sources	**Inside the firm**		0.318**	0.403**	0.273**	0.241**	0.249**	0.205**	0.183**	0.228**	0.149**
	Suppliers			0.195**	0.272**	0.235**	0.206**	0.146**	0.290**	0.221**	0.159**
Market Sources	**Clients**				0.564**	0.225**	0.236**	0.191**	0.326**	0.269**	0.281**
	Competitors					0.356**	0.308**	0.294**	0.363**	0.304**	0.334**
	Consultants & Private						0.460**	0.465**	0.289**	0.390**	0.315**
Institutional Sources	**Universities**							0.681**	0.365**	0.398**	0.310**
	Government Labs								0.344**	0.384**	0.367**
	Conferences									0.618**	0.470**
Other Sources	**Scientific Journals**										0.547**
	Firm associations										

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS

Table 44 - Correlation among innovation sources for the CIS 10 for the constructed panel

		Correlations among innovation sources (CIS 10)									
		Inside the firm	**Suppliers**	**Clients**	**Competitors**	**Consultants & Private**	**Universities**	**Government Labs**	**Conferences**	**Scientific Journals**	**Firm associations**
Internal Sources	**Inside the firm**		0.237**	0.372**	0.231**	0.220**[*]	0.194**	0.190**	0.188**	0.251**	0.153**
	Suppliers			0.294**	0.315**	0.389**	0.298**	0.226**	0.313**	0.327**	0.256**
Market Sources	**Clients**				0.494**[*]	0.323**	0.271**	0.241*	0.310**	0.313**	0.265**
	Competitors					0.406**	0.262**	0.296**	0.373**	0.360**	0.322**
	Consultants & Private						0.505*	0.501**	0.381**	0.439**	0.432**
Institutional Sources	**Universities**							0.669**	0.372**	0.436**	0.344**
	Government Labs								0.405**	0.440**	0.462**
	Conferences									0.638**	0.476**
Other Sources	**Scientific Journals**										0.554**
	Firm associations										

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 10

4. Econometric analysis

This chapter presents the results of the empirical analysis. The main outcomes will be presented by means of the following descriptive statistics, the alternative hurdle models run. The estimations were produced based on stata version 13.

The remainder of the chapter will be structured as follows: Firstly, the main measurements in use (section 4.1), secondly the descriptive statistics of the variables are provided (section 4.2); section 4.3 provides the explanation of the econometric model. Section 4.4 presents the alternative models used to accurately capture hypothesis in test and the outcomes of the estimation. Finally, section 4.5 discusses the results of each model.

4.1. Measures

The dependent variable conveys information concerning the importance attributed by firms to the use of universities as a source of information for their innovative activities. Originally the data collection is done by a multinomial scale: 0-1-2-3. So, 0 means that the firm finds the use of the University irrelevant, and the 1-2-3 is an increasing scale of importance.

The first part of the hurdle neglects the degree of importance of the innovation source, taking into consideration the binomial - use, not use; independent of the importance attributed to this source. The second part of the hurdle is committed to the analysis of importance, which means that, after surmounting the hurdle, the second estimation evidences the probability of finding it of low importance, medium importance or high importance.

The different explanatory variables are proxied in the usual forms and can be seen in detail in the following table along with the descriptive statistics. Further information can be seen in the variable codebook included in the appendix 1.

4.2. Descriptive statistics

Table 45 - Descriptive statistics for explanatory variables

Variable	Description	N	Mean	Std. Dev.	Minimum	Maximum
tech_intensity	Technological intensity (1-low tech; 2 - mid tech; 3 - high tech)	3297	2.298	0.778	1	3
sector	Economic Sector (aggregation : 1 - primary; 2 - secondary; 3 - tertiary)	3297	2.329	0.517	1	3
size	Firm size (2 - small; 3 - medium; 4 - large)	3297	2.868	0.748	2	4
group	Economic Group (binary: 1 - yes)	3297	0.485	0.5	0	1
prod_innov	Product Innovation (binary: 1 - yes)	3297	0.362	0.481	0	1
serv_innov	Service Innovation (binary: 1 - yes)	3297	0.307	0.461	0	1
process_innov	Process Innovation (binary: 1 - yes)	3297	0.57	0.495	0	1
org_innov	Organisational Innovation (binary: 1 - yes)	3297	0.558	0.497	0	1
mkting_innov	Marketing Innovation (binary: 1 - yes)	3297	0.424	0.494	0	1
innov_in_general	Innovation in general, independent of the vector (binary: 1 - yes)	3297	0.758	0.428	0	1
expenditures_RD_intramural	Expenditures RD intramural (€)	3297	450951	3399602	0	7.140×10^{7}
expenditures_RD_extramural	Expenditures RD extramural (€)	3297	127791	959163	0	1.640×10^{7}
expenditures_RD_machinery	Expenditures RD machinery (€)	3297	527456	4693380	0	1.270×10^{8}
expenditures_RD_others	Expenditures RD others (€)	3297	59876	823605	0	2.370×10^{7}
expenditures_RD_Total	Expenditures RD Total (sum of the R&D expenditures, in €)	3297	1166075	6579944	0	1.410×10^{8}
funds_general	Use of funds to innovate, independent of the origin (binary: 1 - yes)	3297	0.189	0.392	0	1
sou_intern	Sources of innovation_internal (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	2.437	0.83	0	3
sou_suppliers	Sources of innovation_supplier (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	1.962	0.894	0	3
sou_consumers	Sources of innovation_consumers (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	1.998	1.028	0	3
sou_competitors	Sources of innovation_competitors (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	1.469	1.008	0	3
sou_consultants	Sources of innovation_consultants (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	1.209	1.069	0	3
sou_universities	Sources of innovation_Universities (0 - not used; 1 - low imp.; 2 -	2200	0.93	1.042	0	3

Variable	Description	N	Mean	Std. Dev.	Minimum	Maximum
	medium imp.; 3 high imp.)					
sou_public_labs	Sources of innovation_R&D Labs (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	0.673	0.919	0	3
sou_conferences	Sources of innovation_conferences (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	1.479	0.994	0	3
sou_journals	Sources of innovation_journals (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	1.37	0.925	0	3
sou_associations	Sources of innovation_associations (0 - not used; 1 - low imp.; 2 - medium imp.; 3 high imp.)	2200	1.107	0.929	0	3
openess	Openness to sources of innovation (count of the sources of innovation in use, independent of the importance)	3297	4.914	4.081	0	10
turnover_growth_rate	Turnover Growth Rate - rate of growth from the begining of the period untill the end (%)	3292	791578	4.540×10^{7}	-100	2.610×10^{9}
rd_intensity	R&D expenditures to Turnover Ratio	3297	4.533	115.682	0	6615.23
education_intensity	Percentage of the labour force with undergraduate trainig or more	3297	2.521	1.557	0	6
persistent_innovator	Performing innovative activities in, at least two continuous periods	1415	1.431	0.495	1	2
innov_act_external_know	Having performed innovative activities consisting of external knowledge (binary: 1 - yes)	2589	0.247	0.431	0	1
innov_act_training	Having performed innovative activities consisting of training (binary: 1 - yes)	2589	0.616	0.486	0	1

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

4.3. Econometric model

Relying on Universities as sources of knowledge for innovative activities is part of the firm strategic behaviour, thus being an option. Firms may find the University as an irrelevant source of knowledge for their innovative activities or find it to some extent important. The econometric specification to illustrate this procedure is the "hurdle model".

To our knowledge this model framework has not yet been used to empirically analyse the importance of Universities as sources of information for the innovative activities representing a methodological contribution to approach this problematic.

The hurdle model considers primarily, a binary choice model (Random Effects binomial logit): choosing or not to rely on Universities; and, secondly an ordered model (the Random Effects Ordered Logit), illustrating the degrees of importance of the University considering that it is relevant as a source of information for innovative activities.

The procedure consists of, one hand not relying on Universities because of it being irrelevant or relying on them regardless of the importance and on the other hand the process by which the firm ranks the importance of this source of knowledge.

As mentioned by Cameron and Trivedi (1998) it is a "modified count model in which two processes generating the zeros and the positives are not constrained to be the same". The underlying idea of the hurdle is that the binomial logit model determines the binary outcome, separating the zeros from the positive concretisations (Botelho, et al., 2009). In this particular case, the hurdle is crossed if the firms mention the University as being a relevant source for its innovative activities, then, the conditional distribution of the positive outcomes (being of poor importance, medium importance or high importance), is determined by a truncated at zero ordered logit model (Mullahy, 1986).

Therefore, the log likelihood function is the sum of the log likelihood for the binomial model and the log likelihood of the ordered model. This function is separable, with respect to the parameters to be estimated, hurdle models can be presented as the sum of two independent models (McDowell, 2003).

The use of a hurdle model is a conceptual refinement which, to us, represents an improvement in determining the role of Universities as sources of information for innovative activities. This model seems to be more accurate as there is a substantial difference among the possible outcomes of the dependent variable. The difference between not using the university as a source of innovation to finding it poorly relevant is larger than when moving

from finding it of low importance to finding it of medium importance; the first change illustrates a structural change. Therefore, due to the existence of substantially different outcomes the use of the hurdle will better accommodate the reality. In doing so, we will allow for changes in the state of the variable and not simple qualitative changes.

As mentioned, the econometric estimations will consider a strongly balanced panel with firms responding to the three CIS waves, it comprises 1099 firms observed in the three biennia. The hurdle model was performed to analyse the probability of relying on university and its degree of importance. Four alternative models were run to verify the hypothesis in test: Model 1 illustrates the hurdle model including the firms' structural traits as explanatory variables; Model 2 controls per economic sector, with the primary sector being the benchmark; Model 3 controls by the different innovation types and Model 4 puts together sectorial control and the innovative type.

4.4 Estimations

Table 46 – Econometric Extimations if the Hurdle Model - α, **β** (alternative models)

	Model 1				Model 2				Model 3				Model 4			
	Estimate	**ρ-value**	**Estimate**	**ρ-value**	**Estimate**	**ρ-value**	**Estimate**	**ρ-value**	**Estimate**	**ρ-value**	**Estimate**	**ρ-value**	**Estimate**	**ρ-value**	**Estimate**	**ρ-value**
Parameter	α		β		α		β		α		β		α		β	
size_medium	0.265	0.105	0.397	0.081	0.228	0.164	0.346	0.133	0.184	0.258	0.467	0.040	0.151	0.354	0.424	0.063
size_large	0.647	0.001	0.672	0.012	0.650	0.001	0.658	0.015	0.563	0.005	0.704	0.008	0.577	0.004	0.706	0.009
group	0.030	0.846	0.100	0.613	0.059	0.697	0.117	0.555	0.004	0.978	0.092	0.636	0.040	0.801	0.113	0.561
mid_tech	-0.019	0.922	-0.463	0.092	0.093	0.650	-0.347	0.223	0.095	0.643	-0.469	0.092	0.244	0.257	-0.313	0.279
high_tech	0.024	0.902	-0.427	0.093	0.194	0.348	-0.263	0.318	0.115	0.566	-0.465	0.068	0.312	0.145	-0.263	0.318
innov_in_general	-5.577	0.000	-2.556	0.023	-5.576	0.000	-2.550	0.021	-	-	-	-	-	-	-	-
prod_innov	-	-	-	-	-	-	-	-	-0.805	0.000	-0.100	0.594	-0.899	0.000	-0.200	0.297
serv_innov	-	-	-	-	-	-	-	-	-0.711	0.000	0.156	0.386	-0.614	0.000	0.255	0.174
process_innov	-	-	-	-	-	-	-	-	-3.196	0.000	-0.167	0.498	-3.199	0.000	-0.205	0.404
org_innov	-	-	-	-	-	-	-	-	0.160	0.316	0.152	0.471	0.160	0.315	0.133	0.528
mkting_innov	-	-	-	-	-	-	-	-	-0.097	0.529	0.064	0.713	-0.042	0.788	0.138	0.441
funds_general	0.605	0.000	0.649	0.000	0.555	0.000	0.623	0.001	0.843	0.000	0.674	0.000	0.794	0.000	0.649	0.000
openess	0.374	0.000	0.096	0.195	0.373	0.000	0.103	0.165	0.468	0.000	0.070	0.366	0.465	0.000	0.076	0.324
rd_intensity	-0.016	0.001	-0.018	0.142	-0.016	0.000	-0.018	0.134	-0.012	0.020	-0.017	0.146	-0.012	0.020	-0.018	0.135
turnover_growth_rate	-7.140×10^{-5}	0.468	0.001	0.233	-7.890×10^{-5}	0.539	0.001	0.230	-4.370×10^{-5}	0.010	0.001	0.320	-4.350×10^{-5}	0.012	0.001	0.322
education_intensity	0.199	0.000	0.292	0.000	0.241	0.000	0.346	0.000	0.085	0.103	0.277	0.000	0.127	0.016	0.337	0.000
occasional_innovator	-0.541	0.001	-0.033	0.892	-0.564	0.001	-0.060	0.802	-0.214	0.273	-0.035	0.883	-0.243	0.210	-0.074	0.758
persistent_innovator	0.047	0.789	0.166	0.470	-0.004	0.980	0.104	0.653	0.482	0.020	0.179	0.448	0.434	0.037	0.110	0.643
innov_act_external_know	0.121	0.382	0.336	0.063	0.151	0.279	0.361	0.047	0.338	0.043	0.312	0.082	0.354	0.034	0.332	0.065
innov_act_training	-1.295	0.000	0.156	0.434	-1.279	0.000	0.156	0.435	-1.266	0.000	0.078	0.697	-1.258	0.000	0.075	0.707
secondary_sector	-	-	-	-	-0.327	0.518	-0.242	0.819	-	-	-	-	-0.261	0.550	-0.458	0.689
tertiary_sector	-	-	-	-	-0.761	0.143	-0.693	0.520	-	-	-	-	-0.789	0.078	-1.049	0.369
constant	3.365	0.000			3.632	0.000	-	-	0.559	0.009			0.757	0.114	-	-
Wald χ^2	χ^2_{15} = 359.99; p-value = 0.0000				χ^2_{17} = 361.75; p-value = 0.0000				χ^2_{19} =320.58; p-value = 0.0000				χ^2_{21} = 324.33; p-value = 0.0000			

Source: Author's computation based on the CIS panel

Table 47 – Econometric Extimations if the Hurdle Model - marginal effects (alternative models)

	Model 1				Model 2				Model 3				Model 4			
VARIABLE	Logit	Ordered Logit			Logit	Ordered Logit			Logit	Ordered Logit			Logit	Ordered Logit		
	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)
size_medium	0.265	-0.085*	0.047*	0.038*	0.228	-0.074	0.040	0.033	0.184	-0.101**	0.055**	0.046**	0.151	-0,091*	0.049*	0.042*
	(0.163)	(0.048)	(0.027)	(0.022)	(0.164)	(0.049)	(0.027)	(0.023)	(0.163)	(0.048)	(0.026)	(0.023)	(0.163)	(0,048)	(0.026)	(0.023)
size_large	0.647***	-0.145***	0.080**	0.065**	0.650***	-0.140**	0.077**	0.063**	0.563***	-0.152***	0.082***	0.070**	0.577***	-0.151***	0.081***	0.070**
	(0.197)	(0.056)	(0.032)	(0.027)	(0.196)	(0.056)	(0.031)	(0.027)	(0.199)	(0.056)	(0.031)	(0.027)	(0.158)	(0.056)	(0.031)	(0.028)
group	0.030	-0.021	0.012	0.010	0.059	-0.025	0.014	0.011	0.004	-0.020	0.011	0.009	0.040	-0.024	0.013	0.011
	(0.152)	(0.042)	(0.023)	(0.019)	(0.152)	(0.042)	(0.023)	(0.019)	(0.158)	(0.042)	(0.023)	(0.019)	(0.158)	(0.042)	(0.022)	(0.019)
mid_tech	-0.019	0.100	-0.055*	-0.044*	0.093	0.074	-0.041	-0.033	0.095	0.101*	-0.055*	-0.046*	0.244	0.067	-0.036	-0.031
	(0.197)	(0.059)	(0.033)	(0.027)	(0.205)	(0.061)	(0.034)	(0.028)	(0.204)	(0.060)	(0.033)	(0.028)	(0.215)	(0.062)	(0.033)	(0.029)
high_tech	0.024	0.092*	-0.051*	-0.041*	0.194	0.056	-0.031	-0.025	0.115	0.101*	-0.055*	-0.046*	0.312	0.056	-0.030	-0.026
	(0.196)	(0.054)	(0.031)	(0.025)	(0.207)	(0.056)	(0.031)	(0.026)	(0.200)	(0.055)	(0.03)	(0.026)	(0.214)	(0.057)	(0.030)	(0.026)
innov_in_general	-5.577***	0.550**	-0.304**	-0.246**	-5.576***	0.545**	-0.299**	-0.246**	-	-	-	-	-	-	-	-
	(-0.461)	(0.241)	(0.141)	(0.106)	(0.460)	(0.234)	(0.136)	(0.105)								
prod_innov	-	-	-	-	-	-	-	-	-0.805***	0.022	-0.012	-0.010	-0.899***	0.043	-0.023	-0.020
									(0.167)	(0.040)	(0.022)	(0.019)	(0.171)	(0.041)	(0.022)	(0.019)
serv_innov	-	-	-	-	-	-	-	-	-0.711***	-0.034	0.018	0.015	-0.614***	-0.055	0.029	0.025
									(0.161)	(0.039)	(0.021)	(0.018)	(0.163)	(0.040)	(0.021)	(0.019)
process_innov	-	-	-	-	-	-	-	-	-3.196***	0.036	-0.020	-0.017	-3.199***	0.044	-0.024	-0.020
									(0.298)	(0.053)	(0.029)	(0.024)	(0.296)	(0.053)	(0.028)	(0.025)
org_innov	-	-	-	-	-	-	-	-	0.160	-0.033	0.018	0.015	0.160	-0.029	0.015	0.013
									(0.160)	(0.045)	(0.025)	(0.021)	(0.159)	(0.045)	(0.024)	(0.021)
mkting_innov	-	-	-	-	-	-	-	-	-0.097	-0.014	0.008	0.006	-0.042	-0.030	0.016	0.014
									(0.153)	(0.038)	(0.021)	(0.017)	(0.155)	(0.038)	(0.021)	(0.018)
funds_general	0.605***	-0.140***	0.077***	0.062***	0.555***	-0.133***	0.073***	0.060**	0.843***	-0.146***	0.079***	0.067***	0.794***	-0.139***	0.074***	0.065***
	(0.154)	(0.039)	(0.022)	(0.019)	(0.155)	(0.039)	(0.022)	(0.019)	(0.178)	(0.039)	(0.022)	(0.020)	(0.178)	(0.039)	(0.021)	(0.020)
openess	0.374***	-0.021	0.011	0.009	0.373***	-0.022	0.012	0.010	0.468***	-0.015	0.008	0.007	0.465***	-0.016	0.009	0.008
	(0.029)	(0.016)	(0.009)	(0.007)	(0.029)	(0.016)	(0.009)	(0.007)	(0.035)	(0.017)	(0.009)	(0.008)	(0.035)	(0.016)	(0.009)	(0.008)
rd_intensity	-0.016***	0.004	-0.002	-0.002	-0.016***	0.004	-0.002	-0.002	-0.012**	0.004	-0.002	-0.002	-0.012**	0.004	-0.002	-0.002
	(0.005)	(0.003)	(0.001)	(0.001)	(0.005)	(0.003)	(0.001)	(0.001)	(0.05)	(0.003)	(0.001)	(0.001)	(0.005)	(0.003)	(0.001)	(0.001)
turnover_growth_rate	-7.140×10^{-5}	-2.295×10^{5}	1.270×10^{-4}***	$1.025 \times 10^{-}$	-7.890×10^{-5}	$-2.320 \times 10^{-}$	1.272×10^{-4}	$1.048 \times 10^{-}$	-4.370×10^{-5}***	-1.897×10^{-4}	1.028×10^{-4}	$8.680 \times 10^{-}$	-4.350×10^{-5}**	1.896×10^{-4}	1.015×10^{-4}	8.800×10^{-5}
	(9.840×10^{-5})	(1.919×10^{-5})	(1.072×10^{-4})	(8.620×10^{-5})	(1.286×10^{-4})	(1.930×10^{-4})	(1.068×10^{-4})	(8.770×10^{-5})	(1.710×10^{-5})	(1.902×10^{-4})	(1.039×10^{-4})	(8.740×10^{-5})	(1.730×10^{-5})	(1.912×10^{-4})	(1.032×10^{-4})	(8.900×10^{-5})
education_intensity	0.199***	-0.063***	0.035***	0.028***	0.241***	-0.074***	0.040***	0.033***	0.085	-0.060***	0.032***	0.027***	0.127**	-0.072***	0.039***	0.034***
	(0.054)	(0.016)	(0.009)	(0.008)	(0.056)	(0.018)	(0.010)	(0.009)	(0.052)	(0.016)	(0.009)	(0.008)	(0.053)	(0.017)	(0.010)	(0.009)
occasional_innovator	-0.541***	0.007	-0.004	-0.003	-0.564***	0.013	-0.007	-0.006	-0.214	0.008	-0.004	-0.003	-0.243	0.016	-0.009	-0.007
	(0.169)	(0.051)	(0.029)	(0.023)	(0.168)	(0.051)	(0.028)	(0.023)	(0.052)	(0.052)	(0.028)	(0.024)	(0.194)	(0.052)	(0.028)	(0.024)
persistent_innovator	0.047	-0.036	0.020	0.016	-0.004	-0.022	0.012	0.010	0.482**	-0.039	0.021	0.018	0.434**	-0.023	0.013	0.011
	(0.176)	(0.049)	(0.027)	(0.022)	(0.176)	(0.049)	(0.027)	(0.022)	(0.208)	(0.051)	(0.028)	(0.024)	(0.208)	(0.051)	(0.027)	(0.024)
innov_act_external_know	0.121	-0.072*	0.040*	0.032*	0.151	-0.077**	0.042**	0.035*	0.338**	-0.067*	0.036*	0.031*	0.354**	-0.071*	0.038*	0.033*
	(0.138)	(0.039)	(0.022)	(0.018)	(0.139)	(0.039)	(0.021)	(0.018)	(0.167)	(0.038)	(0.021)	(0.018)	(0.167)	(0.038)	(0.021)	(0.018)
innov_act_training	-1.295***	-0.034	0.019	0.015	-1.279***	-0.033	0.018	0.015	-1.266***	-0.017	0.009	0.008	-1.258***	-0.016	0.009	0.007
	(0.161)	(0.043)	(0.024)	(0.019)	(0.161)	(0.043)	(0.024)	(0.019)	(0.181)	(0.043)	(0.024)	(0.020)	(0.180)	(0.043)	(0.023)	(0.020)
secondary_sector	-	-	-	-	-0.327	0.052	-0.028	-0.023	-	-	-	-	-0.261	0.098	-0.052	-0.046
					(0.506)	(0.226)	(0.124)	(0.102)					(0.436)	(0.245)	(0.131)	(0.114)
tertiary_sector	-	-	-	-	-0.761	0.148	-0.081	-0.067	-	-	-	-	-0.789*	0.225	-0.120	-0.104
					(0.520)	(0.230)	(0.126)	(0.104)					(0.448)	(0.249)	(0.134)	(0.117)

Source: Author's computation based on the CIS panel

4.5 Results[3]

In this section we will discuss the alternative econometric models presented in the previous section. Models 1, 2, and 3 will be shortly discussed and model 4 will be discussed in detail.

4.5.1 Model 1

In model 1, size appears as being statistically significant for large firms. Compared to small firms, they have an increased probability to find the Universities of use of 64.7 percentage points (pp); these firms have an increased probability of finding this source of knowledge of high importance of 6.5 pp compared to the small. Larger firms will have a higher probability of use and of finding Universities as highly relevant. Medium firms will present similar results in the degree of importance.

Technological intensity (mid tech and high tech), in this model, appear as being statistically insignificant in most of the cases, and, when significant, the marginal impact is negative, meaning that high tech firms have a lower probability of finding this source of knowledge of extreme importance.

Innovative firms, regardless of the vector, find the use of Universities as being of low importance (557.7pp) more often than non-innovative firms, and have a lower probability of finding the University of medium and high importance (respectively 30.4 and 24.6 pp).

The use of public funds is highly significant in determining the use of Universities. Firms that use public finance to develop their innovative activities have a lower probability to find the University of low importance compared to those who do not use funds (14 pp), reinforcing this trend, the odds of finding the University as being of medium and high importance is higher than the benchmark by 7.7 and 6.2 pp, respectively).

Firms with "top educated employees" are more prone to find the University as a relevant source of information for their innovative activities. Thus, increasing one level in terms of Education intensity category decreases the probability of finding the Universities as being a source of information of low importance (6.3 percentage points). A unitary

[3] Details in appendix 16, 17, 18 and 19

increase in terms of the Education intensity upturns the odds of finding the University as being highly important per 2.8 percentage points.

4.5.2. Model 2

The hurdle estimated in Model 2 contains all the explanatory variables of model 1 and includes a control for the economic sector. The estimation results hold in the same line with the previous model, except for the technological intensity, which becomes insignificant in either mid tech and high tech.

The use of funds, the innovative performance as well as the education intensity present similar statistical significance as well as the directions of the effects.

The sectoral segmentation fails to be statistically significant in both thresholds.

4.5.3. Model 3

In the model 3, a segmentation among innovation vectors was made to capture eventual differences in relying on Universities depending on the type of innovation performed which means that the threshold comprises: product, service, process, marketing and organisational innovation.

This segmentation failed to achieve the statistical significance, in terms of the degree of importance, even though being significance in determining the propensity of use. Still product, service or process innovators have a decreased probability of using the University as a source of information. This effect goes in the opposite direction from what was expected, as one would think that innovators will be more prone to rely on the University. The marginal effects of medium sized and large firms go in the same line as the model 1, although with higher magnitudes. In terms of technological intensity, model 3 seizes the same effects as the first, as well as the impact of public funding and education intensity.

4.5.4. Model 4

Model 4 combines innovation per vector as well as sector segmentation. The significance of the different innovation vectors is similar to the results of model 2.

The size of firms appears as being relevant to explain the propensity to draw upon the Universities as a relevant source of knowledge. Compared to small firms, medium firms have a lower probability to find the University as being of low importance of 9.1 percentage points (pp), a higher probability of 4.9 pp of finding it of medium importance, and an increased probability of finding it of high importance (4.2 pp).

Large firms have an increased probability of finding the Universities as a relevant source of knowledge, compared to small firms, the probability is higher in 57.7 pp large firms have a lower probability than small firms to find the University as being of low importance of 15.1 pp, moreover, they have a higher probability (8.1 pp) to find it of medium importance and (7 pp) of high importance. In sum, large firms tend to use more often the Universities and to find this source of knowledge as being of high importance.
Being part of an economic group does not determine the probability of drawing upon the University, as well as the technological intensity of the firm.

The present model divides innovation into its five types. Being a product innovator decreases the probability of using the University as a source of knowledge by 89.9 pp compared to the non-innovative firms. Service and process innovators have a lower probability to draw upon the University of 61.44 and 319.9 pp, respectively. Marketing and organisational innovations fail to be significant in explaining the probability to rely upon the University. The different innovation types are not statistically significant to explain the degree of importance of using the University.

The use of public funds, independent of their provenience appears as being statistically significant to explain the use of the University as a source of information for innovation. Using funds raises the probability of using the University by 79.4 pp; it decreases the probability of finding the University of being of low importance by 13.9 pp, raises the probability of finding it of medium and high importance by 7.4 and 6.5 pp, respectively. In sum, firms that rely on public funding to perform their innovative activities tend to find the Universities more important as a source of information for innovation than others.

To perform their innovative activities firms will draw upon external sources of knowledge, establishing vertical and horizontal links. The use of alternative sources of information for innovation is part of a managerial strategy, and the evidence points to openness as a proxy for innovation dynamism and an intensive use of the Universities. Increased openness raises the probability of using the University by 46.5 pp. This variable is not a determinant of the degree of importance.

R&D intensity will illustrate the proportion of the turnover devoted to innovative activities; higher intensities will demonstrate the strategic option for innovation. Higher levels of R&D intensity decrease the probability of using the University as a source of knowledge. This is perhaps due to the fact that internal and external sources of knowledge will work more as substitutes rather than complements. Still, the variable fails to be statistically significant in terms of the degree of importance of the source.

Financial constraints are often mentioned as hindering factors to perform R&D activities and pursuit innovation. In this vein, firms with higher turnover growth are expected to devote more funds to innovation and innovative activities. With a higher innovative dynamism, the firms were also expected to be more prone to rely on the Universities, although, the evidence shows that raising the turnover growth decreases the probability to rely upon the universities.

Having a higher proportion of top educated workers raises the probability of using the University as a source of knowledge by 12.7 pp; moreover it decreases the probability of finding this source of innovation of low importance by 7.2 pp and increases the probability of finding it of medium importance by 3.9 pp. The availability of educated employees seems to reinforce the knowledge proximity to the University and enhances the establishment of these links.

Persistent innovators have and increased probability of using the Universities of 43.4 pp compared to non-innovative firms; the latter, due to strategical reasons do not perform innovative activities, therefore finding useless the connection with the University. Firms that do acquire external knowledge are also more prone to rely upon the Universities as sources of knowledge. These firms have an increased probability of 35.4 pp of using the universities. Likewise they are less prone of finding the University of low importance (7.1 pp) and more prone of finding it of medium and high importance (3.8 and 3.3 pp,

respectively). Still, firms that develop training activities have a lower probability from using the University (125.8 pp), compared to those who don't.

Tertiary sector firms have a lower probability of using the Universities of 78.9 pp compared to firms in the primary sector. This evidence is perhaps due to the facts that the knowledge produced by this source of knowledge is perceived as not importance by service firms.

5. Conclusion

Previous policy approaches have privileged the stronger sectors "picking-winners" choosing which profiles should be supported and the desirable characteristics of firms. Smart specialization is expected to avoid Government failure, associated with centralized and disconnected policy actions, extreme bureaucracy preventing SME's to reach financial support (Foray e Goenaga, 2013). The Portuguese NSI is the past decades has developed and matured, consolidating competences in all its elements generating skills and recognised capacities. Albeit, the empirical evidence shows that large firms are more likely to use the Universities and finding them as important; this may highlight some proximity among complex structures and the rigid approach to firms linkages performed by the Academia. This finding may shed some light in the fact that, at present, notwithstanding the implementation of the RIS3, SME's are distant from these sources of knowledge.

R&D intensive firms are expectably more innovation active therefore raising the probability to rely upon the University, although, in our evidence this hypothesis is not supported. This finding will reinforce the need for a careful evaluation of the differentiating domains; moreover, the empirical evidence points towards an inverse direction of the effect, which neglect the knowledge produced in the Universities. Policy makers must take into consideration the disconnection of these sectors to the Academia and take action to approach them.

Empirical findings reinforce the success of the past efforts to provide the workforce skills in order to raise productivity. The availability of to educated workers will enhance the absorptive capacity and the proximity to the University. Firms with high education intensity will be more prone to use the University. In sum, the public investments in education are accomplishing their targets in various domains: the productivity raise, the approach to the University. The results reinforce the need for a continuous support in terms of the Education Policy.

Previous findings of Laursen and Salter (2004) and Costa (2005) pointed towards the firm openness as being determinant to enhance linkages within Universities. Our empirical results did notice that the fact of being open does rise the probability of using the University as a source of knowledge, but is does not influence the importance attributed to this source of knowledge. When firms pursuit a managerial strategy in which they rely

upon a variety of knowledge sources, apart from their internal resources, it may be seen as preference for multi-actor innovative process, the ability to absorb and exploit the existing synergies in the firm context. This process requires proximity, absorptive capacity and given these characteristics, the firm should be more available for cooperation with the University.

As innovative processes require working and collaborating outside the boundaries of the organization, it is expectable to find our firms as being open. Partially supporting this hypothesis is perhaps due to the fact that our firms do indeed collaborate with other external actors to pursuit their innovative processes, despite their collaboration is limited to simple and sporadic topics.

Firms do invest in innovation to maximize profit, being focused in collecting the returns of their efforts. Invariably, the marketization of innovation requires protection, which is unfeasible under a perfectly open strategy. Our firms may find important the assurance of the secrecy, avoiding unplanned outward spillovers, therefore using the Universities but not for complex innovative tasks. The use of Universities may not be linear, which is explained in the literature as the paradox of openness (Laursen and Salter, 2014). Establishment of bulletproofed protocols and non-bureaucratic procedures may create the proper environment for the entrepreneurs to believe that their knowledge is fully protected.

Research suggests that rarely does the work of universities directly translate into new products or services for industrial organizations (Pavitt, 2001). The ability to innovate as well as innovation persistence will be affected by the structural characteristics of National Systems of Innovation, along with demand; persistent innovators are not consistently proved to draw upon this source of knowledge which can be explained by having solid R&D departments. These findings may capture the policy attention as internal sources of knowledge may not be substitutes but complement to the internal. The evidence points to results in the opposite direction, which means that innovative firms are less prone to rely upon the Universities; Governance must understand which link is missing, to push innovators inside their R&D labs rather than using the academia. Once again, the eventual revision of the differentiating domains must be considered.

Availability of trained personnel, their competences, specialisation in high-tech sectors and the design of proper policy frameworks as well as financial support arising

from public or private institutions will allow the firms to offset eventual hindering factors in performing innovative activities.

The use of Public funds appears as being of major importance as financing the innovative activities as firms have severe financial constraints to overcome. Finding external sources of finance rather than the proper funds to support these projects is normally unfeasible; therefore, a careful policy support is of major importance. The empirical evidence points to the fact that firms which draw upon public funds being more prone to use the Universities and finding this source of knowledge of major importance. This evidence reinforces the cohesion of the NSI since it approaches Governance, firms and Universities.

The use of public money in the scope of the Innovation Policy lies in a paradox as less developed regions require more money, despite being less effective in the use of funds. SME's tend to neglect the scientific potential embedded in their regions devaluating the role of the Universities in the promotion of knowledge for their innovative activities, our evidence goes along with this perception. Rodrigues (2014) finds that firms use the Universities for immediate solutions in simple problem solving situations, rather than the establishment of formal long term relations. This connection must be observed in detail as the implementation of the RIS3 requires the establishment of strong linkages among Universities and firms.

The following table enounces the empirical results of the paper compared to the hypotheses in test; it summarises the major findings as well as highlights the contributions.

Table 48 - Investigation hypotheses compared to the results

Hypothesis	Description	Results
[H1]	Larger firms are more likely to draw from universities.	Supported
[H2]	R&D intensity positively influences the draw from universities.	Not supported (inverse direction)
[H3]	Education intensity positively influences the draw from universities.	Supported
[H4]	Technological intensity positively influences the draw from universities.	Not supported

Hypothesis	Description	Results
[H5]	Innovative firms are more likely to draw from universities.	Not supported (inverse direction)
[H6]	Firms that rely on funds to finance their innovative activities are more likely to draw from universities.	Supported
[H7]	"Open" firms are more likely to draw from universities.	Partially supported
[H8]	Persistent innovators are more likely to draw from universities.	Partially supported

Source: Author's composition according to the literature and the econometric results

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Appendix 1 - Codebook

Table 49 - Codebook

CODEBOOK	
nipc	Firm's fiscal number (anonimous due to statistical secrecy)
sic	Economic Sector (two-digit SIC code)
sector	Economic Sector (agregation) : 1 primary, 2 secondary, 3 tertiary
tech_intensity	Technological intensity : 1- low; 2 mid -low; 3 mid high
size	Firm size (2 small, 3 medium, 4 large)
group	Economic Group 1 if the firm belongs to an economic group 0 otherwise
prod_innov	Product Innovation 1 Yes 0 Otherwise
serv_innov	Service Innovation 1 Yes 0 Otherwise
proc_production	Process Innovation - manufacturing activities 1 Yes
proc_logistic	Process Innovation - logistics 1 Yes
proc_support	Process Innovation - support activities 1 Yes
process_innov	Process Innovation in general (agregation) 1 Yes
org_innov_procedure	Organisational Innovation_procedures 1 Yes
org_innov_responsibility	Organisational Innovation_decision making 1 Yes
org_innov_external_rel	Organisational Innovation_external relations 1 Yes
org_innov	Process Innovation in general (agregation) 1 Yes
mkt_innov_package	Marketing Innovation_ package 1 Yes
mkt_innov_promotion	Marketing Innovation_ promotion 1 Yes
mkt_innov_distribuition	Marketing Innovation_ distribution 1 Yes
mkt_innov_price_policy	Marketing Innovation_ pricing policy 1 Yes
mkt_innov	Marketing Innovation (agregação) 1 Yes
innov_geral	Innovation in one vector (at least) 1 Yes
act_inov_internal	Internal R&D activities 1 Yes
act_inov_persistence	R&D Frequency 1 CONTINUOUS, 2 OCCASIONAL (further recoded)
act_innov_extramural_know	Extramural Innovation activities 1 Yes
act_innov_machinery	R&D Activities Machinery 1 Yes
act_innov_external_know	R&D Activities External Knowledge 1 Yes
act_innov_training	R&D Activities Training 1 Yes
act_innov_launch	R&D Activities launch new products 1 Yes

CODEBOOK

act_innov_design	R&D Activities Design 1 Yes
act_innov_others	R&D Activities Others 1 Yes
gastos_rd_intramural	Expenditures RD intramural €
gastos_rd_extramural	Expenditures RD extramural €
gastos_rd_machinery	Expenditures RD machinery €
gastos_rd_others	Expenditures RD others €
gastos_rd_total	Expenditures RD Total (€)
fundos_locals	Use of funds to innovate - Local 1 Yes
fundos_gov	Use of funds to innovate - Government 1 Yes
fundos_european	Use of funds to innovate - European 1 Yes
funds_general	Use of funds to innovate - General 1 Yes
sou_internal	Sources of innovation_internal 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_suppliers	Sources of innovation_suppliers 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_consumers	Sources of innovation_consumers 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_competitors	Sources of innovation_competitors 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_consultants	Sources of innovation_consultants 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_universities	Sources of innovation_Universities 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_public_labs	Sources of innovation_R&D Labs. 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_conferences	Sources of innovation_Conferences 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_journals	Sources of innovation_journals 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
sou_associations	Sources of innovation_associations 0- irrelevant; 1- scarcely important, 2- medium, 3 - high
openness	Openness to sources of innovation - count of how many sources being used 1 to 10
obj_enlarge_scope	Innovation objectives_scope_of_products: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_replace	Innovation objectives_replace products: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_new_market	Innovation objectives_new markets: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_quality	Innovation objectives_quality: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_flexibility	Innovation objectives_flexibility: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_productive_capacity	Innovation objectives_productive capacity : 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_costss_trab	Innovation objectives_labour costs: 0 - irrelevant, 1 - scarcely

CODEBOOK	
	important; 2 - medium, 3 - high
obj_material	Innovation objectives_materials and energy: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_environment	Innovation objectives_environmental impact: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
obj_HS	Innovation objectives_hygiene and security: 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_internal_finance	Barriers to innovation_internal_fianace 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_external_equity	Barriers to innovation lack of external equity 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_inov_expensive	Barriers to innovation_too_expensive 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_qualified_personel	Barriers to innovation qualified personnel 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_inform_tecnol	Barriers to innovation_lack_ information_technology 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_inform_mkt	Barriers to innovation_info_markets 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_partners	Barriers to innovation_lack_info_partners 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_market_dominated	Barriers to innovation_market dominted 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
barr_uncertainty	Barriers to innovation_market_uncertainty 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
ninnov_previous	Does not innovate - unnecessary; former innov products - 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
ninnov_unnecessary	Does not innovate - unnecessary; inexisting demand - 0 - irrelevant, 1 - scarcely important; 2 - medium, 3 - high
turnover_beginning	Turnover in the beginning of the period (€)
turnover_end	Turnover in the end of the period (€)
Turnover_growth_rate	Turnover Growth Rate - percentage (%)
rd_intensity	R&D expenditures to Turnover Ratio - percentage (%)
education_intensity	Percentage of the labour force with undergraduate trainig or more 0 - 0%; 1 - 1 to 4%; 2 - 5 to 9%; 3 - 10 to 24%; 4 -25 to 49%; 5 - 50 to 74% ; 6- 75 to 100%
innov_abandoned	Did not innovate due to abandon before conclusion (1 DID ABANDON)
innov_in course	Did not innovate - in course (1 IF IN COURSE)

Source: Author's own construction

Appendix 2 – Portuguese SIC codes Rev. 2

Table 50 - Portuguese classification of economic activities – Rev. 2

Portuguese Classification of Economic Activities **REVISION 2 - NACE Rev. 1 (1/1/1994 until 31/12/2002)**
011 - Agriculture
012 - Farming of animals
013 - Growing of crops combined with farming of animals (mixed farming)
014 - Agricultural and animal husbandry service activities, except veterinary activities; landscape gardening
015 - Hunting, trapping and game propagation, including related service activities
020 - Sylviculture, logging and related service activities
05 - Fishing, fish farming and related service activities
10 - Mining of coal and lignite; extraction of peat
11 - Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
12 - Mining of uranium and thorium ores
13 - Mining and preparation of metal ores
14 - Other mining and quarrying
15 - Manufacture of food products and beverages
16 - Manufacture of tobacco products
17 - Manufacture of textiles
18 - Manufacture of wearing apparel; dressing and dyeing of fur
19 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21 - Manufacture of pulp, paper and paper products
22 - Publishing, printing and reproduction of recorded media
23 - Manufacture of coke, refined petroleum products and nuclear fuel
24 - Manufacture of chemicals and chemical products
25 - Manufacture of rubber and plastic products
26 - Manufacture of other non-metallic mineral products
27 - Manufacture of basic metals
28 - Manufacture of fabricated metal products, except machinery and equipment
29 - Manufacture of machinery and equipment n.e.c.
30 - Manufacture of office machinery and computers
31 - Manufacture of electrical machinery and apparatus n.e.c.
32 - Manufacture of radio, television and communication equipment and apparatus
33 - Manufacture of medical, precision and optical instruments, watches and clocks
34 - Manufacture of motor vehicles, trailers and semi-trailers
35 - Manufacture of other transport equipment
36 - Manufacture of furniture; others manufacturing activities, n.e.c.
37 - Recycling
40 - Production and distribution of electricity, of gas, of steam and of hot water supply

Portuguese Classification of Economic Activities REVISION 2 - NACE Rev. 1 (1/1/1994 until 31/12/2002)
41 - Water collection, treatment and distribution
45 - Construction
50 - Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51 - Wholesale trade and commission trade, except of motor vehicles and motorcycles
52 - Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
55 - Hotels and restaurants
60 - Land transport; transport via pipelines
61 - Water transport
62 - Air transport
63 - Supporting and auxiliary transport activities; activities of travel agencies and others tourist assistance activities
64 - Post and telecommunications
65 - Financial intermediation, except insurance and pension funding
66 - Insurance, pension funding and others complementary activities of social security
67 - Activities auxiliary to financial intermediation
70 - Real estate activities
71 - Renting of machinery and equipment without operator and of personal and household goods
72 - Computer and related activities
73 - Research and development
74 - Other business activities
75 - Public administration and defence; compulsory social security
80 - Education
85 - Health and social work
90 - Sewage and refuse disposal, sanitation and similar activities
91 - Activities of membership organizations n.e.c.
92 - Recreational, cultural and sporting activities
93 - Other service activities
95 - Activities of households as employers of domestic staff
99 - Extra-territorial organizations and bodies

Source: INE – Classification of economics activities

Appendix 3 – Portuguese SIC codes Rev. 2.1

Table 51 - Portuguese classification of economic activities – Rev. 2.1

Portuguese Classification of Economic Activities **REVISION 2.1 - NACE Rev. 1.1 (1/1/2003 until 31/12/2007)**
011 - Agriculture
012 - Farming of animals
013 - Growing of crops combined with farming of animals (mixed farming)
014 - Agricultural and animal husbandry service activities, except veterinary activities; landscape gardening
015 - Hunting, trapping and game propagation, including related service activities
020 - Sylviculture, logging and related service activities
05 - Fishing, fish farming and related service activities
10 - Mining of coal and lignite; extraction of peat
11 - Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction, excluding surveying
12 - Mining of uranium and thorium ores
13 - Mining and preparation of metal ores
14 - Other mining and quarrying
15 - Manufacture of food products and beverages
16 - Manufacture of tobacco products
17 - Manufacture of textiles
18 - Manufacture of wearing apparel; dressing and dyeing of fur
19 - Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear
20 - Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials
21 - Manufacture of pulp, paper and paper products
22 - Publishing, printing and reproduction of recorded media
23 - Manufacture of coke, refined petroleum products and nuclear fuel
24 - Manufacture of chemicals and chemical products
25 - Manufacture of rubber and plastic products
26 - Manufacture of other non-metallic mineral products
27 - Manufacture of basic metals
28 - Manufacture of fabricated metal products, except machinery and equipment
29 - Manufacture of machinery and equipment n.e.c
30 - Manufacture of office machinery and computers
31 - Manufacture of electrical machinery and apparatus n.e.c.
32 - Manufacture of radio, television and communication equipment and apparatus
33 - Manufacture of medical, precision and optical instruments, watches and clocks
34 - Manufacture of motor vehicles, trailers and semi-trailers
35 - Manufacture of other transport equipment
36 - Manufacture of furniture; others manufacturing activities, n.e.c.
37 - Recycling
40 - Production and distribution of electricity, of gas, of steam and of hot water supply
41 - Water collection, treatment and distribution

Portuguese Classification of Economic Activities REVISION 2.1 - NACE Rev. 1.1 (1/1/2003 until 31/12/2007)
45 - Construction
50 - Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel
51 - Wholesale trade and commission trade, except of motor vehicles and motorcycles
52 - Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods
55 - Hotels and restaurants
60 - Land transport; transport via pipelines
61 - Water transport
62 - Air transport
63 - Supporting and auxiliary transport activities; activities of travel agencies and others tourist assistance activities
64 - Post and telecommunications
65 - Financial intermediation, except insurance and pension funding
66 - Insurance, pension funding and others complementary activities of social security
67 - Activities auxiliary to financial intermediation
70 - Real estate activities
71 - Renting of machinery and equipment without operator and of personal and household goods
72 - Computer and related activities
73 - Research and development
74 - Other business activities
75 - Public administration and defence; compulsory social security
80 - Education
85 - Health and social work
90 - Sewage and refuse disposal, sanitation and similar activities
91 - Activities of membership organizations n.e.c.
92 - Recreational, cultural and sporting activities
93 - Other service activities
95 - Activities of households as employers of domestic staff
96 - Undifferentiated goods producing activities of private households for own use
97 - Undifferentiated services producing activities of private households for own use
99 - Extra-territorial organizations and bodies

Source: INE – Classification of economics activities

Appendix 4 – Portuguese SIC codes Rev. 3

Table 52 - Portuguese classification of economic activities – Rev. 3

	Portuguese Classification of economic activities REVISION 3 - NACE Rev. 3 (1/1/2008- ….)
1	Agriculture, farming of animals, hunting and related service activities
2	Forestry and logging
3	Fishing and aquaculture
5	Mining of coal and lignite
6	Extraction of crude petroleum and natural gas
7	Mining and preparation of metal ores
8	Other mining and quarrying
9	Mining and quarrying related service activities
10	*Manufacture of food products*
11	*Manufacture of beverages*
12	*Manufacture of tobacco products*
13	*Manufacture of textiles*
14	*Manufacture of wearing apparel*
15	*Manufacture of leather and related products*
16	*Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials*
17	*Manufacture of paper and paper products*
18	*Printing and reproduction of recorded media*
19	*Manufacture of coke, refined petroleum products and fuels briquettes*
20	*Manufacture of chemicals, chemical products and man-made fibres, except pharmaceutical products*
21	*Manufacture of basic pharmaceutical products and pharmaceutical preparations*
22	*Manufacture of rubber and plastic products*
23	*Manufacture of other non-metallic mineral products*
24	*Manufacture of basic metals*
25	*Manufacture of fabricated metal products, except machinery and equipment*
26	*Manufacture of computer, communication equipment, electronic and optical products*
27	*Manufacture of electrical equipment*
28	*Manufacture of machinery and equipment n.e.c.*
29	*Manufacture of motor vehicles, trailers, semi-trailers and parts and accessories for motor vehicles*
30	*Manufacture of other transport equipment*
31	*Manufacture of furniture*
32	*Other manufacturing activities*
33	*Repair, maintenance and installation of machinery and equipment*
35	Electricity, gas, steam, cold and hot water and cold air
36	Water collection, treatment and distribution
37	Collection, drainage and treatment of sewage
38	Waste collection, treatment and disposal activities; materials recovery
39	Remediation and similar activities
41	Development of building projects; Construction of buildings
42	Civil engineering
43	Specialised construction activities
45	Wholesale and retail trade and repair of motor vehicles and motorcycles
46	Wholesale trade (include commission trade), except of motor vehicles and motorcycles
47	Retail trade, except of motor vehicles and motorcycles
49	Land transport and transport via pipelines
50	Water transport
51	Air transport

Portuguese Classification of economic activities REVISION 3 - NACE Rev. 3 (1/1/2008- ….)	
52	Warehousing and support activities for transportation (include cargo handling)
53	Postal and courier activities
55	Accommodation
56	Food and beverage service activities
58	Publishing activities
59	Motion picture, video and television programme production, sound recording and music publishing activities
60	Radio and television activities
61	Telecommunications
62	Computer programming, consultancy and related activities
63	Information service activities
64	Financial service activities, except insurance and pension funding
65	Insurance, reinsurance and pension funding, except compulsory social security
66	Activities auxiliary to financial services and insurance activities
68	Real estate activities
69	Legal and accounting activities
70	Activities of head offices; management consultancy activities
71	Architectural, engineering and related technical activities; technical testing and analysis
72	Scientific research and development
73	Advertising, market research and public opinion polling
74	Other consultancy, scientific and technical activities
75	Veterinary activities
77	Renting activities
78	Employment activities
79	Travel agency, tour operator, reservation service and related activities
80	Security and investigation activities
81	Services to buildings and landscape activities
82	Office administrative, office support and other business support activities
84	Public administration and defence; compulsory social security
85	Education
86	Human health activities
87	Social work activities with accommodation
88	Social work activities without accommodation
90	Creative, arts, artistic and literary activities
91	Libraries, archives, museums and other cultural activities
92	Gambling and betting activities
93	Sports activities and amusement and recreation activities
94	Activities of membership organisations
95	Repair of computers and personal and household goods
96	Other personal service activities
97	Activities of households as employers of domestic personnel
98	Undifferentiated goods- and services-producing activities of private households for own use
99	Activities of extraterritorial organisations and bodies

Source: INE – Classification of economics activities

Appendix 5 – Aggregation of Portuguese SIC Codes according to Rev.3

Table 53 - Portuguese classification of economic activities – Rev. 3 – Author's aggregation

	Portuguese Classification of economic activities REVISION 3 - NACE Rev. 3 (1/1/2008- ….)		
	SIC - Code		**Aggregation**
PRIMARY	1	Agriculture, farming of animals, hunting and related service activities	Agriculture, fishery and extractive industry
	2	Forestry and logging	
	3	Fishing and aquaculture	
	5	Mining of coal and lignite	
	6	Extraction of crude petroleum and natural gas	
	7	Mining and preparation of metal ores	
	8	Other mining and quarrying	
	9	Mining and quarrying related service activities	
SECONDARY	*10*	*Manufacture of food products*	Food, Drink and tobacco
	11	*Manufacture of beverages*	
	12	*Manufacture of tobacco products*	
	13	*Manufacture of textiles*	Textiles
	14	*Manufacture of wearing apparel*	
	15	*Manufacture of leather and related products*	
	16	*Manufacture of wood and of products of wood and cork, except furniture;*	Wood, paper and printing
	17	*Manufacture of paper and paper products*	
	18	*Printing and reproduction of recorded media*	
	19	*Manufacture of coke, refined petroleum products and fuels briquettes*	Chemicals and plastics
	20	*Manufacture of chemicals, chemical products and man-made fibres, except pharmaceutical products*	
	21	*Manufacture of basic pharmaceutical products and pharmaceutical preparations*	
	22	*Manufacture of rubber and plastic products*	
	23	*Manufacture of other non-metallic mineral products*	Non-metallic minerals
	24	*Manufacture of basic metals*	Basic metals and fabric metal products
	25	*Manufacture of fabricated metal products, except machinery and equipment*	
	26	*Manufacture of computer, communication equipment, electronic and optical products*	Electrical
	27	*Manufacture of electrical equipment*	
	28	*Manufacture of machinery and equipment n.e.c.*	
	29	*Manufacture of motor vehicles, trailers, semi-trailers and parts and accessories for motor vehicles*	Transport and other manufacturing

	Portuguese Classification of economic activities REVISION 3 - NACE Rev. 3 (1/1/2008- ….)		
	SIC - Code		**Aggregation**
	30	*Manufacture of other transport equipment*	
	31	*Manufacture of furniture*	
	32	*Other manufacturing activities*	
	33	*Repair, maintenance and installation of machinery and equipment*	
	35	Electricity, gas, steam, cold and hot water and cold air	
	36	Water collection, treatment and distribution	
	37	Collection, drainage and treatment of sewage	
	38	Waste collection, treatment and disposal activities; materials recovery	Utilities and construction
	39	Remediation and similar activities	
	41	Development of building projects; Construction of buildings	
	42	Civil engineering	
	43	Specialised construction activities	
	45	Wholesale and retail trade and repair of motor vehicles and motorcycles	
	46	Wholesale trade (include commission trade), except of motor vehicles and motorcycles	Wholesale
	47	Retail trade, except of motor vehicles and motorcycles	
	49	Land transport and transport via pipelines	
	50	Water transport	
	51	Air transport	Other Services
	52	Warehousing and support activities for transportation (include cargo handling)	
	53	Postal and courier activities	
	55	Accommodation	
	56	Food and beverage service activities	Other Services
	58	Publishing activities	
TERTIARY	59	Motion picture, video and television programme production, sound recording and music publishing activities	
	60	Radio and television activities	Communication and Services
	61	Telecommunications	
	62	Computer programming, consultancy and related activities	
	63	Information service activities	
	64	Financial service activities, except insurance and pension funding	
	65	Insurance, reinsurance and pension funding, except compulsory social security	Other Services
	66	Activities auxiliary to financial services and insurance activities	
	68	Real estate activities	
	69	Legal and accounting activities	
	70	Activities of head offices; management consultancy activities	R&D and Firm Services

Portuguese Classification of economic activities REVISION 3 - NACE Rev. 3 (1/1/2008- ….)		
SIC - Code		**Aggregation**
71	Architectural, engineering and related technical activities; technical testing and analysis	
72	Scientific research and development	
73	Advertising, market research and public opinion polling	
74	Other consultancy, scientific and technical activities	
75	Veterinary activities	Other Services
77	Renting activities	
78	Employment activities	
79	Travel agency, tour operator, reservation service and related activities	
80	Security and investigation activities	
81	Services to buildings and landscape activities	
82	Office administrative, office support and other business support activities	
84	Public administration and defence; compulsory social security	
85	Education	
86	Human health activities	
87	Social work activities with accommodation	
88	Social work activities without accommodation	
90	Creative, arts, artistic and literary activities	
91	Libraries, archives, museums and other cultural activities	
92	Gambling and betting activities	
93	Sports activities and amusement and recreation activities	
94	Activities of membership organisations	
95	Repair of computers and personal and household goods	
96	Other personal service activities	
97	Activities of households as employers of domestic personnel	
98	Undifferentiated goods- and services-producing activities of private households for own use	
99	Activities of extraterritorial organisations and bodies	

Source: Author's computation based on Portuguese SIC codes revision 3

Appendix 6 – Distribution of firms according to the technological intensity (adapted from Pavitt's taxonomy)

Table 54 – Technological intensity per SIC code

Portuguese Classification of economic activities REVISION 3 - NACE REV 3 (1/1/2008- ….) SIC - Code			**Aggregation**
1	low-tech	Agriculture, farming of animals, hunting and related service activities	Agriculture, fishery and extractive industry
2	low-tech	Forestry and logging	
3	mid-low	Fishing and aquaculture	
5	mid-low	Mining of coal and lignite	
6	mid-low	Extraction of crude petroleum and natural gas	
7	mid-low	Mining and preparation of metal ores	
8	mid-low	Other mining and quarrying	
9	mid-low	Mining and quarrying related service activities	
10	low-tech	*Manufacture of food products*	Food, Drink and tobacco
11	low-tech	*Manufacture of beverages*	
12	low-tech	*Manufacture of tobacco products*	
13	low-tech	*Manufacture of textiles*	Textiles
14	low-tech	*Manufacture of wearing apparel*	
15	low-tech	*Manufacture of leather and related products*	
16	low-tech	*Manufacture of wood and of products of wood and cork, except furniture;*	Wood, paper and printing
17	low-tech	*Manufacture of paper and paper products*	
18	*high and mid*	*Printing and reproduction of recorded media*	
19	*high and mid*	*Manufacture of coke, refined petroleum products and fuels briquettes*	Chemicals and plastics
20	*high and mid*	*Manufacture of chemicals, chemical products and man-made fibres, except pharmaceutical products*	
21	*high and mid*	*Manufacture of basic pharmaceutical products and pharmaceutical preparations*	
22	mid-low	*Manufacture of rubber and plastic products*	

Portuguese Classification of economic activities REVISION 3 - NACE REV 3 (1/1/2008- ….) SIC - Code			**Aggregation**
23	mid-low	*Manufacture of other non-metallic mineral products*	Non-metallic minerals
24	mid-low	*Manufacture of basic metals*	Basic metals and fabric metal products
25	mid-low	*Manufacture of fabricated metal products, except machinery and equipment*	
26	*high and mid*	*Manufacture of computer, communication equipment, electronic and optical products*	Electrical
27	*high and mid*	*Manufacture of electrical equipment*	
28	*high and mid*	*Manufacture of machinery and equipment n.e.c.*	
29	*high and mid*	*Manufacture of motor vehicles, trailers, semi-trailers and parts and accessories for motor vehicles*	Transport and other manufacturing
30	*high and mid*	*Manufacture of other transport equipment*	
31	mid-low	*Manufacture of furniture*	
32	mid-low	*Other manufacturing activities*	
33	mid-low	*Repair, maintenance and installation of machinery and equipment*	
35	*high and mid*	Electricity, gas, steam, cold and hot water and cold air	Utilities and construction
36	low-tech	Water collection, treatment and distribution	
37	low-tech	Collection, drainage and treatment of sewage	
38	low-tech	Waste collection, treatment and disposal activities; materials recovery	
39	low-tech	Remediation and similar activities	
41	low-tech	Development of building projects; Construction of buildings	
42	*high and mid*	Civil engineering	
43	*high and mid*	Specialised construction activities	
45	mid-low	Wholesale and retail trade and repair of motor vehicles and motorcycles	Wholesale
46	mid-low	Wholesale trade (include commission trade), except of motor vehicles and motorcycles	
47	mid-low	Retail trade, except of motor vehicles and motorcycles	
49	*high and mid*	Land transport and transport via pipelines	Other Services
50	*high and mid*	Water transport	
51	*high and mid*	Air transport	
52	*high and mid*	Warehousing and support activities for transportation (include cargo handling)	

Portuguese Classification of economic activities REVISION 3 - NACE REV 3 (1/1/2008- ….) SIC - Code			**Aggregation**
53	mid-low	Postal and courier activities	
55	low-tech	Accommodation	
56	low-tech	Food and beverage service activities	Other Services
58	mid-low	Publishing activities	
59	*high and mid*	Motion picture, video and television programme production, sound recording and music publishing activities	
60	*high and mid*	Radio and television activities	Communication and Services
61	*high and mid*	Telecommunications	
62	*high and mid*	Computer programming, consultancy and related activities	
63	*high and mid*	Information service activities	
64	*high and mid*	Financial service activities, except insurance and pension funding	
65	*high and mid*	Insurance, reinsurance and pension funding, except compulsory social security	Other Services
66	*high and mid*	Activities auxiliary to financial services and insurance activities	
68	mid-low	Real estate activities	
69	*high and mid*	Legal and accounting activities	
70	*high and mid*	Activities of head offices; management consultancy activities	
71	*high and mid*	Architectural, engineering and related technical activities; technical testing and analysis	R&D and Firm Services
72	*high and mid*	Scientific research and development	
73	*high and mid*	Advertising, market research and public opinion polling	
74	*high and mid*	Other consultancy, scientific and technical activities	
75	mid-low	Veterinary activities	
77	low-tech	Renting activities	
78	low-tech	Employment activities	
79	low-tech	Travel agency, tour operator, reservation service and related activities	
80	low-tech	Security and investigation activities	Other Services
81	low-tech	Services to buildings and landscape activities	
82	low-tech	Office administrative, office support and other business support activities	
84	mid-low	Public administration and defence; compulsory social security	
85	*high and mid*	Education	

Portuguese Classification of economic activities REVISION 3 - NACE REV 3 (1/1/2008- ….) SIC - Code			**Aggregation**
86	*high and mid*	Human health activities	
87	low-tech	Social work activities with accommodation	
88	low-tech	Social work activities without accommodation	
90	mid-low	Creative, arts, artistic and literary activities	
91	mid-low	Libraries, archives, museums and other cultural activities	
92	low-tech	Gambling and betting activities	
93	low-tech	Sports activities and amusement and recreation activities	
94	low-tech	Activities of membership organisations	
95	low-tech	Repair of computers and personal and household goods	
96	low-tech	Other personal service activities	
97	low-tech	Activities of households as employers of domestic personnel	
98	low-tech	Undifferentiated goods- and services-producing activities of private households for own use	
99	*high and mid*	Activities of extraterritorial organisations and bodies	

Source: Author's own construction adapted from Pavitt's taxonomy

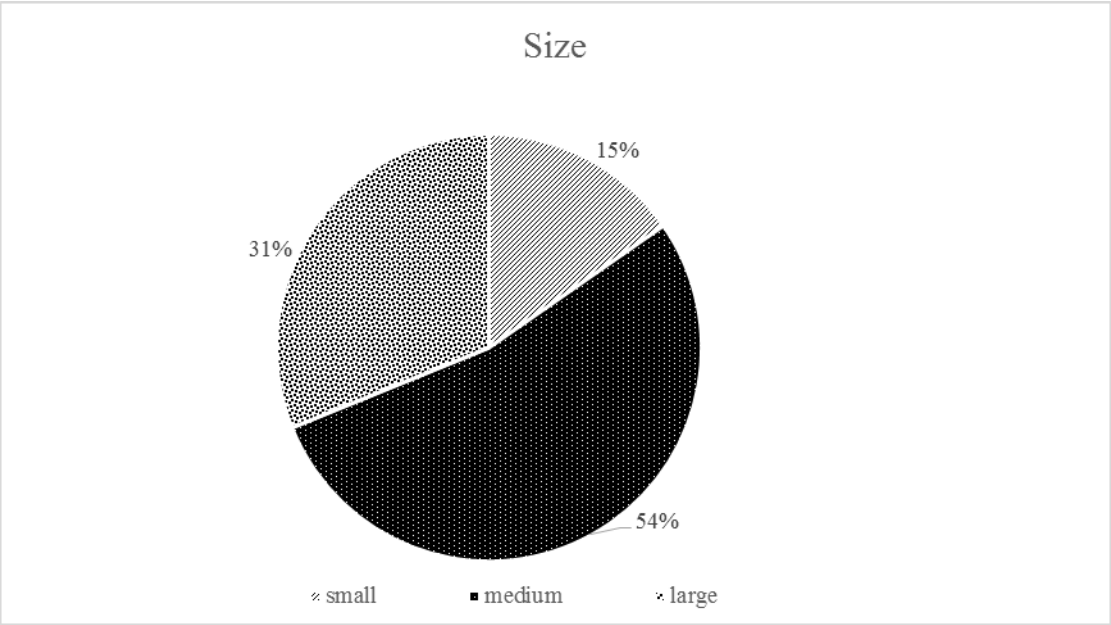
Appendix 7 – Persistent innovators (product) – structural straits

The number of firms reporting having performed product innovation over the three biennia is near to 18%. Approximately one out of five firms has performed product innovation in a continuous base, it is a poor achievement compared to other innovation vectors. Yet, to an important number of sectors, performing product innovation in a continuous base is economically irrational.

In order to seize the traits of the firms reporting continuous innovation we have constructed a descriptive analysis of their structural traits. We expect to get full understanding of potential patterns and the compare these firms to the rest of the sample.

Size

Graphic 59 – Persistent innovators per size

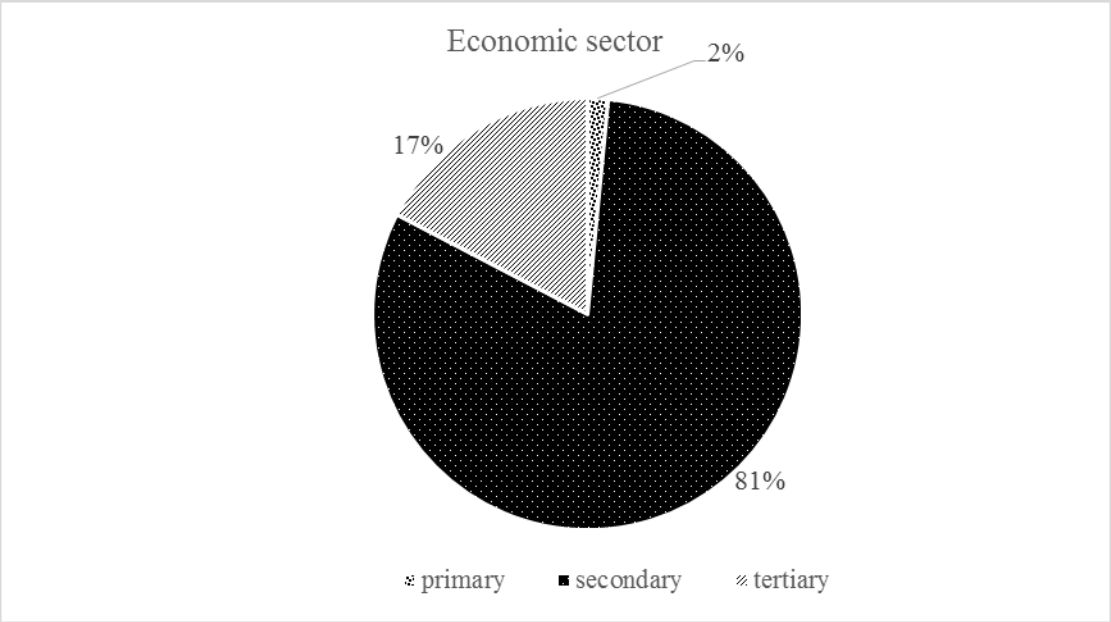


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Half of the firms performing innovation in a persistent base are medium sized, nearly one third large and one seventh small. This evidence illustrates no clear pattern concerning the size to determine the option for persistent innovation.

Economic sector

Graphic 60 – Persistent innovators per economic sector

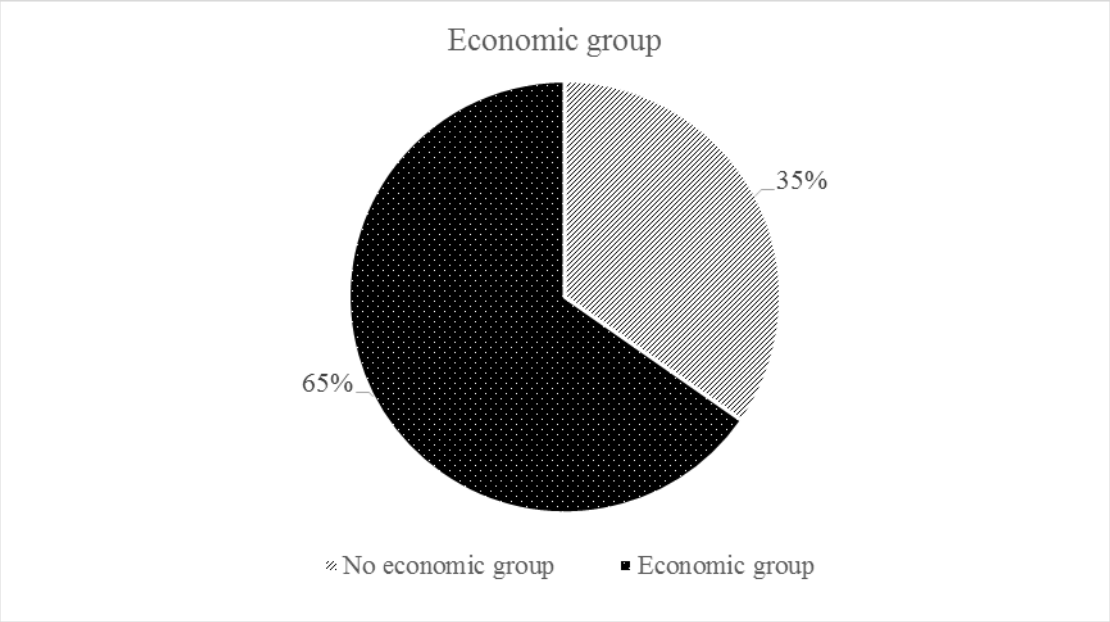


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The distribution of persistent innovators per economic sector is quite similar from the respondent sample. Most of the firms operate in the secondary sector, as expected. These results show that the CIS panel has 159 industrial firms performing product innovations with no discontinuity.

Economic group

Graphic 61 - Persistent innovators per economic group



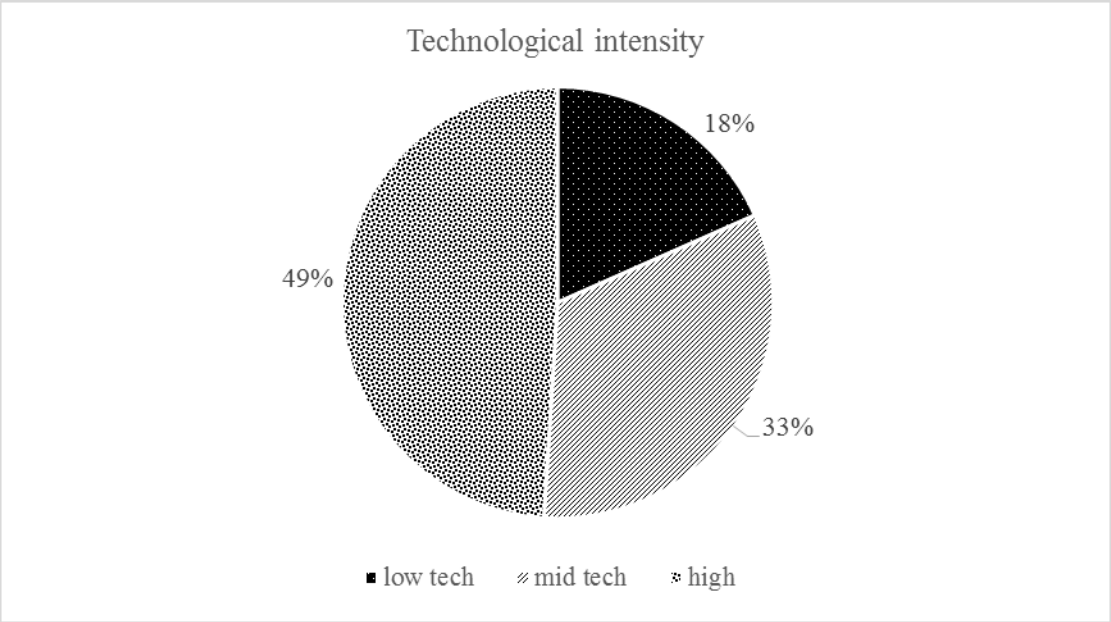
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Belonging to an economic group, according to the literature raises the innovative dynamism of the firms. Group members can diffuse the costs of innovation as well as easily spread the knowledge improvements in order to internalise innovation returns.

Concerning the persistent innovators, 65% amongst them belong to an economic group; this result goes along with the expected result.

Technological intensity

Graphic 62 - Persistent innovators per technological intensity

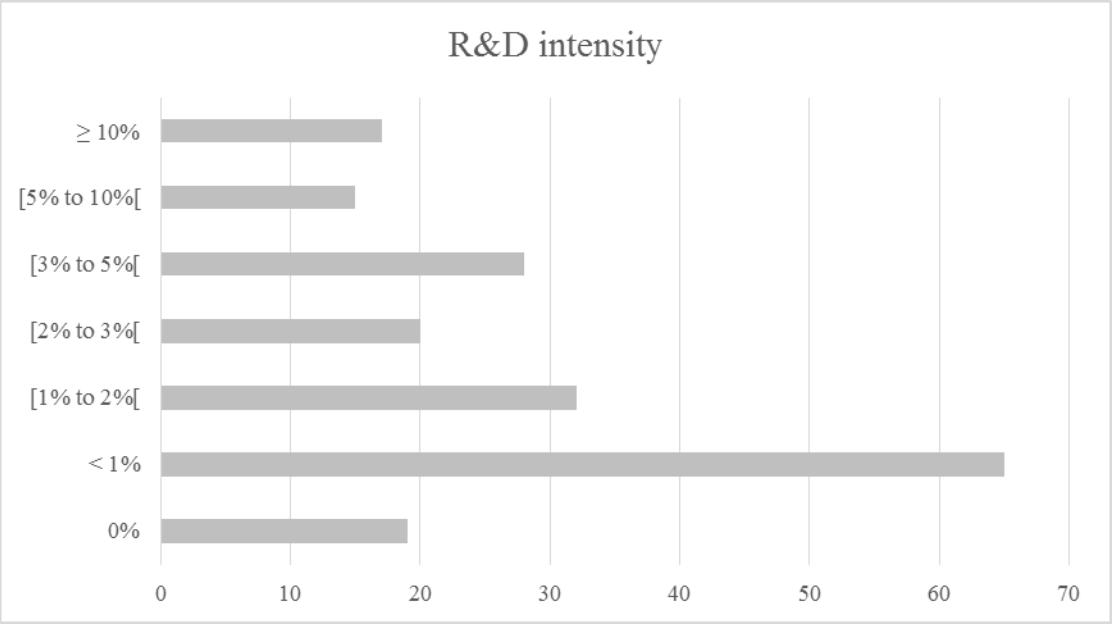


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

As expected, the higher proportion of persistent innovators belongs to a high tech activity. Low tech gathers 18% of the sub-set and mid tech, one third. These evidence reinforces the theoretical framework – high tech firms develop innovative activities in a continuous base as it is a requirement of the managerial strategy.

R&D intensity

Graphic 63 - Persistent innovators per R&D intensity



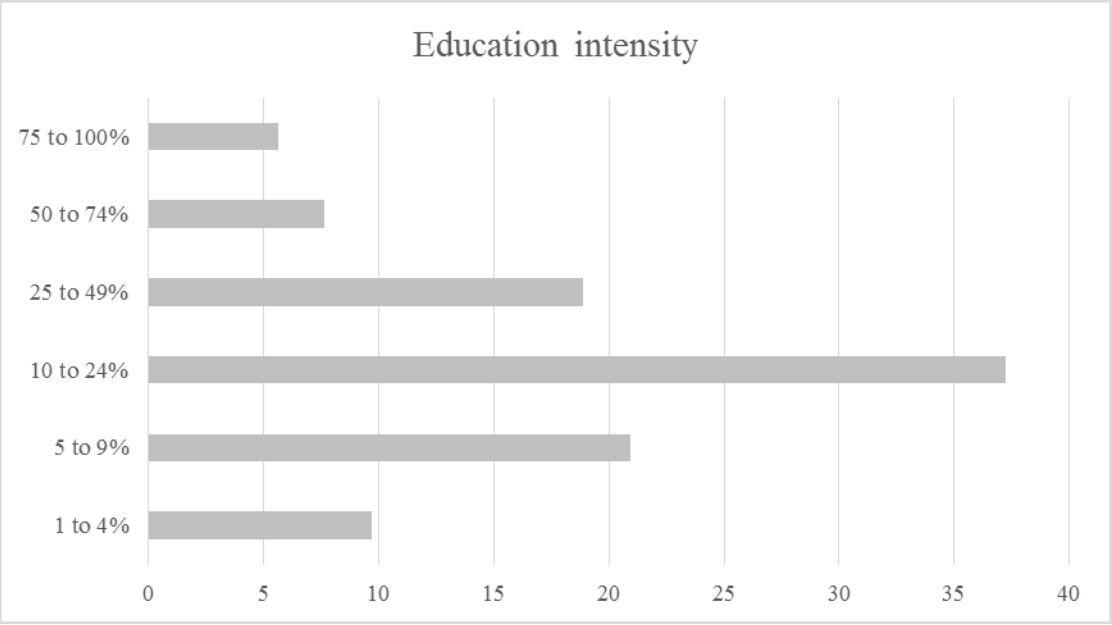
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

It is worth mentioning the change in the pattern of R&D intensity. When observing the entire sample or even the existing panel invariably a large proportion of firms report the absence of expenses in R&D; in the sub sample of persistent innovators only 19 firms have nil R&D expenses; the most frequent intensity of R&D stands on 1% (65 firms) and 30% of the persistent innovators present standards of R&D intensity above the European target of 3%.

These results reinforce the hints arising from the existing literature, persistence in innovative activities allows exploiting feedback, despite being insufficient; there must be a continuous action in this area to continue collecting the results and keep innovation in track.

Education intensity

Graphic 64 – Persistent innovators per education intensity



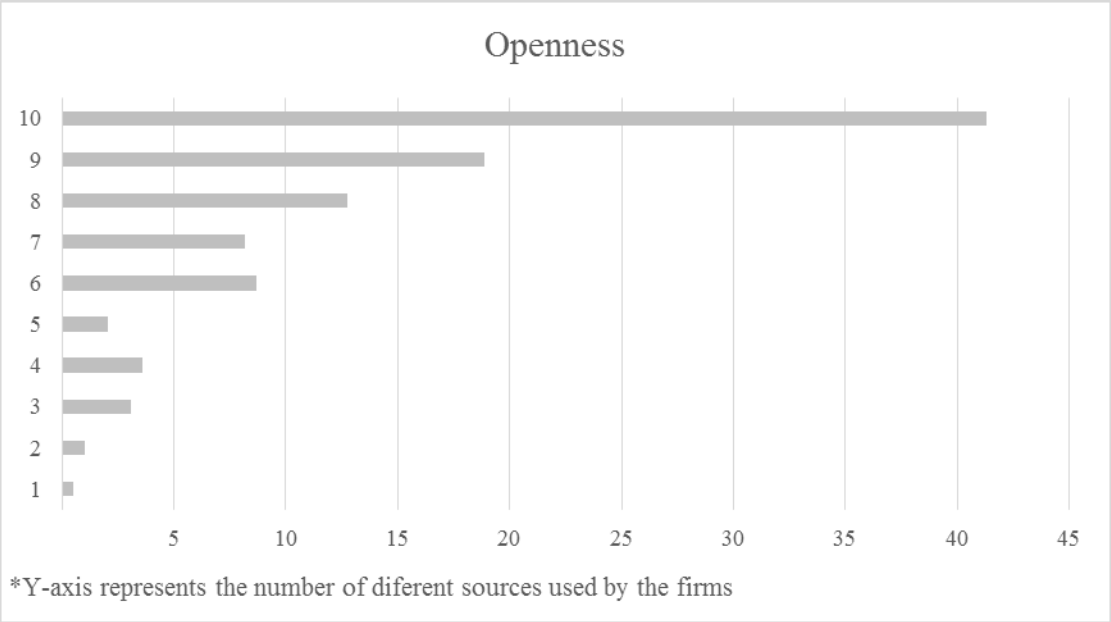
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The proportion of top educated employees compared to the total is higher in this sub-sample tan in the entire panel. Nearly one third of the firms have less than 9% of top educated amongst their staff. 37.2% of the persistent innovators have from 10% to 24% of their staff with at least undergraduate levels.

Among persistent innovators there is a higher average proportion of top educated operatives. Having a highly educated labour force secure the firm with "problem solvers", and reinforces its absorptive capacity.

Openness

Graphic 65- Persistent innovators per openness

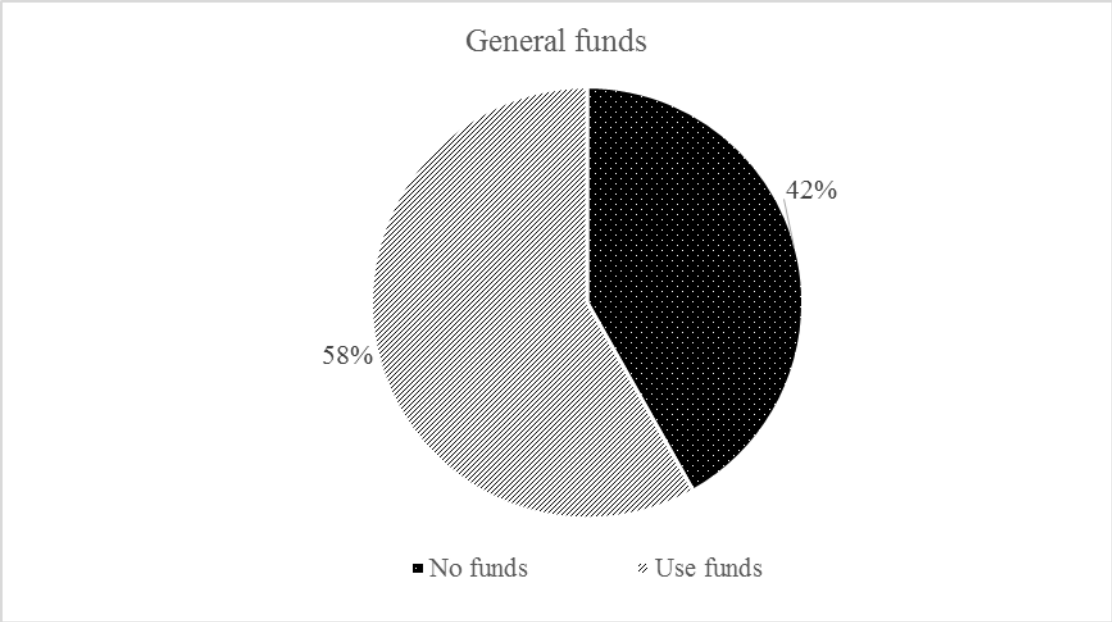


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Persistent innovators are presented as being open. The count of the number of sources reveals that most of the firms rely on six or more different sources. The fact of using different sources for their innovative activities speeds up the pace of innovation. Performing innovations in a continuous base will raise the efficiency of the activities, the establishment of networks and the enrichment of the absorptive capacity.

Funds

Graphic 66 - Persistent innovators per general funds



Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Persistent innovators have important needs in terms of finance, performing continuous innovation requires high finance, therefore, the firms demand for collaboration in terms of the institutions and financial support. Public financing leverages the innovative activities thus being an innovation booster. In the sub sample 58% of the firms referred the use of public finance. The proportion of public finance use, is far above the results of the sample.

Non-innovative (product) – structural traits

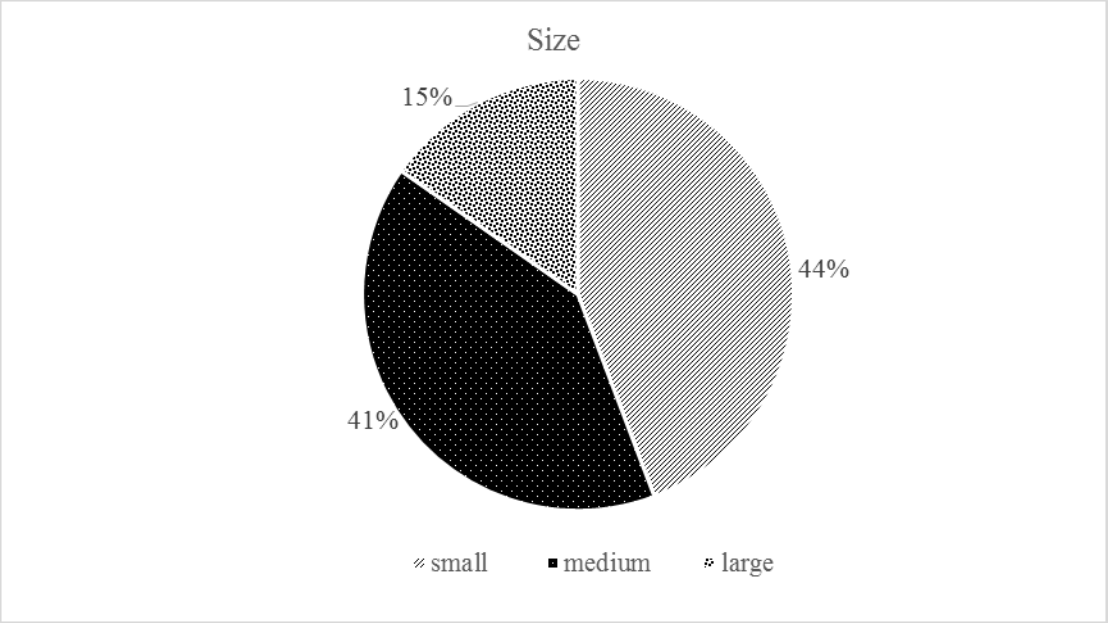
The opposite strategy of being a persistent innovator is being a non-innovator. Nearly 44% of the firms in the sub-sample referred as not performing any innovative activity in the period. Product innovation is a complex process, and in many sectors it does not take part of the managerial strategy.

Not developing product innovation is part of a strategical option, these firms may prefer behave as technology adopters or imitators.

The analysis comprises a six-year period, the option for not innovating in this time span cannot be attributed to economic volatility or any cyclical constraint, it is a persistent option for not generating any product innovation.

Size

Graphic 67 – Non-innovative firms per size

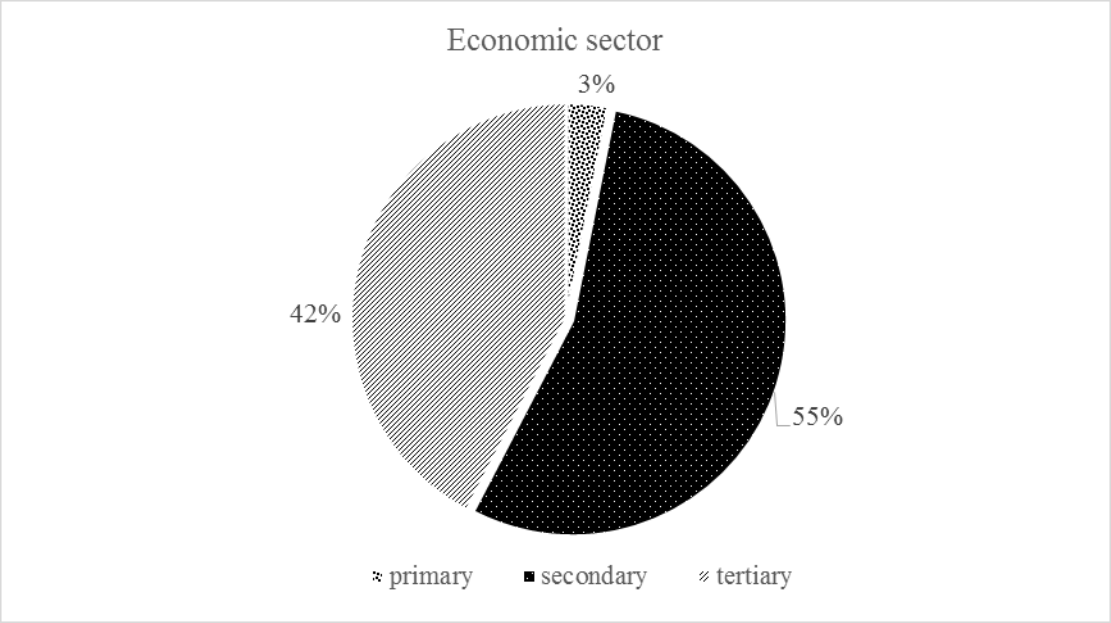


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Non innovators are distributed as follows: 44% of the firms are small, 40% are medium and 15% are large. No straight forward pattern can be designed; therefore we can state that there are not innovative firms are distributed by the different sizes without a precise pattern.

Economic sector

Graphic 68 – Non-innovative per sector

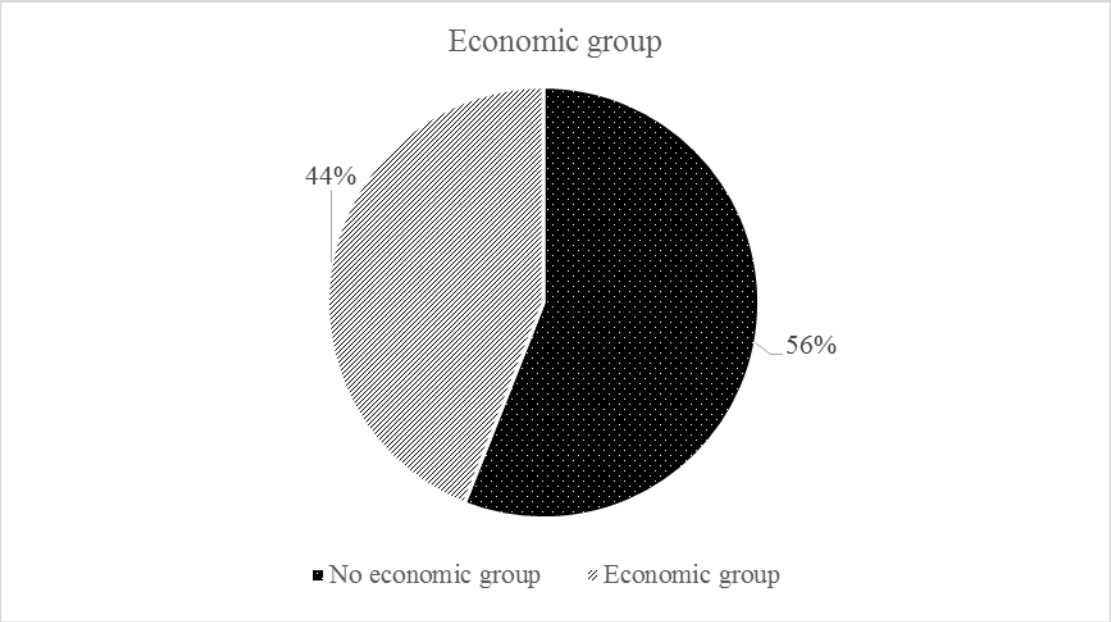


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The distribution of non-innovative firms per sector is very similar to the entire sample. Firms in the primary sector represent 3% of the total, the secondary sector represents 55% and the tertiary 42%.

Economic group

Graphic 69 – Non-innovative firms economic group

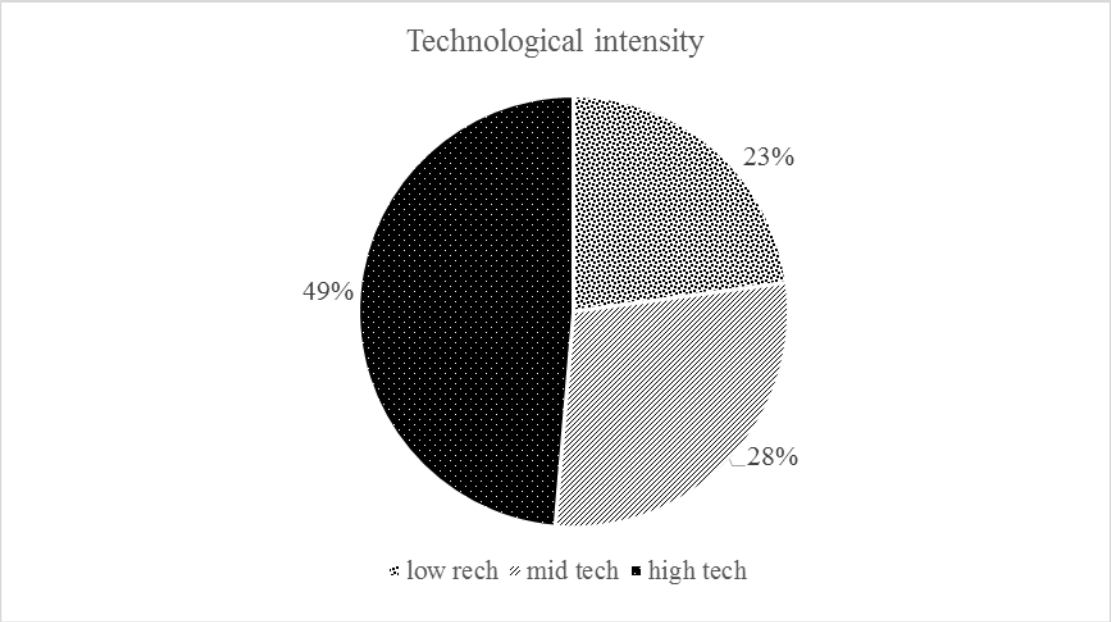


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Concerning the non-innovative, the proportion of firms not integrating an economic group is 56%. This proportion is higher than for the persistent innovators analysed in the previous point. But, there is no clear trend in terms of the connection between being part of an economic group and strategically choosing being a non- innovator.

Technological intensity

Graphic 70 – Non-innovative firms per technological intensity

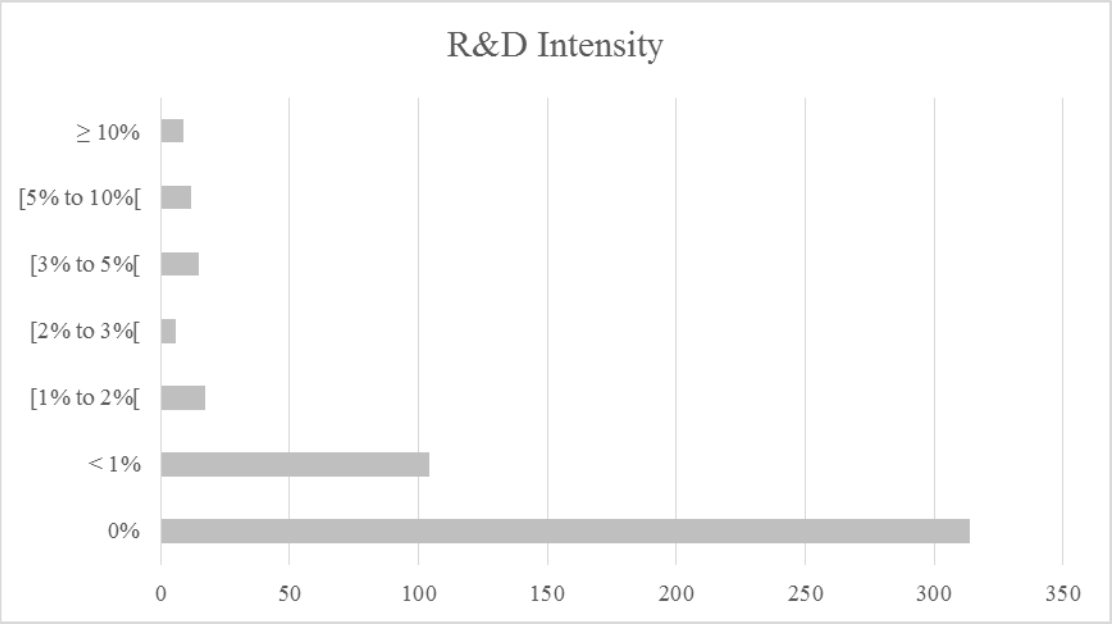


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The proportion of non-innovators belonging to a high tech sector is surprisingly high (49%). Non innovative firms in the low-tech sectors is 23% and in the mid-tech 29%. It was expectable to grasp a lower proportion of high tech firms, although these firms may absorb the product innovation arising from others.

R&D intensity

Graphic 71 - Non-innovative firms per R&D intensity



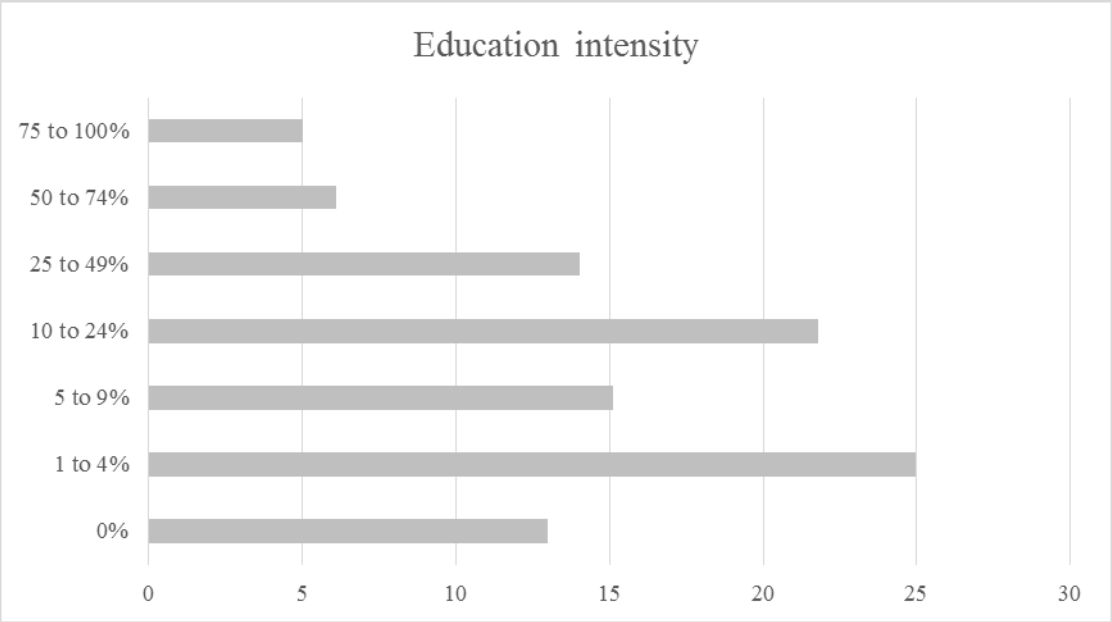
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Non-surprisingly a very important proportion of the non-innovators mention not applying any money in R&D activities, two thirds, which means 314 firms. In the next degree, 104 firms are placed; having 1% or more is mentioned by 59 firms.

Given that these firms have opted for non-innovating, is perfectly coherent that the expenses in R&D should be lower.

Education intensity

Graphic 72 – Non-innovative firms per education intensity

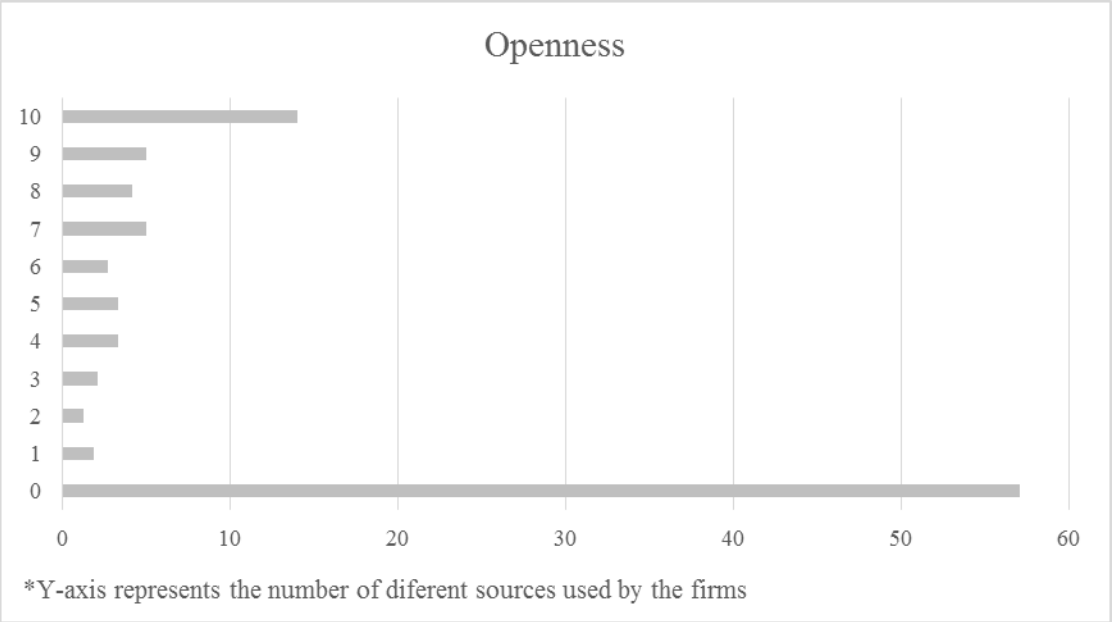


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

In terms of education intensity, the patterns of the non-innovative firms, approach the entire panel; the percentage of firms having up to 10% achieves 53% of the total. The proportion of firms with 50% or more will sum 11.1%.

Openness

Graphic 73 – Openness for the non-innovative firms

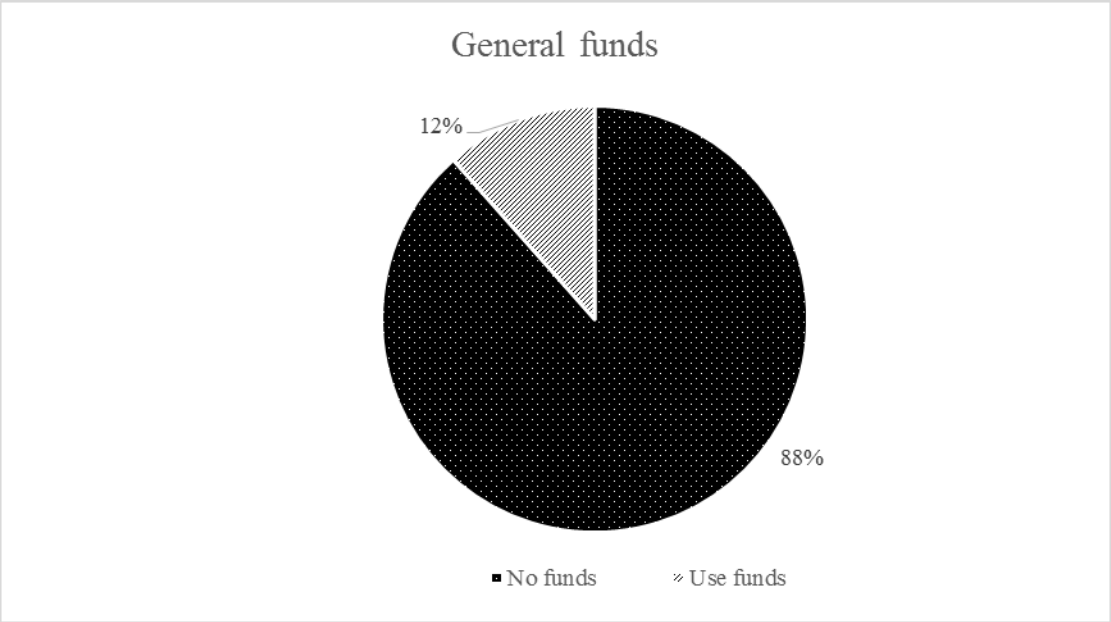


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The pattern described by the non-innovative firms in terms of relying on the sources of information for innovative activities is contrary to the persistent innovators. The total percentage of firms that did not use any source of information goes up to 57%. Unexpectedly, 14% of these non-innovative have mentioned relying on all the possible sources of innovation. Concerning the intermediate scales there is a homogeneous distribution.

Funds

Graphic 74 – Use of funds per non-innovative firms



Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

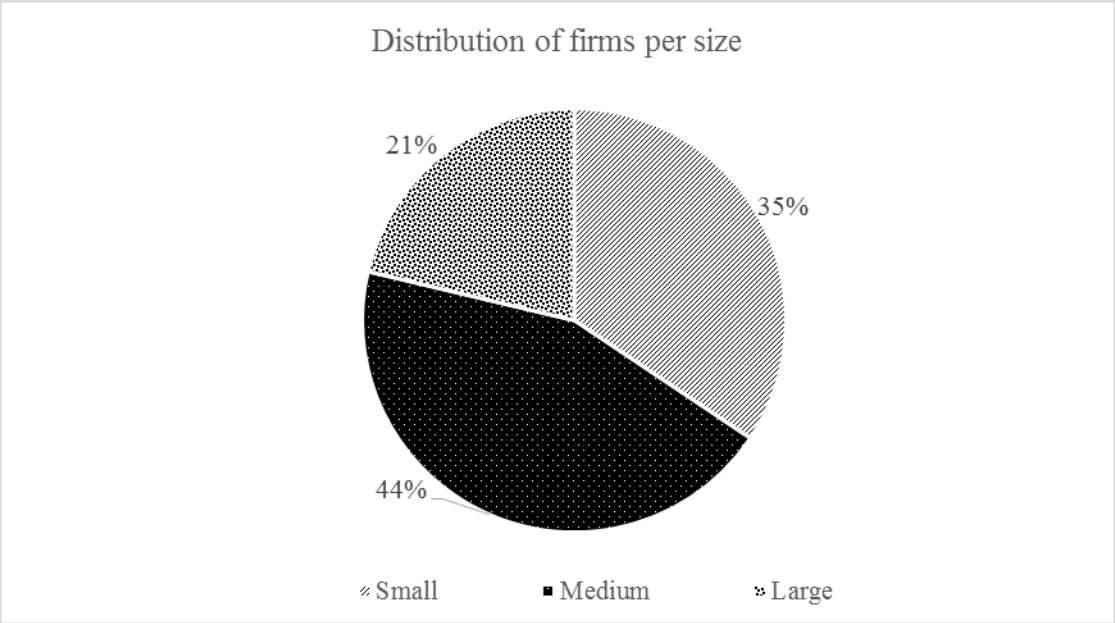
In what concerns the use of public finance to support the innovative projects, the pattern described by the non-innovators is very different from the persistent innovators. In the case, 88% of the firms mentioned not relying on public funds, which is the same to say that only 12% of the non-innovators grasped public funding.

Appendix 8 –Exploratory analysis of the panel - Structural Traits

An exploratory analysis of the constructed panel was run to understand the distribution of the respondent firms according to their structural traits. This preliminary analysis will provide relevant information about what to expect by comparing to the literature as well as an understanding of how far it is connected to the Portuguese reality.

Size

Graphic 75 - Proportion of firms in the panel per size

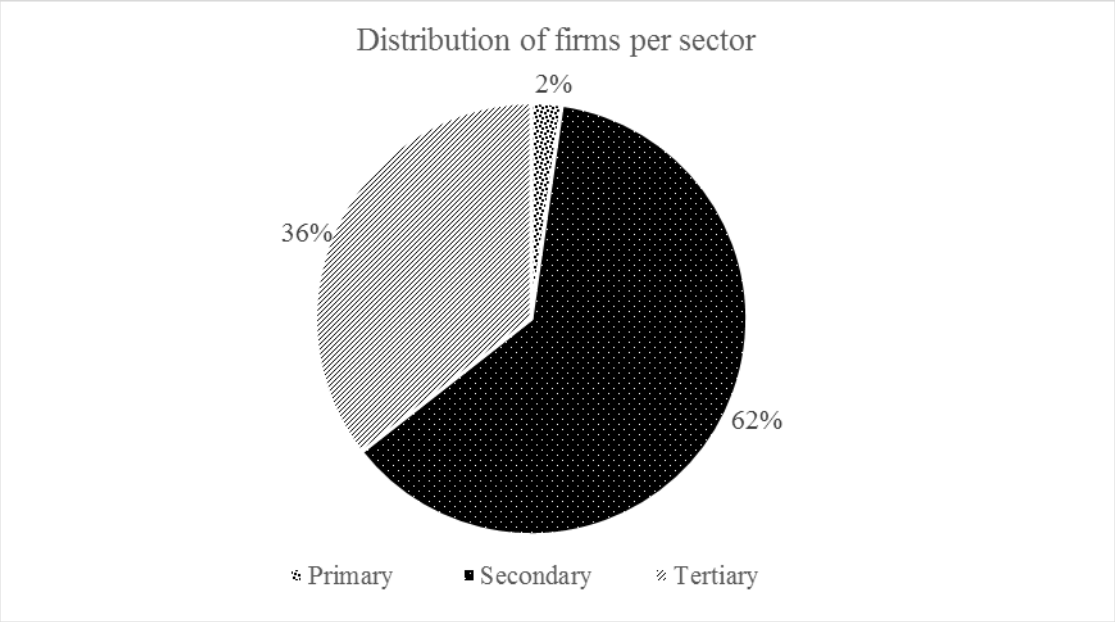


Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The panel is essentially composed by medium firms (44%), which describes an organization with more than 50 employees and less than 250. The small firms represent 35% and the large firms represent 21% of the panel. The Portuguese entrepreneurial environment is mainly composed by structures classified as SME's thus the panel will accurately reproduce the real scenario. As mentioned before, the responses of large firms are expected to be artificially high as their presence in the survey is, by constructing high.

Economic Sector

Graphic 76 - Proportion of firms in the panel per economic sector



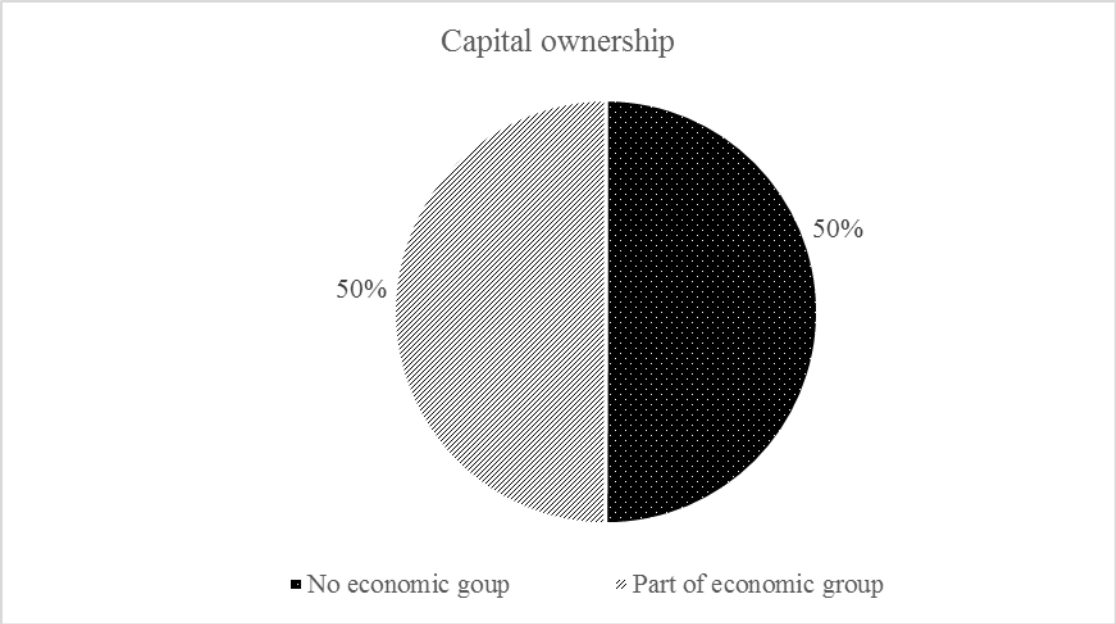
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The constructed panel comprises firms in the secondary sector in a proportion of 62%, which include all industries, manufacturing and others. The primary sector is represented by 2% of the firms in the panel, and the services achieve 36% of the total.

The presence of primary sector firms is unfortunately very low, even though nothing can be done in methodological terms to increase its representativeness.

Economic group

Graphic 77 - Proportion of firms in the panel per capital ownership



Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

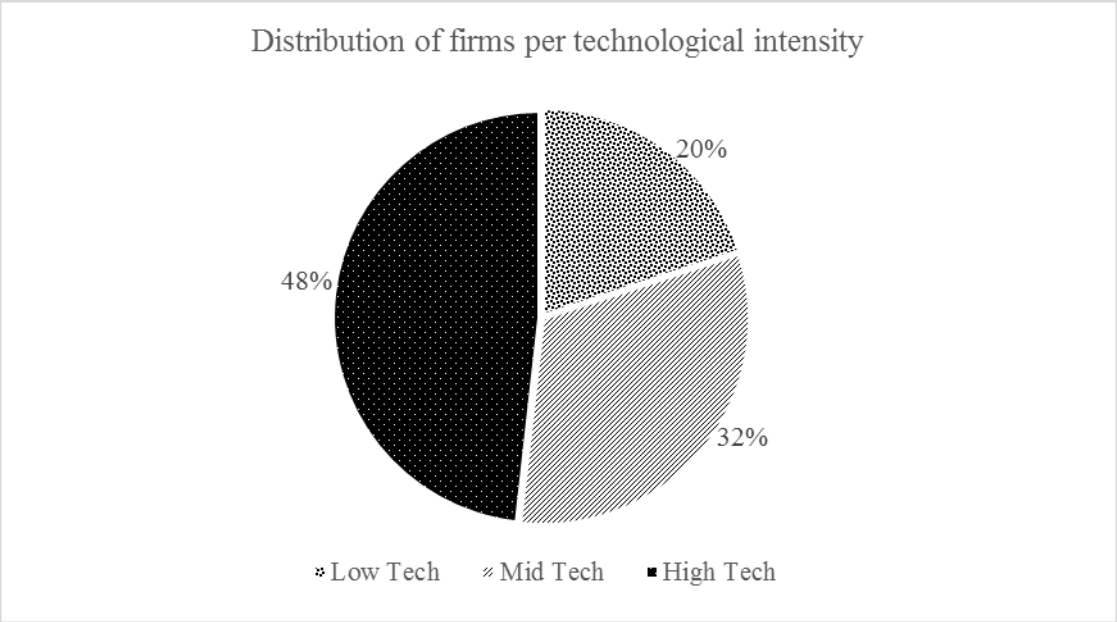
The globalised world and the highly competitive markets have pushed firms towards a merger and acquisition movement. Very often firms feel the need to integrate and for economic group to benefit from scale economies in different areas as well as the enlargement of their area if influence.

The constructed panel presents an equivalent division of firms not integrating an economic group and firms developing their activities individually.

Regarding innovation, economic groups have the diffusion advantage, consequently achieving scale economies in the division of the costs of innovation activities. Although, the centralised decision making processes may force innovative structures to redesign their priorities as well as their strategies in areas with high risk such as innovation.

Technological intensity

Graphic 78 - Proportion of firms in the panel per technological intensity



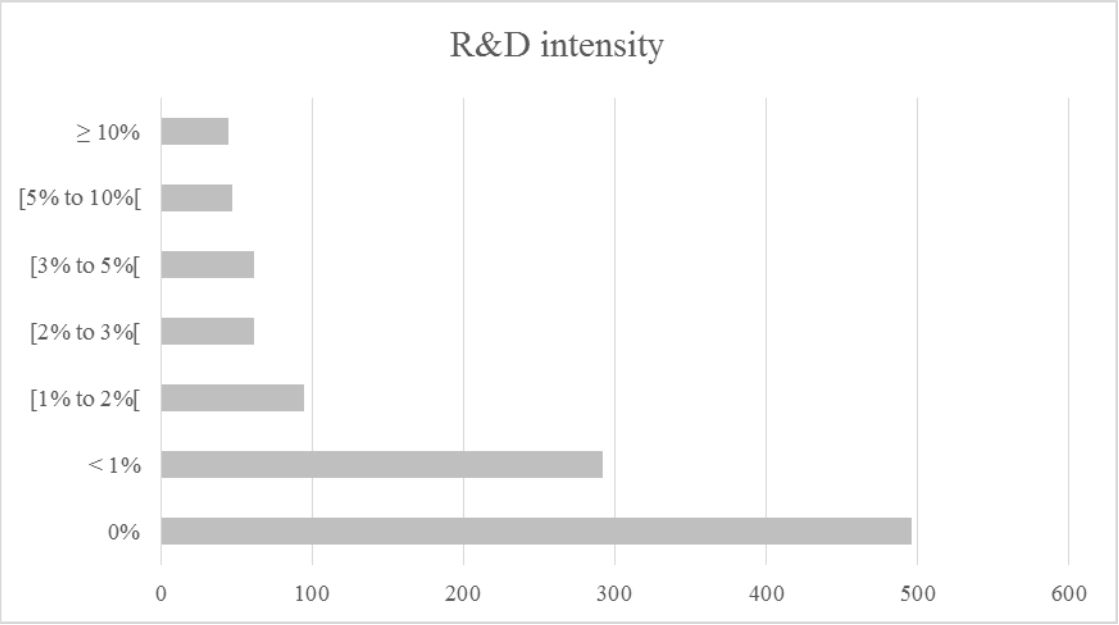
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

To classify the technological intensity of the respondent panel, an enlarged approach to the Pavitt's taxonomy (Pavitt, 1984;1987) was implemented (see appendix 6). Following this procedure, nearly half of the panel was classified as belonging to a high tech sector, one fifth to a low tech and one third to a mid tech.

Due to their inherent requirements in terms of technology, high tech firms are naturally expected to be far more innovative than others, therefore more prone to rely on the innovative sources to pursuit their projects.

R&D intensity

Graphic 79 - Proportion of firms in the panel per R&D intensity



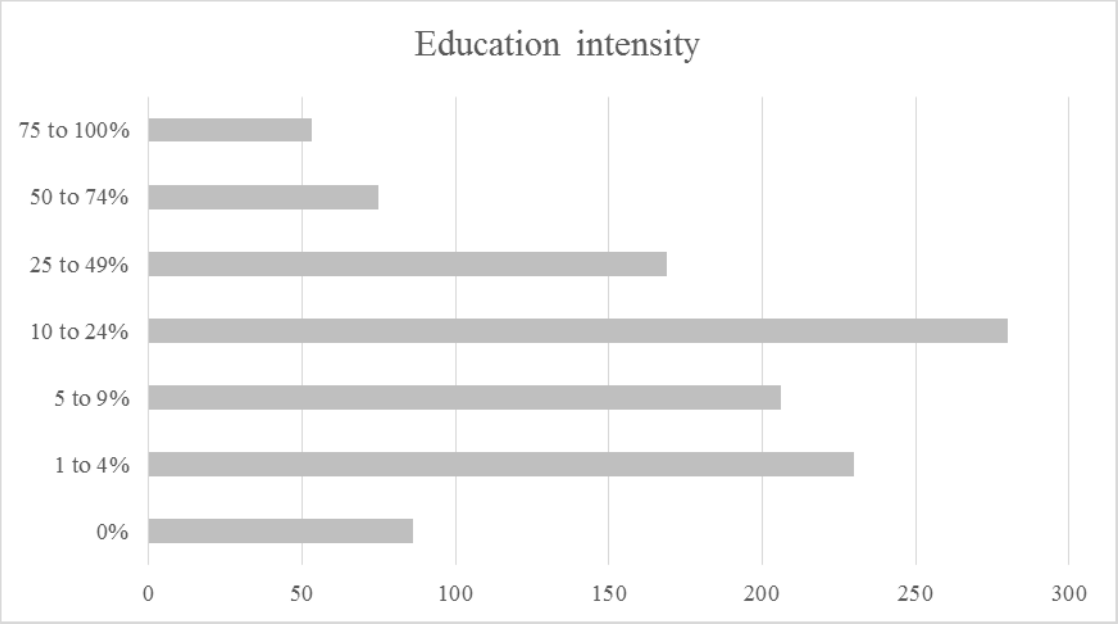
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The R&D intensity illustrates the amount of resources devoted to innovative activities compared to the total turnover. In the panel, nearly 45% of the firms reported having zero expenses in this vector. On the other hand, 154 firms report R&D intensities above the European target of 3%. With R&D intensity up to 3% of the panel includes 449 firms.

The overall picture is of heterogeneous managerial strategies. An important part of firms have outstanding achievements in this component, ranking at top levels, and a set of other firms that do not include in their daily routines the development of R&D activities in their daily routines.

Education intensity

Graphic 80 - Proportion of firms in the panel per education intensity



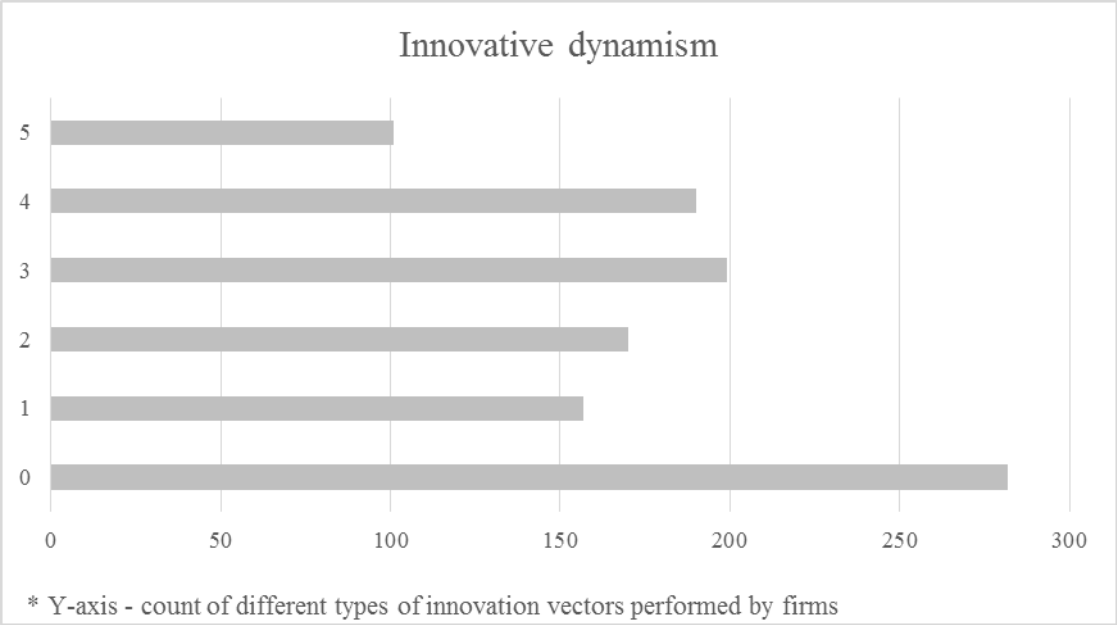
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The number of workers with undergraduates or educational titles is often used as a proxy for education intensity. Here, and following the same procedure, firms are divided into categories according to the number of highly educated workers compared to the total number of workers. Having completed higher degrees of education is expected to increase the total productivity level as well as the ability to understand, implement and create innovations.

In the panel, 86 firms have no workers with a top education profile, thus all their workforce is classified as unskilled. Conversely, 53 firms report between 75% and 100% of their workforce as being highly skilled.

Innovative Dynamism

Graphic 81 - Different types of innovation performed by firms



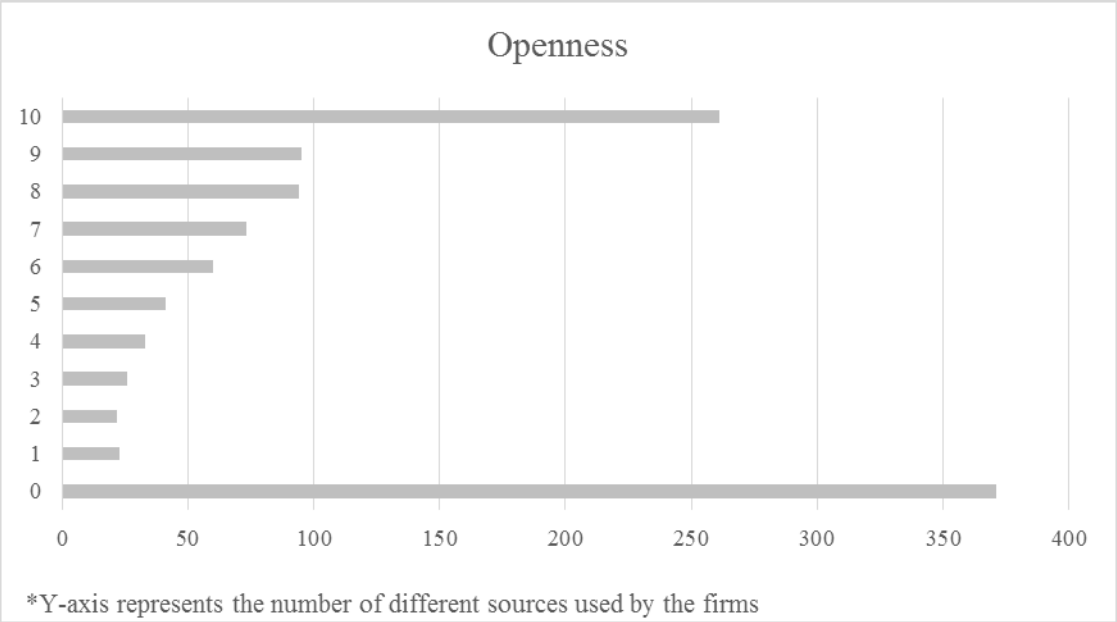
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

The CIS questionnaire asks firms about their innovative activities in different areas, such as product and service innovation, process innovation, marketing and organisational. The innovative dynamism was constructed by a count of different vectors in which firms have reported innovative activities.

One quarter of the firms in the respondent panel did mention not performing any innovative activity during the period of analysis. The proportion of firms that mentioned from one dimension to four was very similar and close to 170. It is noteworthy that almost 9% of the firms in the panel have reported innovative activities in all the mentioned vectors.

Openness

Graphic 82 - Proportion of firms in the panel per openness



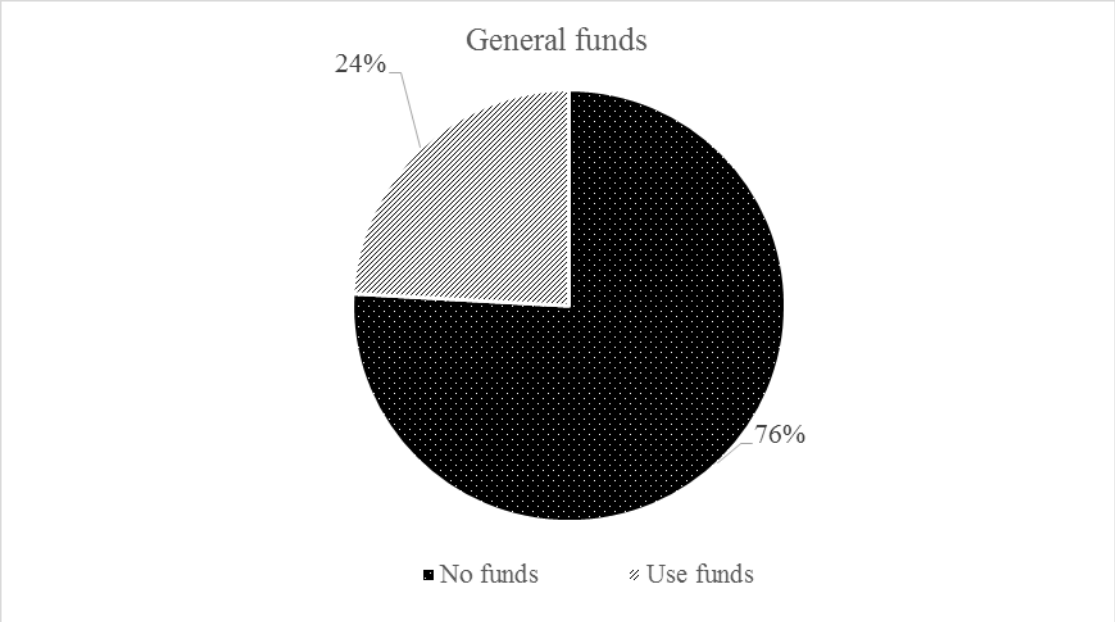
Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

To develop their innovative activities, firms naturally rely on different sources of information regardless of being internal or external, public or private. The openness is a count variable that sums the different sources mentioned by firms as being relevant sources of information they draw upon. Among the respondent panel, 371 firms reported not finding relevant any source of information. On the other hand, there is an increasing number of firms relying on an increasing number of different sources, and 261 firms have reported relying on all the sources enumerated in the survey.

The use of different sources of information will naturally increase the probability of performing innovation and open firms are expected to be more efficient in their innovative activities.

Funds

Graphic 83 - Proportion of firms in the panel per general funs



Source: Author's computation based on the panel (CIS 6, CIS 8 and CIS 10)

Innovative activities have high risk levels. Managers due to both risk aversion and weak finance tend to postpone these projects when the economic context is unfavourable.

The use of public funds will deleverage the needs of own equity of firms, raising the propensity of developing innovative projects.

In the panel, near three quarters of the firms have mentioned not relying on any type of external funds, in other words, these firms have developed theirs initiative projects with their own financial assets or by means of external finance. It is expectable that during negative phases of the business cycle firms tend to grasp finance from this source; the empirical evidence did not support this belief.

Appendix 9 – Main results

Descriptive statistics

Table 55 - Descriptive statistics of the variables in analysis

Variable	Obs	Mean	Std. Dev.	Min	Max
sic	3297	35.677	18.057	7	74
tech_intensity	3297	2.298	0.778	1	3
sector	3297	2.329	0.517	1	3
size	3297	2.868	0.748	2	4
group	3297	0.485	0.500	0	1
prod_innov	3297	0.362	0.481	0	1
serv_innov	3297	0.307	0.461	0	1
proc_production	3297	0.393	0.488	0	1
proc_logistic	3297	0.244	0.430	0	1
proc_support	3297	0.439	0.496	0	1
process_innov	3297	0.570	0.495	0	1
org_innov_procedure	3297	0.451	0.498	0	1
org_innov_responsibility	3297	0.442	0.497	0	1
org_innov_external_rel	3297	0.288	0.453	0	1
org_innov	3297	0.558	0.497	0	1
mkting_innov_package	3297	0.258	0.438	0	1
mkting_innov_promotion	3297	0.290	0.454	0	1
mkting_innov_distribuition	3297	0.159	0.365	0	1
mkt_innov_price_pol	3297	0.205	0.404	0	1
mkting_innov	3297	0.424	0.494	0	1
innov_general	3297	0.758	0.428	0	1
FUNDS_GENERAL	3297	0.189	0.392	0	1
OPENNESS	3297	4.914	4.081	0	10
RD_intensity	3297	4.533	115.682	0	6615.23
Education_intensity	3297	2.521	1.557	0	6

Source: Author's own computation based on CIS 6, 8 and 10

Estimation results: Innovation in general

Table 56 - Innovation in general: Marginal effects of dynamic probit model equation 1

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
$Inno_{t-1}$	0.025	0.026	0.96	0.335	-0.026	0.075
RD_intensity	0.013	0.006	2.12	0.034	0.001	0.025
Mid_tech	0.014	0.019	0.74	0.457	-0.023	0.051
High_tech	-0.025	0.021	-1.2	0.229	-0.065	0.016
Balance	0.033	0.059	0.56	0.577	-0.083	0.150
Education_intensity	0.012	0.010	1.15	0.250	-0.008	0.031
Openness	0.056	0.004	14.19	0.000	0.048	0.064
Funds	-0.036	0.040	-0.91	0.362	-0.114	0.042
Medium_size	-0.013	0.014	-0.94	0.349	-0.041	0.015
Large_size	0.035	0.022	1.62	0.105	-0.007	0.078
group	0.003	0.016	0.22	0.825	-0.027	0.034
$Inno_0$	0.066	0.021	3.09	0.002	0.024	0.108
mean_rd_intensity	0.001	0.001	0.69	0.488	-0.001	0.002
mean_education_intensity	-0.008	0.011	-0.66	0.508	-0.030	0.015
mean_openness	4.432×10^{-4}	0.005	0.09	0.930	-0.009	0.010
Industry	0.009	0.036	0.24	0.812	-0.062	0.079
Services	0.025	0.038	0.67	0.500	-0.049	0.100

Obs.: 2198 Number of groups: 1099.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{17} = 160.63$ (p-value < 0.001).

Table 57 – Innovation in general: Marginal effects of dynamic probit model equation 2

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
P_innov_geral_lag1	0.001	0.012	0.12	0.907	-0.021	0.024
E_innov_geral_lag1	-0.035	0.018	-1.91	0.057	-0.071	0.001
N_innov_geral_lag1	0.102	0.017	6.01	0.000	0.069	0.136
RD_intensity	-6.94×10^{-5}	1.861×10^{-4}	-0.37	0.709	-4.343×10^{-4}	2.954×10^{-4}
Mid_tech	0.014	0.013	1.11	0.267	-0.011	0.040
High_tech	-0.006	0.014	-0.46	0.643	-0.034	0.021
Balance	0.049	0.049	0.99	0.323	-0.048	0.146
Education_intensity	0.001	0.008	0.14	0.888	-0.015	0.017
Openness	0.049	0.004	13.71	0.000	0.042	0.056
Funds	-0.019	0.032	-0.59	0.554	-0.081	0.043
Medium_size	-0.009	0.010	-0.95	0.343	-0.029	0.010
Large_size	0.031	0.014	2.16	0.030	0.003	0.059
group	-0.008	0.011	-0.73	0.467	-0.029	0.014
$Inno_0$	0.190	0.010	19.49	0.000	0.171	0.209
mean_rd_intensity	2.446×10^{-4}	0.001	0.43	0.669	-0.001	0.001
mean_education_intensity	0.003	0.009	0.35	0.727	-0.014	0.020
mean_openness	-0.003	0.003	-0.91	0.365	-0.008	0.003
Industry	-0.001	0.026	-0.04	0.967	-0.052	0.049
Services	0.002	0.027	0.09	0.930	-0.050	0.054

Obs.: 3296 Number of groups: 1098.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{19} = 750.14$ (p-value < 0.001).

Estimation results: Product innovation

Table 58 – Product innovation: Marginal effects of dynamic probit model equation 1

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
$Inno_{t-1}$	0.025	0.034	0.74	0.457	-0.041	0.092
RD_intensity	0.002	0.001	1.38	0.167	-0.001	0.005
Mid_tech	0.173	0.029	6.07	0.000	0.117	0.229
High_tech	0.070	0.029	2.41	0.016	0.013	0.128
Balance	0.065	0.024	2.67	0.008	0.017	0.113
Education_intensity	-0.007	0.016	-0.48	0.631	-0.038	0.023
Openness	0.043	0.003	13.42	0.000	0.037	0.049
Funds	0.036	0.023	1.55	0.122	-0.010	0.082
Medium_size	-0.004	0.024	-0.17	0.865	-0.050	0.042
Large_size	0.012	0.030	0.41	0.682	-0.046	0.071
group	-0.008	0.023	-0.35	0.725	-0.053	0.037
$Inno_0$	0.191	0.031	6.08	0.000	0.130	0.253
mean_rd_intensity	-2.73×10^{-4}	0.001	-0.21	0.830	-0.003	0.002
mean_education_intensity	-0.004	0.017	-0.23	0.816	-0.038	0.030
mean_openness	0.011	0.006	1.94	0.053	-1.392×10^{-4}	0.022
Industry	0.117	0.051	2.28	0.023	0.017	0.218
Services	-0.002	0.055	-0.04	0.964	-0.110	0.105

Obs.: 2198 Number of groups: 1099.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{17} = 273.40$ (p-value < 0.001).

Table 59 –Product innovation: Marginal effects of dynamic probit model equation 2

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
P_innov_geral_lag1	-0.050	0.017	-3	0.003	-0.083	-0.017
E_innov_geral_lag1	-0.172	0.019	-9.23	0.000	-0.209	-0.136
N_innov_geral_lag1	0.112	0.018	6.37	0.000	0.078	0.147
RD_intensity	1.59×10^{-5}	3.9×10^{-5}	0.41	0.684	0.000	0.000
Mid_tech	0.108	0.017	6.47	0.000	0.075	0.141
High_tech	0.044	0.017	2.52	0.012	0.010	0.078
Balance	0.029	0.015	1.93	0.054	-0.001	0.059
Education_intensity	-0.002	0.011	-0.14	0.885	-0.023	0.020
Openness	0.037	0.002	16.93	0.000	0.033	0.041
Funds	0.037	0.016	2.38	0.017	0.007	0.068
Medium_size	-0.007	0.014	-0.5	0.617	-0.035	0.021
Large_size	-0.001	0.018	-0.04	0.967	-0.037	0.035
group	-0.007	0.014	-0.55	0.585	-0.034	0.019
$Inno_0$	0.358	0.009	39.25	0.000	0.340	0.376
mean_rd_intensity	-8.47×10^{-5}	1.115×10^{-4}	-0.76	0.447	-3.032×10^{-4}	1.338×10^{-4}
mean_education_intensity	-0.003	0.012	-0.25	0.802	-0.027	0.021
mean_openness	-0.005	0.003	-1.59	0.113	-0.011	0.001
Industry	0.061	0.032	1.88	0.060	-0.003	0.124
Services	-0.012	0.034	-0.34	0.733	-0.079	0.055

Obs.: 3296 Number of groups: 1098.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{19} = 1202.76$ (p-value < 0.001).

Estimation results: Service innovation

Table 60 – Service innovation: Marginal effects of dynamic probit model equation 1

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
$Inno_{t-1}$	0.076	0.040	1.87	0.062	-0.004	0.155
RD_intensity	0.001	0.001	0.89	0.375	-0.001	0.003
Mid_tech	0.038	0.031	1.23	0.22	-0.023	0.098
High_tech	0.064	0.030	2.17	0.030	0.006	0.122
Balance	0.121	0.022	5.51	0.000	0.078	0.164
Education_intensity	-0.031	0.016	-1.94	0.053	-0.062	3.62×10^{-4}
Openness	0.046	0.004	13.22	0.000	0.039	0.053
Funds	0.009	0.023	0.38	0.703	-0.037	0.054
Medium_size	-0.047	0.023	-2.03	0.042	-0.092	-0.002
Large_size	-0.028	0.028	-0.99	0.323	-0.082	0.027
group	-0.008	0.021	-0.39	0.698	-0.049	0.033
$Inno_0$	0.115	0.035	3.27	0.001	0.046	0.185
mean_rd_intensity	-1.788×10^{-4}	7.27×10^{-5}	-2.46	0.014	-3.212×10^{-4}	-3.63×10^{-5}
mean_education_intensity	0.036	0.018	2.01	0.044	0.001	0.071
mean_openness	-0.009	0.006	-1.48	0.138	-0.020	0.003
Industry	0.060	0.099	0.6	0.547	-0.134	0.253
Services	0.233	0.100	2.34	0.019	0.038	0.429

Obs.: 2198 Number of groups: 1099.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{17} = 301.12$ (p-value < 0.001).

Table 61 - Service innovation: Marginal effects of dynamic probit model equation 2

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
P_innov_geral_lag1	-0.061	0.019	-3.29	0.001	-0.098	-0.025
E_innov_geral_lag1	-0.176	0.020	-8.81	0.000	-0.215	-0.137
N_innov_geral_lag1	0.116	0.020	5.74	0.000	0.077	0.156
RD_intensity	-1.13×10^{-5}	2.19×10^{-5}	-0.52	0.606	-5.41×10^{-5}	3.16×10^{-5}
Mid_tech	0.019	0.019	1.04	0.300	-0.017	0.056
High_tech	0.040	0.018	2.25	0.025	0.005	0.075
Balance	0.073	0.015	4.93	0.000	0.044	0.102
Education_intensity	-0.006	0.011	-0.52	0.602	-0.028	0.016
Openness	0.039	0.002	16.57	0.000	0.034	0.044
Funds	0.006	0.015	0.4	0.686	-0.024	0.037
Medium_size	-0.033	0.014	-2.28	0.023	-0.061	-0.005
Large_size	-0.030	0.017	-1.72	0.086	-0.064	0.004
group	-0.001	0.013	-0.05	0.962	-0.026	0.025
$Inno_0$	0.337	0.009	35.87	0.000	0.319	0.356
mean_rd_intensity	-1.016×10^{-4}	5.61×10^{-5}	-1.81	0.07	-2.115×10^{-4}	8.29×10^{-6}
mean_education_intensity	0.009	0.012	0.73	0.468	-0.015	0.033
mean_openness	-0.014	0.003	-4.32	0.000	-0.021	-0.008
Industry	0.032	0.057	0.55	0.579	-0.081	0.144
Services	0.140	0.058	2.43	0.015	0.027	0.253

Obs.: 3296 Number of groups: 1098.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{19} = 1071.10$ (p-value < 0.001).

Estimation results: Process innovation

Table 62 – Process innovation: Marginal effects of dynamic probit model equation 1

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
$Inno_{t-1}$	0.057	0.026	2.18	0.029	0.006	0.108
RD_intensity	0.004	0.003	1.53	0.126	-0.001	0.010
Mid_tech	-0.006	0.021	-0.31	0.754	-0.047	0.034
High_tech	-0.002	0.022	-0.09	0.928	-0.045	0.041
Balance	0.083	0.028	3.02	0.003	0.029	0.137
Education_intensity	0.007	0.012	0.61	0.545	-0.016	0.030
Openness	0.054	0.003	18.04	0.000	0.048	0.060
Funds	0.061	0.024	2.53	0.012	0.014	0.109
Medium_size	0.026	0.017	1.53	0.125	-0.007	0.059
Large_size	0.066	0.022	2.99	0.003	0.023	0.109
group	-0.002	0.018	-0.11	0.912	-0.036	0.032
$Inno_0$	0.054	0.022	2.49	0.013	0.012	0.097
mean_rd_intensity	1.93×10^{-4}	5.69×10^{-5}	3.39	0.001	8.15×10^{-5}	3.045×10^{-4}
mean_education_intensity	-0.017	0.013	-1.29	0.198	-0.044	0.009
mean_openness	-0.011	0.005	-2.09	0.037	-0.021	-0.001
Industry	0.034	0.048	0.72	0.473	-0.060	0.128
Services	0.001	0.050	0.02	0.985	-0.097	0.098

Obs.: 2198 Number of groups: 1099.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{17} = 344.24$ (p-value < 0.001).

Table 63 – Process innovation: Marginal effects of dynamic probit model equation 2

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
P_innov_geral_lag1	-0.051	0.015	-3.45	0.001	-0.080	-0.022
E_innov_geral_lag1	-0.121	0.018	-6.81	0.000	-0.156	-0.086
N_innov_geral_lag1	0.090	0.017	5.17	0.000	0.056	0.124
RD_intensity	0.001	0.001	1.06	0.290	-0.001	0.002
Mid_tech	-0.006	0.015	-0.4	0.687	-0.036	0.024
High_tech	-0.002	0.016	-0.11	0.909	-0.033	0.029
Balance	0.067	0.018	3.68	0.000	0.031	0.102
Education_intensity	0.007	0.009	0.71	0.477	-0.012	0.025
Openness	0.052	0.002	26.94	0.000	0.048	0.056
Funds	0.048	0.019	2.57	0.01	0.011	0.084
Medium_size	0.016	0.012	1.27	0.203	-0.009	0.040
Large_size	0.038	0.016	2.37	0.018	0.006	0.069
group	-0.003	0.013	-0.2	0.844	-0.028	0.022
$Inno_0$	0.268	0.011	24.84	0.000	0.247	0.289
mean_rd_intensity	0.000	5.38×10^{-5}	2.24	0.025	0.000	0.000
mean_education_intensity	-0.013	0.010	-1.26	0.206	-0.033	0.007
mean_openness	-0.020	0.003	-6.66	0.000	-0.026	-0.014
Industry	0.024	0.035	0.69	0.487	-0.044	0.092
Services	-0.001	0.036	-0.02	0.983	-0.070	0.069

Obs.: 3296 Number of groups: 1098.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{19} = 1365.99$ (p-value < 0.001).

Estimation results: Organisational innovation

Table 64 – Organisational innovation: Marginal effects of dynamic probit model equation 1

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
$Inno_{t-1}$	0.030	0.039	0.78	0.435	-0.046	0.106
RD_intensity	0.004	0.002	2.16	0.031	3.863×10^{-4}	0.008
Mid_tech	0.060	0.031	1.94	0.052	-0.001	0.120
High_tech	0.038	0.030	1.26	0.209	-0.021	0.097
Balance	0.142	0.031	4.61	0.000	0.082	0.202
Education_intensity	0.003	0.017	0.2	0.842	-0.030	0.037
Openness	0.039	0.004	10.99	0.000	0.032	0.046
Funds	-0.002	0.027	-0.08	0.934	-0.055	0.051
Medium_size	-0.014	0.024	-0.55	0.58	-0.061	0.034
Large_size	0.015	0.031	0.48	0.631	-0.045	0.075
group	-0.002	0.023	-0.09	0.928	-0.047	0.042
$Inno_0$	0.153	0.034	4.51	0.000	0.086	0.219
mean_rd_intensity	3.842×10^{-4}	2.829×10^{-4}	1.36	0.174	-1.703×10^{-4}	0.001
mean_education_intensity	0.012	0.019	0.63	0.529	-0.025	0.049
mean_openness	0.008	0.006	1.34	0.182	-0.004	0.020
Industry	0.000	0.070	0	1.000	-0.138	0.138
Services	0.043	0.072	0.59	0.553	-0.098	0.184

Obs.: 2198 Number of groups: 1099.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{17} = 349.43$ (p-value < 0.001).

Table 65 - Organisational innovation: Marginal effects of dynamic probit model equation 2

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
P_innov_geral_lag1	0.011	0.018	0.64	0.522	-0.023	0.046
E_innov_geral_lag1	-0.123	0.019	-6.57	0.000	-0.159	-0.086
N_innov_geral_lag1	0.167	0.022	7.61	0.000	0.124	0.209
RD_intensity	0.001	0.001	1.16	0.247	-0.001	0.003
Mid_tech	0.037	0.018	1.99	0.047	4.863×10^{-4}	0.073
High_tech	0.030	0.018	1.67	0.095	-0.005	0.066
Balance	0.111	0.021	5.25	0.000	0.069	0.152
Education_intensity	-0.009	0.012	-0.75	0.452	-0.033	0.015
Openness	0.030	0.003	11.71	0.000	0.025	0.035
Funds	-0.019	0.020	-1	0.319	-0.058	0.019
Medium_size	-0.012	0.015	-0.82	0.414	-0.042	0.017
Large_size	0.007	0.019	0.39	0.696	-0.029	0.044
group	-0.011	0.014	-0.78	0.435	-0.039	0.017
$Inno_0$	0.359	0.011	34	0.000	0.338	0.380
mean_rd_intensity	2.123×10^{-4}	1.362×10^{-4}	1.56	0.119	-5.460×10^{-5}	4.791×10^{-4}
mean_education_intensity	0.021	0.013	1.56	0.119	-0.005	0.047
mean_openness	-0.002	0.003	-0.56	0.576	-0.009	0.005
Industry	-0.010	0.040	-0.25	0.800	-0.089	0.069
Services	0.008	0.041	0.2	0.843	-0.073	0.089

Obs.: 3296 Number of groups: 1098.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{19} = 1187.57$ (p-value < 0.001).

Estimation results: Marketing innovation

Table 66 – Marketing innovation: Marginal effects of dynamic probit model equation 1

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
$Inno_{t-1}$	0.125	0.041	3.03	0.002	0.044	0.206
RD_intensity	0.002	0.002	1.26	0.209	-0.001	0.005
Mid_tech	-0.030	0.030	-1.01	0.311	-0.088	0.028
High_tech	-0.109	0.030	-3.65	0.000	-0.167	-0.050
Balance	0.130	0.027	4.73	0.000	0.076	0.184
Education_intensity	-0.007	0.016	-0.47	0.64	-0.039	0.024
Openness	0.034	0.004	9.34	0.000	0.027	0.041
Funds	0.022	0.026	0.84	0.404	-0.029	0.072
Medium_size	-0.067	0.024	-2.79	0.005	-0.113	-0.020
Large_size	-0.045	0.030	-1.5	0.133	-0.104	0.014
group	-0.038	0.022	-1.74	0.082	-0.081	0.005
$Inno_0$	0.157	0.038	4.14	0.000	0.083	0.232
mean_rd_intensity	-0.005	0.003	-1.93	0.054	-0.010	8.450×10^{-5}
mean_education_intensity	0.025	0.018	1.4	0.163	-0.010	0.061
mean_openness	0.005	0.006	0.89	0.372	-0.006	0.017
Industry	-0.043	0.067	-0.64	0.521	-0.174	0.088
Services	0.079	0.069	1.16	0.248	-0.055	0.214

Obs.: 2198 Number of groups: 1099.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{17} = 386.67$ (p-value < 0.001).

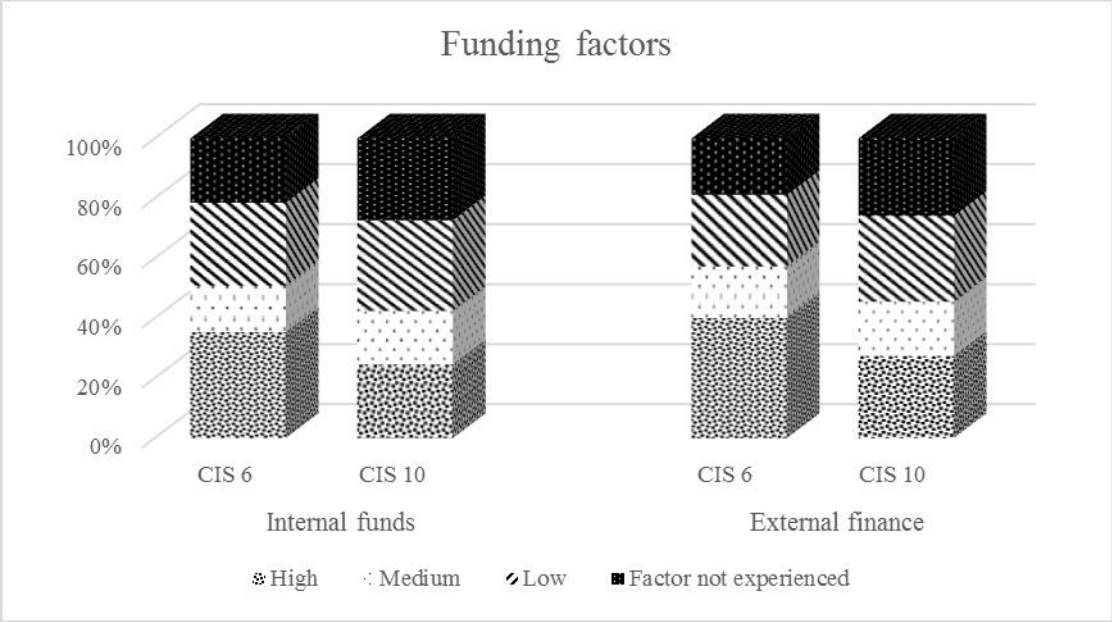
Table 67 – Marketing innovation: Marginal effects of dynamic probit model equation 2

	dy/dx	Delta-method Std. Err.	z	P > |z|	[95% Conf. Interval]	
P_innov_geral_lag1	-0.037	0.017	-2.16	0.031	-0.071	-0.003
E_innov_geral_lag1	-0.163	0.020	-8.15	0.000	-0.203	-0.124
N_innov_geral_lag1	0.161	0.019	8.4	0.000	0.123	0.198
RD_intensity	0.001	0.001	0.8	0.426	-0.001	0.002
Mid_tech	-0.013	0.019	-0.7	0.485	-0.050	0.024
High_tech	-0.062	0.018	-3.36	0.001	-0.098	-0.026
Balance	0.090	0.018	5.08	0.000	0.055	0.124
Education_intensity	-0.007	0.011	-0.63	0.531	-0.030	0.015
Openness	0.025	0.003	9.83	0.000	0.020	0.030
Funds	0.019	0.018	1.02	0.310	-0.017	0.054
Medium_size	-0.044	0.015	-2.9	0.004	-0.073	-0.014
Large_size	-0.028	0.019	-1.48	0.14	-0.065	0.009
group	-0.034	0.014	-2.43	0.015	-0.061	-0.007
$Inno_0$	0.408	0.009	45.86	0.000	0.390	0.425
mean_rd_intensity	-0.003	0.002	-1.85	0.064	-0.006	1.653×10^{-4}
mean_education_intensity	0.021	0.013	1.63	0.104	-0.004	0.046
mean_openness	-0.001	0.003	-0.16	0.875	-0.007	0.006
Industry	-0.035	0.042	-0.83	0.406	-0.117	0.047
Services	0.037	0.043	0.87	0.386	-0.047	0.122

Obs.: 3296 Number of groups: 1098.
mean_: time-average of the corresponding variable. Wald test: $\chi^2_{19} = 1231.88$ (p-value < 0.001).

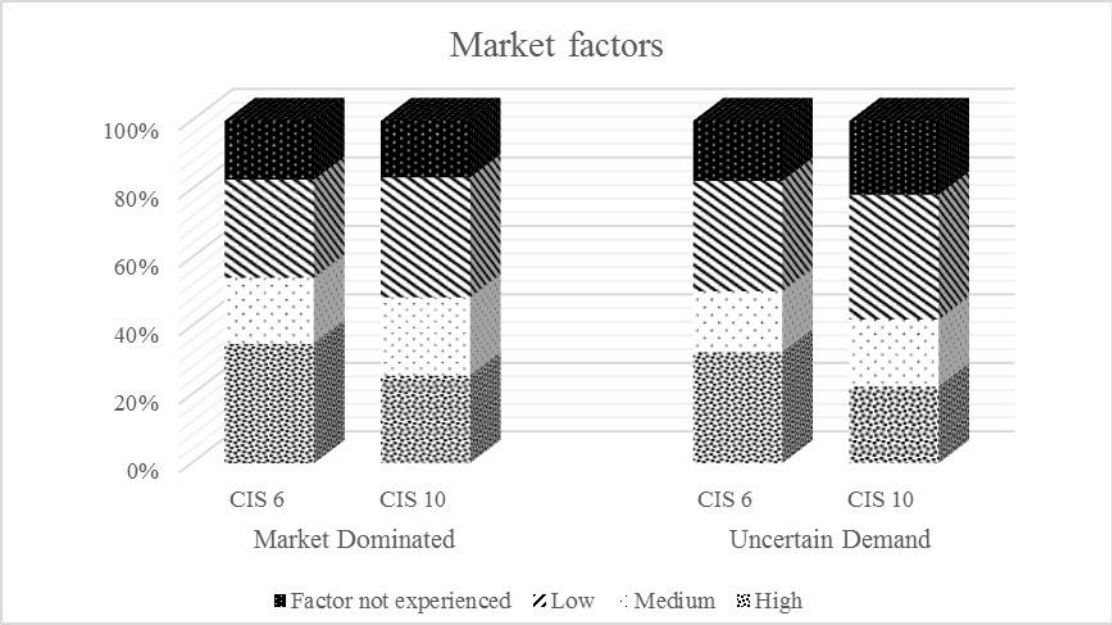
Appendix 10 – Innovation hampering factors for the entire sample

Graphic 84 - Overall funding factors



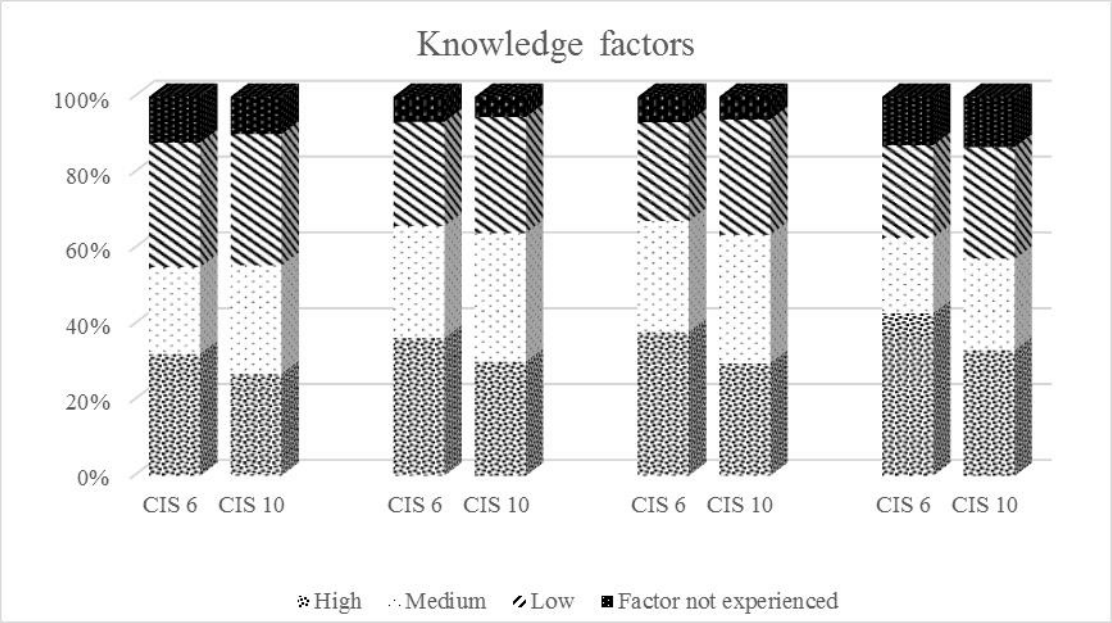
Source: Author's computation based on CIS 6 and CIS 10

Graphic 85 - Overall market factors



Source: Author's computation based on CIS 6 and CIS 10

Graphic 86 - Overall knowledge factors



Source: Author's computation based on CIS 6 and CIS 10

Appendix 11 – Model 1 - Determinants of the abandon of the innovative activities – General model

Table 68 – Determinants of abandon - random effects probit regression

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Isize_3	Firm Size - Medium	0.038	0.098	0.697	-0.154	0.230
_Isize_4	Firm Size - Large	0.143	0.116	0.217	-0.084	0.370
group	Economic Group	-0.103	0.095	0.276	-0.289	0.083
_Itech_inte_2	Tech Intensity - Mid Tech	-0.092	0.114	0.417	-0.315	0.130
_Itech_inte_3	Tech Intensity - High Tech	-0.045	0.107	0.674	-0.254	0.164
innov_general	Innovation in one vector (at least)	-0.870	0.373	0.02	-1.601	-0.139
expenditures_rd_total	Expenditures RD Total (€)	7.540×10^{-9}	7.010×10^{-9}	0.282	-6.200×10^{-9}	2.130×10^{-8}
funds_general	Use of funds to innovate	0.064	0.087	0.461	-0.107	0.235
openness	Openness to sources of innovation	0.018	0.025	0.477	-0.031	0.067
internal_S_Low		-0.006	0.250	0.982	-0.496	0.485
internal_S_Mid		0.010	0.190	0.959	-0.362	0.382
internal_S_High		0.030	0.187	0.873	-0.336	0.396
university_Low		-0.188	0.137	0.171	-0.457	0.081
university_Mid		-0.093	0.139	0.505	-0.366	0.180
university_High		0.235	0.172	0.172	-0.103	0.573
public_Low		0.066	0.127	0.605	-0.183	0.314
public_Mid		0.236	0.150	0.115	-0.058	0.530
public_High		0.048	0.205	0.816	-0.355	0.450
rd_intensity	R&D expenditures to Turnover Ratio	0.002	0.002	0.39	-0.003	0.007

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
Turnover_growth_rate	Turnover Growth Rate - percentage (%)	0.001	4.456×10^{-3}	0.179	-2.740×10^{-4}	0.001
education_intensity	Percentage of the labour force with undergraduate training or more	-0.012	0.031	0.695	-0.073	0.049
_IOcCasional_act_i_1	Performing Innov Activities Occasional	0.465	0.108	0.000	0.253	0.677
_IPersistent_act_i_2	Performing Innov Activities Persistent	0.829	0.116	0.000	0.602	1.056
act_innov_external_know	R&D Activities External Knowledge	0.221	0.084	0.008	0.056	0.385
_Ibarr_capi_1		0.323	0.140	0.021	0.049	0.597
_Ibarr_capi_2		0.007	0.143	0.962	-0.274	0.287
_Ibarr_capi_3		0.409	0.164	0.013	0.088	0.730
_Ibarr_capia1		-0.495	0.139	0.000	-0.767	-0.222
_Ibarr_capia2		-0.410	0.140	0.003	-0.685	-0.136
_Ibarr_capia3		-0.502	0.161	0.002	-0.816	-0.187
_Ibarr_inov_1		0.255	0.149	0.087	-0.037	0.547
_Ibarr_inov_2		0.261	0.146	0.074	-0.025	0.547
_Ibarr_inov_3		0.192	0.162	0.238	-0.126	0.510
_Ibarr_pess_1		0.030	0.151	0.845	-0.266	0.325
_Ibarr_pess_2		0.152	0.158	0.334	-0.157	0.462
_Ibarr_pess_3		0.387	0.186	0.038	0.021	0.752
_Ibarr_info_1		0.073	0.160	0.649	-0.241	0.386
_Ibarr_info_2		-0.027	0.184	0.883	-0.388	0.334
_Ibarr_info_3		-0.083	0.264	0.754	-0.601	0.435
_Ibarr_infoa1		-0.156	0.138	0.257	-0.426	0.114

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Ibarr_infoa2		-0.214	0.167	0.201	-0.543	0.114
_Ibarr_infoa3		-0.399	0.250	0.11	-0.888	0.091
_Ibarr_parc_1		0.179	0.127	0.158	-0.069	0.428
_Ibarr_parc_2		0.118	0.135	0.382	-0.147	0.383
_Ibarr_parc_3		0.414	0.169	0.014	0.083	0.744
_Ibarr_merc_1		-0.138	0.136	0.31	-0.404	0.128
_Ibarr_merc_2		0.017	0.135	0.90	-0.247	0.281
_Ibarr_merc_3		0.348	0.154	0.024	0.047	0.650
_Ibarr_ince_1		-0.335	0.134	0.013	-0.597	-0.072
_Ibarr_ince_2		-0.198	0.134	0.141	-0.461	0.065
_Ibarr_ince_3		-0.185	0.161	0.252	-0.501	0.132
_constant		-0.610	0.405	0.132	-1.404	0.184

Note: Random effects probit regression N = 1839 responses from 1167 subjects; Wald test of H0: $\alpha = \beta = 0$ has $\chi^2_{51} = 160.63$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Appendix 12 – Model 2 - Determinants of the abandon of the innovative activities – Controlling by sector

Table 69 –Determinants of abandon controlling by sector- random effects probit regression

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Isize_3	Firm Size - Medium	0.034	0.098	0.727	-0.157	0.226
_Isize_4	Firm Size - Large	0.135	0.116	0.246	-0.093	0.362
group	Economic Group	-0.098	0.095	0.300	-0.283	0.087
_Itech_inte_2	Tech Intensity - Mid Tech	-0.060	0.118	0.610	-0.292	0.171
_Itech_inte_3	Tech Intensity - High Tech	-0.027	0.114	0.815	-0.250	0.196
innov_general	Innovation in one vector (at least)	-0.871	0.373	0.019	-1.602	-0.141
gastos_rd_total		7.760×10^{-9}	7.050×10^{-9}	0.271	-6.050×10^{-9}	2.160×10^{-8}
Funds_general	Use of funds to innovate	0.061	0.088	0.488	-0.112	0.234
openness	Openness to sources of innovation	0.019	0.025	0.453	-0.030	0.068
internal_S_Low		5.950×10^{-4}	0.251	1.000	-0.491	0.491
internal_S_Mid		0.001	0.191	0.994	-0.372	0.375
internal_S_High		0.028	0.187	0.883	-0.340	0.395
university_Low		-0.196	0.138	0.154	-0.466	0.074
university_Mid		-0.101	0.139	0.471	-0.374	0.173
university_High		0.227	0.173	0.189	-0.112	0.566
public_Low		0.068	0.127	0.595	-0.181	0.316
public_Mid		0.237	0.151	0.116	-0.058	0.532
public_High		0.042	0.205	0.836	-0.360	0.445
rd_intensity	R&D expenditures to Turnover Ratio	0.002	0.002	0.376	-0.003	0.007

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
turnover_growth_rate	Turnover Growth Rate - percentage (%)	0.001	4.483×10^{-4}	0.179	-2.763×10^{-4}	0.001
education_intensity	Percentage of the labour force with undergraduate training or more	-0.009	0.032	0.782	-0.073	0.055
_IOccasional_act_i_1	Performing Innov Activities Occasional	0.468	0.108	0.000	0.255	0.680
_IPersistent_act_i_2	Performing Innov Activities Persistent	0.823	0.117	0.000	0.594	1.052
act_innov_external_know	R&D Activities External Knowledge	0.223	0.084	0.008	0.059	0.388
_Ibarr_capi_1		0.331	0.140	0.018	0.057	0.605
_Ibarr_capi_2		0.013	0.143	0.928	-0.268	0.293
_Ibarr_capi_3		0.412	0.164	0.012	0.091	0.734
_Ibarr_capia1		-0.500	0.139	0.000	-0.771	-0.228
_Ibarr_capia2		-0.417	0.140	0.003	-0.691	-0.143
_Ibarr_capia3		-0.507	0.160	0.002	-0.821	-0.193
_Ibarr_inov_1		0.259	0.149	0.081	-0.032	0.551
_Ibarr_inov_2		0.262	0.146	0.073	-0.024	0.547
_Ibarr_inov_3		0.195	0.162	0.228	-0.122	0.513
_Ibarr_pess_1		0.031	0.151	0.835	-0.264	0.327
_Ibarr_pess_2		0.153	0.158	0.333	-0.156	0.462
_Ibarr_pess_3		0.378	0.186	0.043	0.012	0.743
_Ibarr_info_1		0.067	0.160	0.674	-0.247	0.382
_Ibarr_info_2		-0.029	0.184	0.874	-0.390	0.332
_Ibarr_info_3		-0.086	0.264	0.745	-0.603	0.432
_Ibarr_infoa1		-0.153	0.138	0.267	-0.424	0.118
_Ibarr_infoa2		-0.214	0.168	0.201	-0.543	0.114
_Ibarr_infoa3		-0.396	0.250	0.113	-0.885	0.094
_Ibarr_parc_1		0.178	0.127	0.16	-0.071	0.427

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Ibarr_parc_2		0.119	0.136	0.38	-0.147	0.385
_Ibarr_parc_3		0.415	0.169	0.014	0.084	0.747
_Ibarr_merc_1		-0.140	0.136	0.302	-0.406	0.126
_Ibarr_merc_2		0.015	0.135	0.909	-0.249	0.280
_Ibarr_merc_3		0.344	0.154	0.026	0.042	0.647
_Ibarr_ince_1		-0.333	0.134	0.013	-0.595	-0.070
_Ibarr_ince_2		-0.199	0.134	0.138	-0.463	0.064
_Ibarr_ince_3		-0.185	0.161	0.251	-0.501	0.131
_Isector_2		0.440	0.338	0.193	-0.222	1.103
_Isector_3		0.392	0.344	0.254	-0.281	1.066
_constant		-1.051	0.526	0.046	-2.081	-0.020

Note: Random effects probit regression N = 1839 responses from 1167 subjects; Wald test of H0: $\alpha = \beta = 0$ has $\chi^2_{53} = 160.85$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Appendix 13 – Model 3 - Determinants of the abandon of the innovative activities – Innovation vectors

Table 70 – Determinants of abandon controlling by innovation vectors- random effects probit regression

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Isize_3	Firm Size - Medium	0.063	0.100	0.526	-0.132	0.259
_Isize_4	Firm Size - Large	0.158	0.117	0.179	-0.072	0.387
group	Economic Group	-0.097	0.095	0.306	-0.284	0.089
_Itech_inte_2	Tech Intensity - Mid Tech	-0.125	0.116	0.281	-0.351	0.102
_Itech_inte_3	Tech Intensity - High Tech	-0.067	0.110	0.542	-0.282	0.148
prod_innov	Product Innovation	0.035	0.087	0.687	-0.135	0.205
serv_innov	Service Innovation	0.028	0.086	0.743	-0.140	0.196
process_innov	Process Innovation in general (agregation	-0.276	0.112	0.014	-0.496	-0.057
org_innov	Process Innovation in general (agregation)	0.240	0.101	0.017	0.042	0.438
mkting_innov	Marketing Innovation (agregação)	0.148	0.086	0.086	-0.021	0.316
expenditures_rd_total	Expenditures RD Total (€)	6.75×10^{-9}	7.05×10^{-9}	0.338	-7.09×10^{-9}	2.06×10^{-8}
funds_general	Use of funds to innovate	0.077	0.089	0.386	-0.097	0.251
openness	Openness to sources of innovation	-0.003	0.026	0.915	-0.053	0.047
internal_S_Low		-0.014	0.253	0.956	-0.510	0.482
internal_S_Mid		-0.017	0.192	0.928	-0.393	0.358
internal_S_High		0.002	0.188	0.991	-0.366	0.370
university_Low		-0.139	0.138	0.314	-0.410	0.132
university_Mid		-0.067	0.141	0.634	-0.343	0.209
university_High		0.315	0.173	0.069	-0.025	0.655
public_Low		0.074	0.128	0.562	-0.177	0.325
public_Mid		0.250	0.150	0.095	-0.043	0.544
public_High		0.038	0.205	0.854	-0.364	0.440

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
rd_intensity	R&D expenditures to Turnover Ratio	0.003	0.003	0.191	-0.002	0.009
turnover_growth_rate	Turnover Growth Rate - percentage (%)	0.001	4.017×10^{-4}	0.203	-2.76×10^{-4}	0.001
education_intensity	Percentage of the labour force with undergraduate trainig or more	-0.029	0.032	0.371	-0.091	0.034
_IOccasional_act_i_1	Performing Innov Activities Occasional	0.445	0.109	0.000	0.230	0.659
_IPersistent_act_i_2	Performing Innov Activities Persistent	0.801	0.118	0.000	0.570	1.032
act_innov_external_know	R&D Activities External Knowledge	0.207	0.085	0.015	0.041	0.372
_Ibarr_capi_1		0.304	0.139	0.029	0.031	0.577
_Ibarr_capi_2		-0.018	0.144	0.901	-0.301	0.265
_Ibarr_capi_3		0.387	0.164	0.018	0.066	0.707
_Ibarr_capia1		-0.480	0.138	0.001	-0.751	-0.208
_Ibarr_capia2		-0.383	0.139	0.006	-0.656	-0.111
_Ibarr_capia3		-0.467	0.159	0.003	-0.779	-0.155
_Ibarr_inov_1		0.267	0.149	0.073	-0.025	0.559
_Ibarr_inov_2		0.279	0.146	0.056	-0.007	0.564
_Ibarr_inov_3		0.188	0.162	0.246	-0.129	0.506
_Ibarr_pess_1		0.013	0.151	0.931	-0.282	0.308
_Ibarr_pess_2		0.115	0.157	0.467	-0.194	0.423
_Ibarr_pess_3		0.386	0.187	0.038	0.020	0.752
_Ibarr_info_1		0.097	0.159	0.544	-0.216	0.409
_Ibarr_info_2		0.013	0.185	0.945	-0.350	0.376
_Ibarr_info_3		0.014	0.267	0.957	-0.509	0.538
_Ibarr_infoa1		-0.153	0.135	0.257	-0.418	0.112
_Ibarr_infoa2		-0.223	0.166	0.18	-0.549	0.103
_Ibarr_infoa3		-0.443	0.252	0.079	-0.936	0.051

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Ibarr_parc_1		0.194	0.127	0.128	-0.056	0.444
_Ibarr_parc_2		0.112	0.136	0.41	-0.155	0.379
_Ibarr_parc_3		0.385	0.168	0.022	0.056	0.713
_Ibarr_merc_1		-0.137	0.135	0.309	-0.402	0.127
_Ibarr_merc_2		0.020	0.134	0.883	-0.243	0.283
_Ibarr_merc_3		0.312	0.156	0.045	0.007	0.618
_Ibarr_ince_1		-0.352	0.134	0.009	-0.615	-0.089
_Ibarr_ince_2		-0.211	0.135	0.118	-0.477	0.054
_Ibarr_ince_3		-0.204	0.163	0.211	-0.523	0.115
_cons		-1.324	0.231	0.000	-1.775	-0.872

Note: Random effects probit regression N = 1839 responses from 1167 subjects; Wald test of H0: $\alpha = \beta = 0$ has $\chi^2_{55} = 163.41$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Appendix 14 – Model 4 - Determinants of the abandon of the innovative activities – controlling for both innovation vectors and economic sectors

Table 71 – Determinants of abandon controlling by sector and innovation vectors- random effects probit regression

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Isize_3	Firm Size - Medium	0.058	0.099	0.557	-0.137	0.253
_Isize_4	Firm Size - Large	0.149	0.117	0.206	-0.082	0.379
group	Economic Group	-0.088	0.095	0.354	-0.274	0.098
_Itech_inte_2	Tech Intensity - Mid Tech	-0.074	0.121	0.54	-0.311	0.163
_Itech_inte_3	Tech Intensity - High Tech	-0.035	0.116	0.764	-0.263	0.193
prod_innov	Product Innovation	0.011	0.089	0.898	-0.164	0.187
serv_innov	Service Innovation	0.043	0.088	0.627	-0.130	0.215
process_innov	Process Innovation in general (agregation	-0.287	0.112	0.011	-0.507	-0.066
org_innov	Process Innovation in general (agregation)	0.242	0.101	0.017	0.044	0.439
mkting_innov	Marketing Innovation (agregação)	0.157	0.086	0.070	-0.013	0.326
expenditures_rd_total	Expenditures RD Total (€)	7.17×10^{-9}	7.1×10^{-9}	0.313	-6.75×10^{-9}	2.11×10^{-8}
funds_general	Use of funds to innovate	0.072	0.090	0.424	-0.104	0.247
openness	Openness to sources of innovation	-0.002	0.026	0.94	-0.052	0.048
internal_S_Low		-0.004	0.254	0.986	-0.502	0.493
internal_S_Mid		-0.025	0.192	0.895	-0.402	0.351
internal_S_High		0.003	0.188	0.988	-0.366	0.372
university_Low		-0.150	0.139	0.279	-0.422	0.122
university_Mid		-0.079	0.141	0.576	-0.355	0.197
university_High		0.302	0.174	0.083	-0.039	0.643
public_Low		0.078	0.128	0.543	-0.173	0.329
public_Mid		0.250	0.150	0.096	-0.045	0.545
public_High		0.034	0.205	0.869	-0.368	0.436

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
rd_intensity	R&D expenditures to Turnover Ratio	0.004	0.003	0.185	-0.002	0.009
turnover_growth_rate	Turnover Growth Rate - percentage (%)	0.001	4.107×10^{-4}	0.21	2.902×10^{-4}	0.001
education_intensity	Percentage of the labour force with undergraduate trainig or more	-0.023	0.033	0.493	-0.087	0.042
_IOccasional_act_i_1	Performing Innov Activities Occasional	0.448	0.110	0.000	0.233	0.663
_IPersistent_act_i_2	Performing Innov Activities Persistent	0.794	0.119	0.000	0.561	1.027
act_innov_external_know	R&D Activities External Knowledge	0.211	0.085	0.013	0.045	0.377
_Ibarr_capi_1		0.314	0.139	0.025	0.040	0.587
_Ibarr_capi_2		-0.011	0.144	0.938	-0.294	0.272
_Ibarr_capi_3		0.390	0.164	0.017	0.069	0.711
_Ibarr_capia1		-0.486	0.138	0.000	-0.756	-0.215
_Ibarr_capia2		-0.390	0.139	0.005	-0.662	-0.118
_Ibarr_capia3		-0.472	0.159	0.003	-0.783	-0.160
_Ibarr_inov_1		0.275	0.149	0.065	-0.017	0.567
_Ibarr_inov_2		0.282	0.146	0.053	-0.003	0.568
_Ibarr_inov_3		0.192	0.162	0.234	-0.124	0.509
_Ibarr_pess_1		0.014	0.151	0.928	-0.282	0.309
_Ibarr_pess_2		0.114	0.157	0.467	-0.194	0.423
_Ibarr_pess_3		0.376	0.187	0.044	0.010	0.742
_Ibarr_info_1		0.091	0.160	0.570	-0.223	0.404
_Ibarr_info_2		0.008	0.185	0.964	-0.355	0.372
_Ibarr_info_3		0.011	0.267	0.967	-0.512	0.535
_Ibarr_infoa1		-0.149	0.136	0.273	-0.414	0.117
_Ibarr_infoa2		-0.220	0.166	0.186	-0.546	0.106
_Ibarr_infoa3		-0.441	0.252	0.080	-0.935	0.052
_Ibarr_parc_1		0.192	0.127	0.132	-0.058	0.442
_Ibarr_parc_2		0.114	0.137	0.405	-0.154	0.382

Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
_Ibarr_parc_3		0.386	0.168	0.022	0.057	0.715
_Ibarr_merc_1		-0.142	0.135	0.291	-0.407	0.122
_Ibarr_merc_2		0.015	0.135	0.914	-0.249	0.278
_Ibarr_merc_3		0.304	0.156	0.051	-0.002	0.610
_Ibarr_ince_1		-0.350	0.134	0.009	-0.613	-0.087
_Ibarr_ince_2		-0.212	0.135	0.118	-0.477	0.054
_Ibarr_ince_3		-0.204	0.163	0.210	-0.522	0.115
_Isector_2		0.493	0.341	0.148	-0.175	1.162
_Isector_3		0.399	0.347	0.250	-0.281	1.079
_constant		-1.815	0.409	0.000	-2.616	-1.014

Note: Random effects probit regression N = 1839 responses from 1167 subjects; Wald test of H0: $\alpha = \beta = 0$ has $\chi^2_{57} = 160.82$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6 and CIS 10

Appendix 15 – Correlations among barriers for the entire sample

Table 72 - Correlation among innovation barriers for the CIS 6

		Correlations among innovation barriers (CIS 6)								
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**
Economic Factors	**Insufficiency of equity (internal finance) (1)**		0.758**	0.688**	0.464**	0.449**	0.463**	0.426**	0.461**	0.447**
	Lack of external sources of finance (2)			0.677**	0.443**	0.449**	0.454**	0.457**	0.435**	0.422**
	Innovation costs excessivelly high (3)				0.514**	0.491**	0.479**	0.478**	0.484**	0.502**
Knowledge Factors	**Lack of skilled labour force (4)**					0.722**	0.641**	0.534**	0.451**	0.468**
	Lack of information about technology (5)						0.772**	0.594**	0.461**	0.491**
	Lack of information about markets (6)							0.629**	0.507**	0.532**
	Difficulty in finding innovation partners (7)								0.509**	0.518**
Market Factors	**Market dominated by established firms (8)**									0.691**
	Uncertainty about the demand (9)									

** Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 6

Table 73 - Correlation among innovation barriers for the CIS 10

		Correlations among innovation barriers (CIS 10)								
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**89)**
Economic Factors	**Insufficiency of equity (internal finance) (1)**		0.758**	0.688**	0.464**	0.449**	0.463**	0.426**	0.461**	0.447**
	Lack of external sources of finance (2)			0.677**	0.443**	0.449**	0.454**	0.457**	0.435**	0.422**
	Innovation costs excessivelly high (3)				0.514**	0.491**	0.479**	0.478**	0.484**	0.502**
Knowledge Factors	**Lack of skilled labour force (4)**					0.722**	0.641**	0.534**	0.451**	0.468**
	Lack of information about technology (5)						0.772**	0.594**	0.461**	0.491**
	Lack of information about markets (6)							0.629**	0.507**	0.532**
	Difficulty in finding innovation partners (7)								0.509**	0.518**
Market Factors	**Market dominated by established firms (8)**									0.691**
	Uncertainty about the demand (9)									

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 10

Correlation among innovation barriers

Table 74 – Correlation between innovation barriers in the constructed panel (CIS 6)

	Barr_internal _finance	Barr_external_ equity	Barr_qualified _personel	Barr_inform_ tecnol	Barr_inform_ mkt	Barr_ partners	Barr_market_ dominated	Barr_ uncertainty
Barr_internal_finance		0.760**	0.457**	0.459**	0.458**	0.407**	0.430**	0.423**
Barr_external_equity			0.465**	0.465**	0.473**	0.462**	0.413**	0.420**
Barr_qualified_personel				0.730**	0.637**	0.530**	0.412**	0.459**
Barr_inform_tecnol					0.772**	0.611**	0.444**	0.483**
Barr_inform_mkt						0.618**	0.472**	0.532**
Barr_partners							0.452**	0.504**
Barr_market_dominated								0.663**
Barr_uncertainty								

Source: Author's computation based on the panel constructed considering the CIS 6

Table 75 – Correlation between innovation barriers in the constructed panel (CIS 10)

	Barr_internal _finance	Barr_external_ equity	Barr_qualified _personel	Barr_inform_ tecnol	Barr_inform_ mkt	Barr_ partners	Barr_market_ dominated	Barr_ uncertainty
Barr_internal_finance		0.740**	0.375**	0.362**	0.397**	0.381**	0.359**	0.354**
Barr_external_equity			0.382**	0.363**	0.407**	0.411**	0.346**	0.354**
Barr_qualified_personel				0.753**	0.677**	0.549**	0.427**	0.439**
Barr_inform_tecnol					0.791**	0.578**	0.430**	0.415**
Barr_inform_mkt						0.605**	0.483**	0.481**
Barr_partners							0.414**	0.463**
Barr_market_dominated								0.655**
Barr_uncertainty								

Source: Author's computation based on the panel constructed considering the CIS 10

Appendix 16 – Use of sources of information for the entire sample

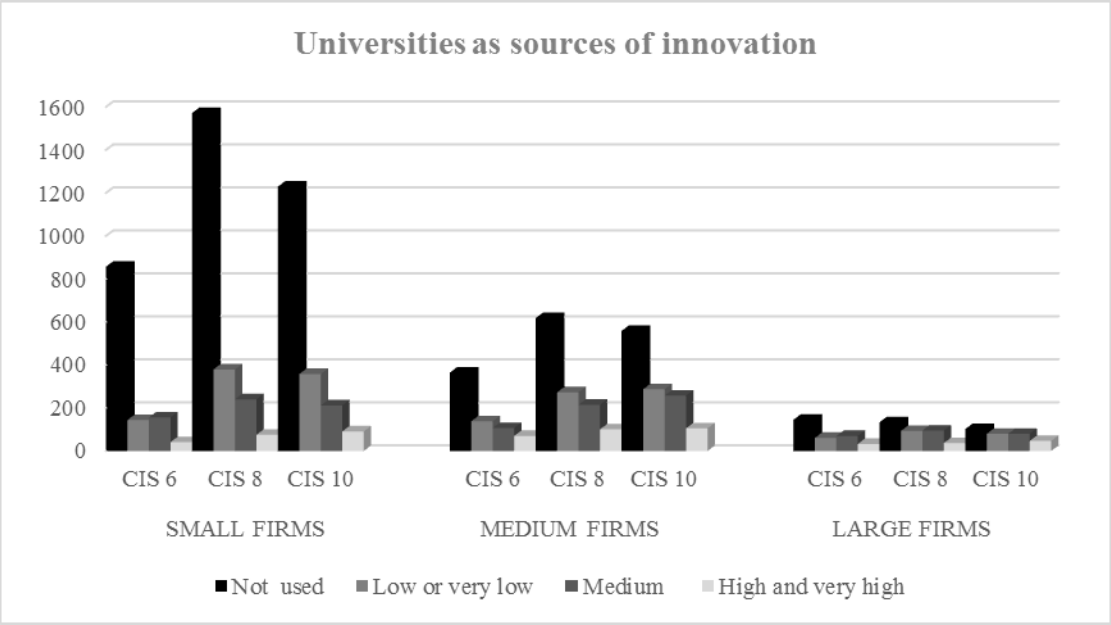
Table 76 - Relative importance of the innovation sources – entire sample (CIS)

	Source		CIS 6				CIS 8				CIS 10			
			Not used	**Low or very low**	**Medium**	**High and very high**	**Not used**	**Low or very low**	**Medium**	**High and very high**	**Not used**	**Low or very low**	**Medium**	**High and very high**
Internal Sources	**Inside the firm**	n	203	120	706	1157	507	371	1350	1602	385	296	1123	1602
		%	4.3	2.5	15.0	24.5	7.69	5.63	20.48	24.30	6.25	4.81	18.23	26.01
Market Sources	**Suppliers**	n	245	268	1058	615	465	646	1904	815	436	529	1628	813
		%	5.2	5.7	22.4	13.0	7.05	9.80	28.88	12.36	7.08	8.59	26.43	13.20
	Clients	n	367	327	744	748	583	607	1411	1229	473	506	1229	1198
		%	7.8	6.9	15.8	15.8	8.84	9.21	21.40	18.64	7.68	8.21	19.95	19.45
	Competitors	n	614	502	774	296	1014	989	1352	475	816	920	1205	465
		%	13.0	10.6	16.4	6.3	15.38	15.00	20.51	7.20	13.25	14.94	19.56	7.55
	Consultants & Private labs	n	1112	381	496	197	1696	893	921	320	1382	883	781	360
		%	23.6	8.1	10.5	4.2	25.72	13.54	13.97	4.85	22.44	14.33	12.68	5.84
Institutional Sources	**Universities**	n	1336	343	333	144	2322	745	550	213	1889	725	549	243
		%	28.9	7.3	7.1	3.1	35.22	11.30	8.34	3.23	30.67	11.77	8.91	3.94
	Government Labs	n	1509	362	242	73	2590	696	396	148	2136	734	385	151
		%	32.0	7.7	5.1	1.5	39.28	10.56	6.01	2.24	34.68	11.92	6.25	2.45
Other Sources	**Conferences**	n	542	478	807	359	907	1026	1374	523	836	827	1193	550
		%	11.5	10.1	17.1	7.6	13.76	15.56	20.84	7.93	13.57	13.43	19.37	8.93
	Scientific Journals	n	554	537	844	251	977	1180	1340	333	979	960	1146	321
		%	11.7	11.4	17.9	5.3	14.82	17.90	20.32	5.05	15.89	15.58	18.60	5.21
	Firm associations	n	744	625	619	198	1334	1135	1100	261	1237	987	960	222
		%	15.8	13.2	13.1	4.2	20.2	17.2	16.7	4.0	20.08	16.02	15.58	3.60

Source: Author's computation based on CIS

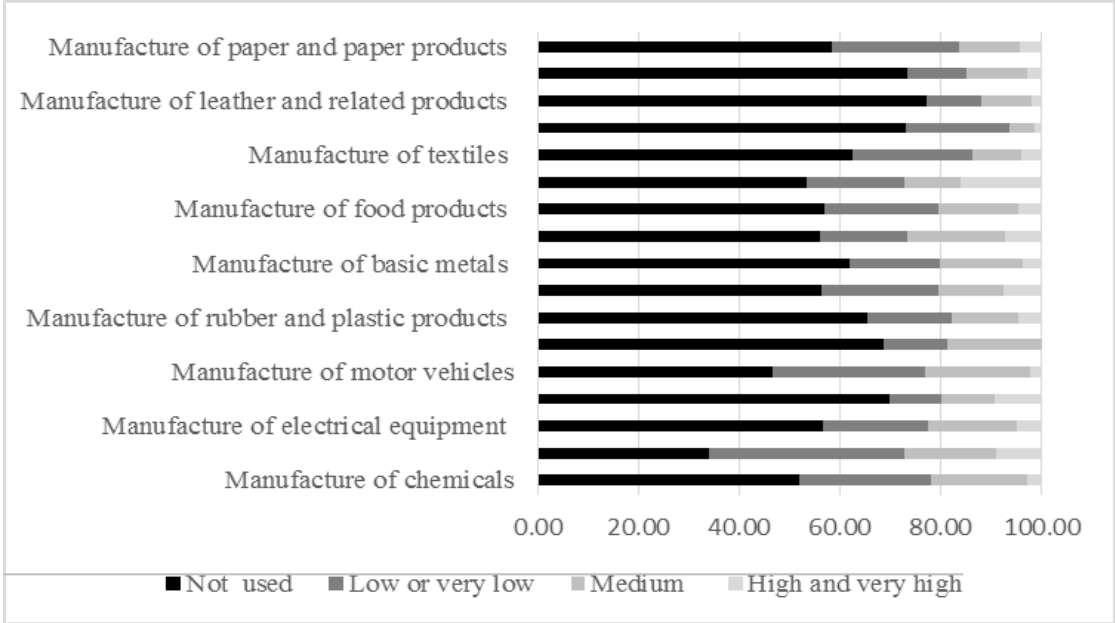
Appendix 17 – Universities as source of information – structural aspects of the entire sample

Table 77 - Firms relying on Universities as sources of innovation for innovation



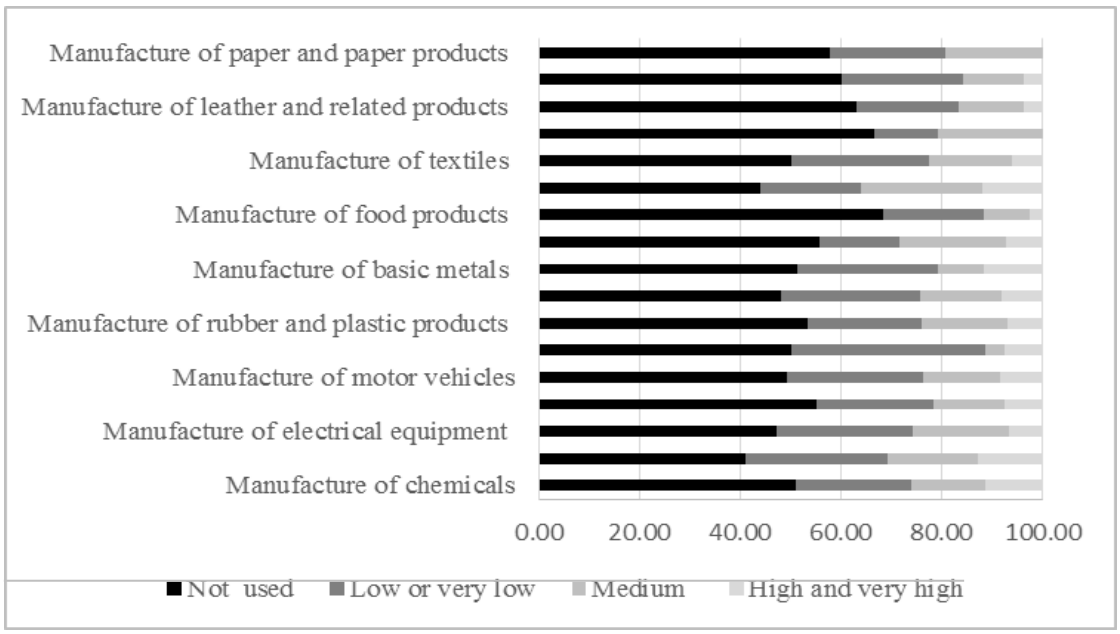
Source: Author's own computation based on CIS 6, 8 and 10

Table 78 - Importance of the University for the different SIC codes using CIS 8



Source: Author's own computation based on CIS 8

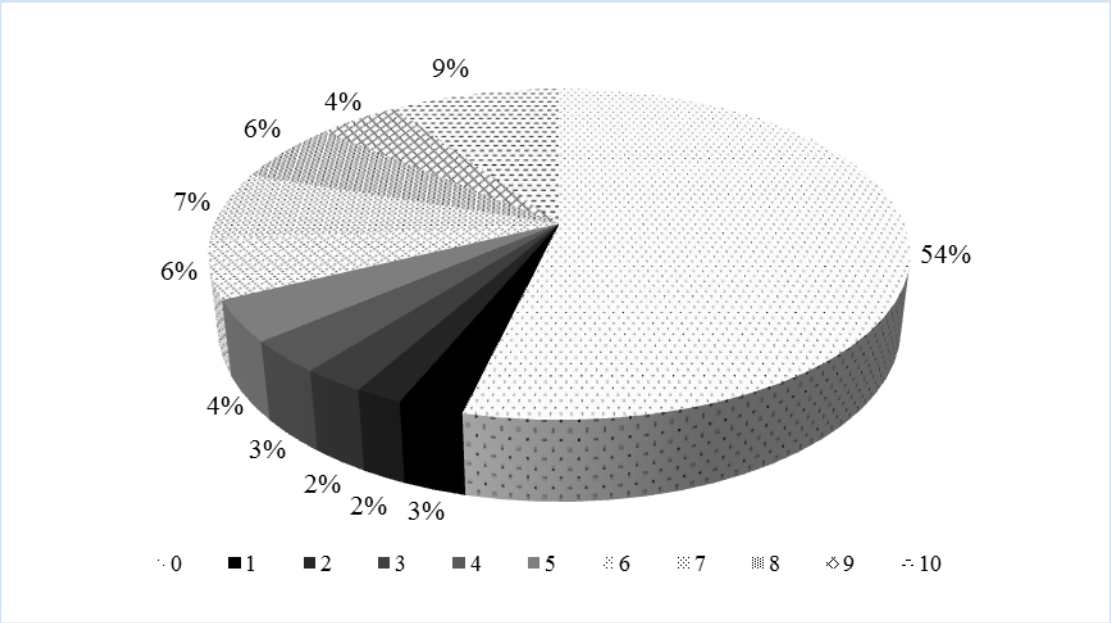
Graphic 87 - Importance of the University for the different SIC codes using CIS 10



Source: Author's own computation based on CIS 10

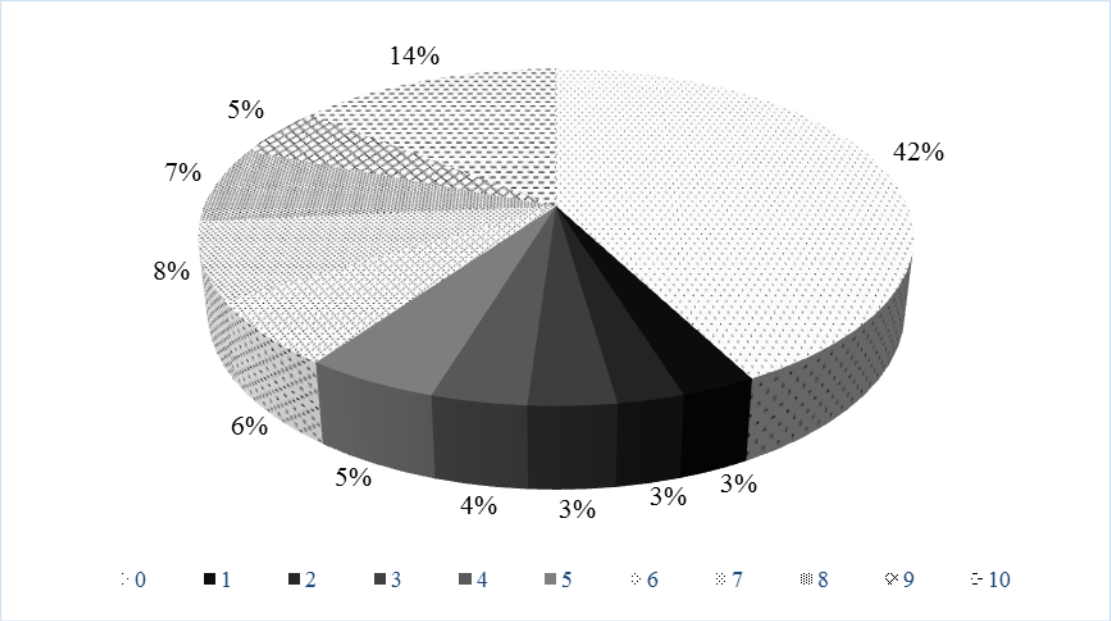
Empirical evidence points to the positive correlation between broader horizons in terms of innovation sources (openness) and successful innovation.

Graphic 88 - Openness - count of different sources of innovation used by firms – 2006



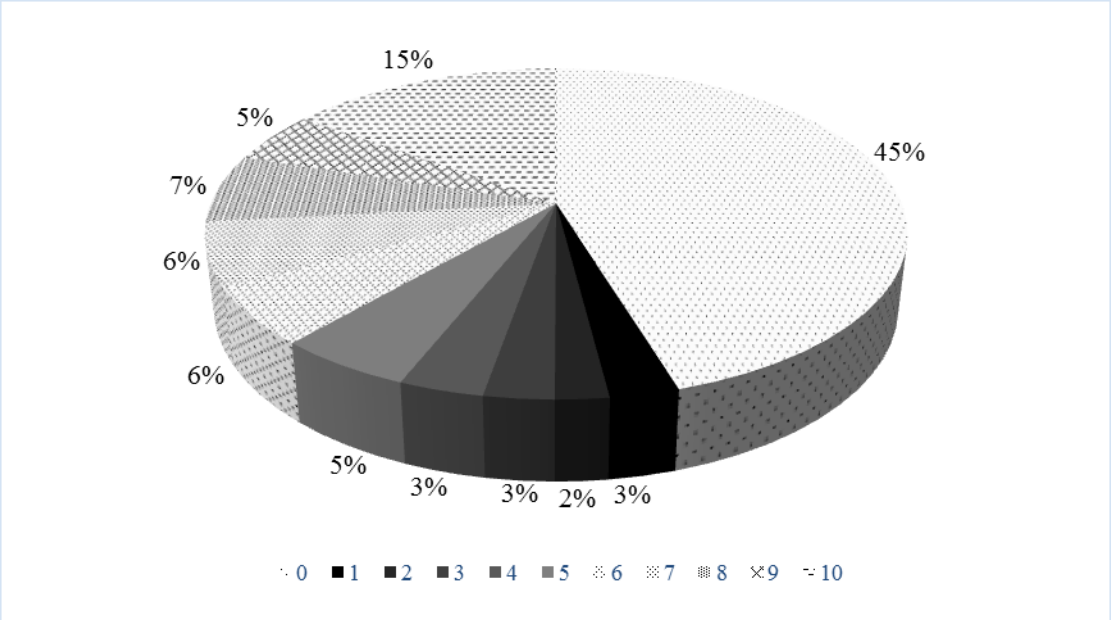
Source: Author's own computation based on CIS 6

Graphic 89 - Openness - count of different sources of innovation used by firms – 2008



Source: Author's own computation based on CIS 8

Graphic 90 - Openness - count of different sources of innovation used by firms – 2010



Source: Author's own computation based on CIS 10

Appendix 18 - Correlations among sources for the entire sample

Table 79 - Correlation among innovation sources for the CIS 6 (entire sample)

		Correlations among innovation sources (CIS 6)									
		Inside the firm	**Suppliers**	**Clients**	**Competitors**	**Consultants & Private**	**Universities**	**Government Labs**	**Conferences**	**Scientific Journals**	**Firm associations**
Internal Sources	**Inside the firm**		0.221**	0.340**	0.243**	0.202**	0.229**	0.187**	0.187**	0.221**	0.115**
	Suppliers			0.290**	0.312**	0.268**	0.173**	0.188**	0.319**	0.310**	0.244**
Market Sources	**Clients**				0.560**	0.246**	0.254**	0.244**	0.348**	0.313**	0.277**
	Competitors					0.342**	0.298**	0.312**	0.351**	0.319**	0.289**
	Consultants & Private						0.394**	0.415**	0.257**	0.284**	0.293**
Institutional Sources	**Universities**							0.675**	0.326**	0.359**	0.296**
	Government Labs								0.328**	0.350**	0.326**
	Conferences									0.641**	0.462**
Other Sources	**Scientific Journals**										0.535**
	Firm associations										

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 6

Table 80 – Correlation among innovation sources for the CIS 8 (entire sample)

		Correlations among innovation sources (CIS 8)									
		Inside the firm	**Suppliers**	**Clients**	**Competitors**	**Consultants & Private**	**Universities**	**Government Labs**	**Conferences**	**Scientific Journals**	**Firm associations**
Internal Sources	**Inside the firm**		0.392**	0.422**	0.327**	0.284**	0.282**	0.233**	0.250**	0.301**	0.163**
Market Sources	**Suppliers**			0.313**	0.340**	0.301**	0.228**	0.218**	0.327**	0.305**	0.241**
	Clients				0.575**	0.289**	0.276**	0.249**	0.337**	0.326**	0.257**
	Competitors					0.375**	0.324**	0.328**	0.363**	0.344**	0.311**
	Consultants & Private						0.518**	0.525**	0.296**	0.394**	0.374**
Institutional Sources	**Universities**							0.717**	0.338**	0.404**	0.349**
	Government Labs								0.316**	0.382**	0.374**
	Conferences									0.632**	0.429**
Other Sources	**Scientific Journals**										0.539**
	Firm associations										

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 8

Table 81 - Correlation among innovation sources for the CIS 10 (entire sample)

		Correlations among innovation sources (CIS 10)									
		Inside the firm	**Suppliers**	**Clients**	**Competitors**	**Consultants & Private**	**Universities**	**Government Labs**	**Conferences**	**Scientific Journals**	**Firm associations**
Internal Sources	**Inside the firm**		0.287**	0.379**	0.251**	0.245**	0.229**	0.191**	0.227**	0.287**	0.159**
Market Sources	**Suppliers**			0.345**	0.338**	0.317**	0.242**	0.231**	0.313**	0.335**	0.281**
	Clients				0.532**	0.280**	0.258**	0.234**	0.353**	0.322**	0.265**
	Competitors					0.383**	0.306**	0.313**	0.368**	0.367**	0.334**
	Consultants & Private						0.521**	0.529**	0.329**	0.379**	0.391**
Institutional Sources	**Universities**							0.704**	0.369**	0.438**	0.371**
	Government Labs								0.345**	0.412**	0.430**
	Conferences									0.655**	0.453**
Other Sources	**Scientific Journals**										0.543**
	Firm associations										

**. Correlation is significant at the 0.01 level (2-tailed).

Source: Author's computation based on CIS 10

Appendix 19 – Probability of using the University as a source of innovation (ML estimators)

Table 82 - Maximum likelihood estimates of the Hurdle model 1 – general innovation without sector control

Parameter	Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
α	size_medium	Firm Size - Medium	0,265	0,163	0,105	-0,055	0,585
	size_large	Firm Size - Large	0,647	0,197	0,001	0,261	1,032
	group	Economic Group	0,030	0,152	0,846	-0,268	0,327
	mid_tech	Tech Intensity - Mid Tech	-0,019	0,197	0,922	-0,406	0,367
	high_tech	Tech Intensity - High Tech	0,024	0,196	0,902	-0,360	0,408
	innov_in_general	Innovation in one vector (at least)	-5,577	0,461	0,000	-6,480	-4,674
	funds_general	Use of funds to innovate	0,605	0,154	0,000	0,302	0,907
	openess	Openness to sources of innovation	0,374	0,029	0,000	0,318	0,431
	rd_intensity	R&D expenditures to Turnover Ratio	-0,016	0,005	0,001	-0,025	-0,007
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	-7.140×10^{-5}	9.840×10^{-5}	0,468	-2.642×10^{-4}	1.215×10^{-4}
	education_intensity	Percentage of the labour force with undergraduate training or more	0,199	0,054	0,000	0,094	0,304
	occasional_innovator	Performing Innov Activities Occasional	-0,541	0,169	0,001	-0,872	-0,210
	persistent_innovator	Performing Innov Activities Persistent	0,047	0,176	0,789	-0,298	0,392
	innov_act_external_know	R&D Activities External Knowledge	0,121	0,138	0,382	-0,150	0,392
	innov_act_training	R&D Activities Training	-1,295	0,161	0,000	-1,610	-0,980
	constant		3,365	0,401	0,000	2,579	4,151
β	size_medium	Firm Size - Medium	0,397	0,228	0,081	-0,050	0,844
	size_large	Firm Size - Large	0,672	0,268	0,012	0,147	1,197
	group	Economic Group	0,100	0,197	0,613	-0,287	0,486
	mid_tech	Tech Intensity - Mid Tech	-0,463	0,274	0,092	-1,001	0,075
	high_tech	Tech Intensity - High Tech	-0,427	0,254	0,093	-0,924	0,071
	innov_in_general	Innovation in one vector (at least)	-2,556	1,127	0,023	-4,766	-0,347
	funds_general	Use of funds to innovate	0,649	0,183	0,000	0,289	1,008
	openess	Openness to sources of innovation	0,096	0,074	0,195	-0,049	0,241
	rd_intensity	R&D expenditures to Turnover Ratio	-0,018	0,012	0,142	-0,041	0,006
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	0,001	0,001	0,233	-0,001	0,003
	education_intensity	Percentage of the labour force with undergraduate training or more	0,292	0,077	0,000	0,141	0,443
	occasional_innovator	Performing Innov Activities Occasional	-0,033	0,239	0,892	-0,501	0,436
	persistent_innovator	Performing Innov Activities Persistent	0,166	0,230	0,470	-0,284	0,617
	innov_act_external_know	R&D Activities External Knowledge	0,336	0,181	0,063	-0,018	0,690
	innov_act_training	R&D Activities Training	0,156	0,199	0,434	-0,235	0,547

Note: Marginal effects for α and β parameters N = 2584 responses from 1099 subjects; Wald test of H0: $\alpha = \beta = 0$ has $\chi^2_{15} = 359.99$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

Table 83 - Marginal effects of the Hurdle model 1

	Logit	Ordered Logit		
	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)
size_medium	0.265 (0.163)	-0,085* (0,048)	0.047* (0.027)	0.038* (0.022)
size_large	0.647*** (0.197)	-0.145*** (0.056)	0.080** (0.032)	0.065** (0.027)
group	0.030 (0.152)	-0.021 (0.042)	0.012 (0.023)	0.010 (0.019)
mid_tech	-0.019 (0.197)	0.100 (0.059)	-0,055* (0,033)	-0,044* (0,027)
high_tech	0.024 (0.196)	0.092* (0.054)	-0,051* (0,031)	-0,041* (0,025)
innov_in_general	-5.577*** (-0.461)	0.550** (0.241)	-0.304** (0.141)	-0.246** (0.106)
funds_general	0.605*** (0.154)	-0.140*** (0.039)	0.077*** (0.022)	0.062*** (0.019)
openess	0.374*** (0.029)	-0.021 (0.016)	0.011 (0.009)	0.009 (0.007)
rd_intensity	-0.016*** (0.005)	0.004 (0.003)	-0.002 (0.001)	-0.002 (0.001)
turnover_growth_rate	-7.14×10^{-5} (9.84×10^{-5})	-2.295×10^{5} (1.919×10^{-5})	1.27×10^{-4}*** (1.072×10^{-4})	1.025×10^{-4} (8.62×10^{-5})
education_intensity	0.199*** (0.054)	-0.063*** (0.016)	0.035*** (0.009)	0.028*** (0.008)
occasional_innovator	-0.541*** (0.169)	0.007 (0.051)	-0.004 (0.029)	-0.003 (0.023)
persistent_innovator	0.047 (0.176)	-0.036 (0.049)	0.020 (0.027)	0.016 (0.022)
innov_act_external_know	0.121 (0.138)	-0,072* (0,039)	0.040* (0.022)	0.032* (0.018)
innov_act_training	-1.295*** (0.161)	-0.034 (0.043)	0.019 (0.024)	0.015 (0.019)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

Table 84 - Maximum likelihood estimates of the Hurdle model 2 – general innovation with sector control

Parameter	Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
α	size_medium	Firm Size - Medium	0,228	0,164	0,164	-0,093	0,549
	size_large	Firm Size - Large	0,650	0,196	0,001	0,266	1,034
	group	Economic Group	0,059	0,152	0,697	-0,239	0,357
	mid_tech	Tech Intensity - Mid Tech	0,093	0,205	0,650	-0,308	0,495
	high_tech	Tech Intensity - High Tech	0,194	0,207	0,348	-0,211	0,599
	innov_in_general	Innovation in one vector (at least)	-5,576	0,460	0,000	-6,477	-4,674
	funds_general	Use of funds to innovate	0,555	0,155	0,000	0,253	0,858
	openess	Openness to sources of innovation	0,373	0,029	0,000	0,316	0,430
	rd_intensity	R&D expenditures to Turnover Ratio	-0,016	0,005	0,000	-0,025	-0,007
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	-7.890×10^{-5}	1.286×10^{-4}	0,539	-3.309×10^{-4}	1.730×10^{-4}
	education_intensity	Percentage of the labour force with undergraduate training or more	0,241	0,056	0,000	0,132	0,350
	occasional_innovator	Performing Innov Activities Occasional	-0,564	0,168	0,001	-0,894	-0,235
	persistent_innovator	Performing Innov Activities Persistent	-0,004	0,176	0,980	-0,350	0,341
	innov_act_external_know	R&D Activities External Knowledge	0,151	0,139	0,279	-0,122	0,423
	innov_act_training	R&D Activities Training	-1,279	0,161	0,000	-1,594	-0,964
	secondary_sector	Secondary Sector (Industry)	-0,327	0,506	0,518	-1,318	0,664
	tertiary_sector	Tertiary Sector (Services)	-0,761	0,520	0,143	-1,780	0,258
	constant		3,632	0,643	0,000	2,371	4,893
β	size_medium	Firm Size - Medium	0,346	0,230	0,133	-0,105	0,796
	size_large	Firm Size - Large	0,658	0,270	0,015	0,129	1,186
	group	Economic Group	0,117	0,199	0,555	-0,272	0,507
	mid_tech	Tech Intensity - Mid Tech	-0,347	0,284	0,223	-0,903	0,210
	high_tech	Tech Intensity - High Tech	-0,263	0,264	0,318	-0,779	0,254
	innov_in_general	Innovation in one vector (at least)	-2,550	1,104	0,021	-4,713	-0,387
	funds_general	Use of funds to innovate	0,623	0,184	0,001	0,264	0,983
	openess	Openness to sources of innovation	0,103	0,074	0,165	-0,042	0,248
	rd_intensity	R&D expenditures to Turnover Ratio	-0,018	0,012	0,134	-0,042	0,006
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	0,001	0,001	0,230	-0,001	0,003
	education_intensity	Percentage of the labour force with undergraduate training or more	0,346	0,086	0,000	0,176	0,515
	occasional_innovator	Performing Innov Activities Occasional	-0,060	0,240	0,802	-0,530	0,410
	persistent_innovator	Performing Innov Activities Persistent	0,104	0,231	0,653	-0,349	0,556
	innov_act_external_know	R&D Activities External Knowledge	0,361	0,182	0,047	0,005	0,717
	innov_act_training	R&D Activities Training	0,156	0,200	0,435	-0,236	0,547
	secondary_sector	Secondary Sector (Industry)	-0,242	1,060	0,819	-2,32	1,836
	tertiary_sector	Tertiary Sector (Services)	-0,693	1,077	0,520	-2,804	1,418

Note: Marginal effects for α and β parameters N = 2584 responses from 1099 subjects; Wald test of H0: α = β = 0 has $\chi^2_{17} = 361.75$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

Table 85 - Marginal effects of the Hurdle model 2

	Logit	Ordered Logit		
	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)
size_medium	0.228 (0.164)	-0.074 (0.049)	0.040 (0.027)	0.033 (0.023)
size_large	0.650*** (0.196)	-0.140** (0.056)	0.077** (0.031)	0.063** (0.027)
group	0.059 (0.152)	-0.025 (0.042)	0.014 (0.023)	0.011 (0.019)
mid_tech	0.093 (0.205)	0.074 (0.061)	-0.041 (0.034)	-0.033 (0.028)
high_tech	0.194 (0.207)	0.056 (0.056)	-0.031 (0.031)	-0.025 (0.026)
innov_in_general	-5.576*** (0.460)	0.545** (0.234)	-0.299** (0.136)	-0.246** (0.105)
funds_general	0.555*** (0.155)	-0.133*** (0.039)	0.073*** (0.022)	0.060** (0.019)
openess	0.373*** (0.029)	-0.022 (0.016)	0.012 (0.009)	0.010 (0.007)
rd_intensity	-0.016*** (0.005)	0.004 (0.003)	-0.002 (0.001)	-0.002 (0.001)
turnover_growth_rate	-7.89×10^{-5} (1.286×10^{-4})	-2.32×10^{-4} (1.93×10^{-4})	1.272×10^{-4} (1.068×10^{-4})	1.048×10^{-4} (8.77×10^{-5})
education_intensity	0.241*** (0.056)	-0.074*** (0.018)	0.040*** (0.010)	0.033*** (0.009)
occasional_innovator	-0.564*** (0.168)	0.013 (0.051^)	-0.007 (0.028)	-0.006 (0.023)
persistent_innovator	-0.004 (0.176)	-0.022 (0.049)	0.012 (0.027)	0.010 (0.022)
innov_act_external_know	0.151 (0.139)	-0.077** (0.039)	0.042** (0.021)	0.035* (0.018)
innov_act_training	-1.279*** (0.161)	-0.033 (0.043)	0.018 (0.024)	0.015 (0.019)
secondary_sector	-0.327 (0.506)	0.052 (0.226)	-0.028 (0.124)	-0.023 (0.102)
tertiary_sector	-0.761 (0.520)	0.148 (0.230)	-0.081 (0.126)	-0.067 (0.104)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

Table 86 - Maximum likelihood estimates of the Hurdle model 3 – controlling for innovation vectors without sector control

Parameter	Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
α	size_medium	Firm Size - Medium	0,184	0,163	0,258	-0,135	0,504
	size_large	Firm Size - Large	0,563	0,199	0,005	0,173	0,952
	group	Economic Group	0,004	0,158	0,978	-0,306	0,314
	mid_tech	Tech Intensity - Mid Tech	0,095	0,204	0,643	-0,306	0,495
	high_tech	Tech Intensity - High Tech	0,115	0,200	0,566	-0,277	0,506
	prod_innov	Product Innovation	-0,805	0,167	0,000	-1,133	-0,477
	serv_innov	Service Innovation	-0,711	0,161	0,000	-1,027	-0,394
	process_innov	Process Innovation in general	-3,196	0,298	0,000	-3,780	-2,613
	org_innov	Organisational Innovation_procedures	0,160	0,160	0,316	-0,153	0,474
	mkting_innov	Marketing Innovation	-0,097	0,153	0,529	-0,397	0,204
	funds_general	Use of funds to innovate	0,843	0,178	0,000	0,494	1,193
	openess	Openness to sources of innovation	0,468	0,035	0,000	0,398	0,537
	rd_intensity	R&D expenditures to Turnover Ratio	-0,012	0,005	0,020	-0,022	-0,002
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	-4.370×10^{-5}	1.710×10^{-5}	0,010	-7.720×10^{-5}	-1.020×10^{-5}
	education_intensity	Percentage of the labour force with undergraduate training or more	0,085	0,052	0,103	-0,017	0,186
	occasional_innovator	Performing Innov Activities Occasional	-0,214	0,195	0,273	-0,597	0,169
	persistent_innovator	Performing Innov Activities Persistent	0,482	0,208	0,020	0,074	0,890
	innov_act_external_know	R&D Activities External Knowledge	0,338	0,167	0,043	0,011	0,666
	innov_act_training	R&D Activities Training	-1,266	0,181	0,000	-1,621	-0,912
	constant		0,559	0,214	0,009	0,139	0,980
β	size_medium	Firm Size - Medium	0,467	0,228	0,040	0,020	0,914
	size_large	Firm Size - Large	0,704	0,267	0,008	0,181	1,227
	group	Economic Group	0,092	0,194	0,636	-0,288	0,471
	mid_tech	Tech Intensity - Mid Tech	-0,469	0,278	0,092	-1,014	0,076
	high_tech	Tech Intensity - High Tech	-0,465	0,255	0,068	-0,966	0,035
	prod_innov	Product Innovation	-0,100	0,187	0,594	-0,467	0,267
	serv_innov	Service Innovation	0,156	0,179	0,386	-0,196	0,507
	process_innov	Process Innovation in general	-0,167	0,247	0,498	-0,652	0,317
	org_innov	Organisational Innovation_procedures	0,152	0,211	0,471	-0,261	0,565
	mkting_innov	Marketing Innovation	0,064	0,175	0,713	-0,279	0,408
	funds_general	Use of funds to innovate	0,674	0,184	0,000	0,314	1,034
	openess	Openness to sources of innovation	0,070	0,078	0,366	-0,082	0,222
	rd_intensity	R&D expenditures to Turnover Ratio	-0,017	0,012	0,146	-0,040	0,006
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	0,001	0,001	0,320	-0,001	0,003
	education_intensity	Percentage of the labour force with undergraduate training or more	0,277	0,077	0,000	0,126	0,428
	occasional_innovator	Performing Innov Activities Occasional	-0,035	0,240	0,883	-0,505	0,435
	persistent_innovator	Performing Innov Activities Persistent	0,179	0,237	0,448	-0,285	0,643
	innov_act_external_know	R&D Activities External Knowledge	0,312	0,179	0,082	-0,040	0,663
	innov_act_training	R&D Activities Training	0,078	0,201	0,697	-0,316	0,472

Note: Marginal effects for α and β parameters N = 2584 responses from 1099 subjects; Wald test of H0: $\alpha = \beta = 0$ has $\chi^2_{19} = 320.58$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

Table 87 - Marginal effects of the Hurdle model 3

	Logit	Ordered Logit		
	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)
size_medium	0.184 (0.163)	-0.101** (0.048)	0.055** (0.026)	0.046** (0.023)
size_large	0.563*** (0.199)	-0.152*** (0.056)	0.082*** (0.031)	0.070** (0.027)
group	0.004 (0.158)	-0.020 (0.042)	0.011 (0.023)	0.009 (0.019)
mid_tech	0.095 (0.204)	0.101* (0.060)	-0,055* (0,033)	-0,046* (0,028)
high_tech	0.115 (0.200)	0.101* (0.055)	-0,055* (0,03)	-0,046* (0,026)
prod_innov	-0.805*** (0.167)	0.022 (0.040)	-0.012 (0.022)	-0.010 (0.019)
serv_innov	-0.711*** (0.161)	-0.034 (0.039)	0.018 (0.021)	0.015 (0.018)
process_innov	-3.196*** (0.298)	0.036 (0.053)	-0.020 (0.029)	-0.017 (0.024)
org_innov	0.160 (0.160)	-0.033 (0.045)	0.018 (0.025)	0.015 (0.021)
mkting_innov	-0.097 (0.153)	-0.014 (0.038)	0.008 (0.021)	0.006 (0.017)
funds_general	0.843*** (0.178)	-0.146*** (0.039)	0.079*** (0.022)	0.067*** (0.020)
openess	0.468*** (0.035)	-0.015 (0.017)	0.008 (0.009)	0.007 (0.008)
rd_intensity	-0.012** (0.05)	0.004 (0.003)	-0.002 (0.001)	-0.002 (0.001)
turnover_growth_rate	-4.37×10^{-5}*** (1.71×10^{-5})	-1.897×10^{-4} (1.902×10^{-4})	1.028×10^{-4} (1.039×10^{-4})	8.68×10^{-5} (8.74×10^{-5})
education_intensity	0.085 (0.052)	-0.060*** (0.016)	0.032*** (0.009)	0.027*** (0.008)
occasional_innovator	-0.214 (0.052)	0.008 (0.052)	-0.004 (0.028)	-0.003 (0.024)
persistent_innovator	0.482** (0.208)	-0.039 (0.051)	0.021 (0.028)	0.018 (0.024)
innov_act_external_know	0.338** (0.167)	-0,067* (0,038)	0.036* (0.021)	0.031* (0.018)
innov_act_training	-1.266*** (0.181)	-0.017 (0.043)	0.009 (0.024)	0.008 (0.020)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

Table 88 - Maximum likelihood estimates of the Hurdle model 4 – controlling for both innovation vectors and economic sector

Parameter	Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
α	size_medium	Firm Size - Medium	0,151	0,163	0,354	-0,168	0,470
	size_large	Firm Size - Large	0,577	0,198	0,004	0,189	0,964
	group	Economic Group	0,040	0,158	0,801	-0,269	0,349
	mid_tech	Tech Intensity - Mid Tech	0,244	0,215	0,257	-0,178	0,665
	high_tech	Tech Intensity - High Tech	0,312	0,214	0,145	-0,108	0,731
	prod_innov	Product Innovation	-0,899	0,171	0.000	-1,235	-0,563
	serv_innov	Service Innovation	-0,614	0,163	0.000	-0,935	-0,294
	process_innov	Process Innovation in general	-3,199	0,296	0.000	-3,779	-2,62
	org_innov	Organisational Innovation_procedures	0,160	0,159	0,315	-0,152	0,472
	mkting_innov	Marketing Innovation	-0,042	0,155	0,788	-0,345	0,262
	funds_general	Use of funds to innovate	0,794	0,178	0.000	0,445	1,142
	openess	Openness to sources of innovation	0,465	0,035	0.000	0,396	0,534
	rd_intensity	R&D expenditures to Turnover Ratio	-0,012	0,005	0,020	-0,022	-0,002
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	-4.350×10^{-5}	1.730×10^{-5}	0,012	-7.730×10^{-5}	-9.620×10^{-6}
	education_intensity	Percentage of the labour force with undergraduate training or more	0,127	0,053	0,016	0,024	0,230
	occasional_innovator	Performing Innov Activities Occasional	-0,243	0,194	0,21	-0,624	0,137
	persistent_innovator	Performing Innov Activities Persistent	0,434	0,208	0,037	0,027	0,841
	innov_act_external_know	R&D Activities External Knowledge	0,354	0,167	0,034	0,027	0,682
	innov_act_training	R&D Activities Training	-1,258	0,18	0.000	-1,611	-0,905
	secondary_sector	Secondary Sector (Industry)	-0,261	0,436	0,55	-1,116	0,594
	tertiary_sector	Tertiary Sector (Services)	-0,789	0,448	0,078	-1,667	0,089
	constant		0,757	0,479	0,114	-0,182	1,696
β	size_medium	Firm Size - Medium	0,424	0,228	0,063	-0,023	0,871
	size_large	Firm Size - Large	0,706	0,269	0,009	0,179	1,232
	group	Economic Group	0,113	0,195	0,561	-0,269	0,495
	mid_tech	Tech Intensity - Mid Tech	-0,313	0,289	0,279	-0,878	0,253
	high_tech	Tech Intensity - High Tech	-0,263	0,264	0,318	-0,78	0,254
	prod_innov	Product Innovation	-0,200	0,192	0,297	-0,577	0,176
	serv_innov	Service Innovation	0,255	0,187	0,174	-0,113	0,622
	process_innov	Process Innovation in general	-0,205	0,246	0,404	-0,687	0,277
	org_innov	Organisational Innovation_procedures	0,133	0,211	0,528	-0,281	0,548
	mkting_innov	Marketing Innovation	0,138	0,179	0,441	-0,213	0,489
	funds_general	Use of funds to innovate	0,649	0,184	0.000	0,290	1,009

Parameter	Variable	Description	Estimate	SE	ρ-value	[95% Conf. Interval]	
	openess	Openness to sources of innovation	0,076	0,077	0,324	-0,074	0,226
	rd_intensity	R&D expenditures to Turnover Ratio	-0,018	0,012	0,135	-0,041	0,006
	turnover_growth_rate	Turnover Growth Rate - percentage (%)	0,001	0,001	0,322	-0,001	0,003
	education_intensity	Percentage of the labour force with undergraduate training or more	0,337	0,086	0.000	0,170	0,505
	occasional_innovator	Performing Innov Activities Occasional	-0,074	0,241	0,758	-0,547	0,398
	persistent_innovator	Performing Innov Activities Persistent	0,110	0,237	0,643	-0,354	0,573
	innov_act_external_know	R&D Activities External Knowledge	0,332	0,180	0,065	-0,02	0,685
	innov_act_training	R&D Activities Training	0,075	0,200	0,707	-0,317	0,468
	secondary_sector	Secondary Sector (Industry)	-0,458	1,143	0,689	-2,698	1,783
	tertiary_sector	Tertiary Sector (Services)	-1,049	1,169	0,369	-3,340	1,241

Note: Marginal effects for α and β parameters N = 2584 responses from 1099 subjects; Wald test of H0: $\alpha = \beta = 0$ has $\chi^2_{21} = 324.33$ (p-value < 0.001)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10

Table 89 - Marginal effects of the Hurdle model 4

	Logit	Ordered Logit		
	Variable Pr(Use)	Pr(Low)	Pr(Medium)	Pr(High)
size_medium	0.151 (0.163)	-0,091* (0,048)	0.049* (0.026)	0.042* (0.023)
size_large	0.577*** (0.158)	-0.151*** (0.056)	0.081*** (0.031)	0.070** (0.028)
group	0.040 (0.158)	-0.024 (0.042)	0.013 (0.022)	0.011 (0.019)
mid_tech	0.244 (0.215)	0.067 (0.062)	-0.036 (0.033)	-0.031 (0.029)
high_tech	0.312 (0.214)	0.056 (0.057)	-0.030 (0.030)	-0.026 (0.026)
prod_innov	-0.899*** (0.171)	0.043 (0.041)	-0.023 (0.022)	-0.020 (0.019)
serv_innov	-0.614*** (0.163)	-0.055 (0.040)	0.029 (0.021)	0.025 (0.019)
process_innov	-3.199*** (0.296)	0.044 (0.053)	-0.024 (0.028)	-0.020 (0.025)
org_innov	0.160 (0.159)	-0.029 (0.045)	0.015 (0.024)	0.013 (0.021)
mkting_innov	-0.042 (0.155)	-0.030 (0.038)	0.016 (0.021)	0.014 (0.018)
funds_general	0.794*** (0.178)	-0.139*** (0.039)	0.074*** (0.021)	0.065*** (0.020)
openess	0.465*** (0.035)	-0.016 (0.016)	0.009 (0.009)	0.008 (0.008)
rd_intensity	-0.012** (0.005)	0.004 (0.003)	-0.002 (0.001)	-0.002 (0.001)
turnover_growth_rate	-4.350×10^{-5}** (1.73×10^{-5})	1.015×10^{-4} (1.032×10^{-4})	1.015×10^{-4} (1.032×10^{-4})	8.800×10^{-5} (8.9×10^{-5})
education_intensity	0.127** (0.053)	-0.072*** (0.017)	0.039*** (0.010)	-0.007*** (0.024)
occasional_innovator	-0.243 (0.194)	0.016 (0.052)	-0.009 (0.028)	-0.007 (0.024)
persistent_innovator	0.434** (0.208)	-0.023 (0.051)	0.013 (0.027)	0.011 (0.024)
innov_act_external_know	0.354** (0.167)	-0,071* (0,038)	0038* (0.021)	0.033* (0.018)
innov_act_training	-1.258*** (0.180)	-0.016 (0.043)	0.009 (0.023)	0.007 (0.020)
secondary_sector	-0.261 (0.436)	0.098 (0.245)	-0.052 (0.131)	-0.046 (0.114)
tertiary_sector	-789* (0.448)	0.225 (0.249)	-0.120 (0.134)	-0.104 (0.117)

Source: Author's computation based on the panel constructed considering the CIS 6, CIS 8 and CIS 10