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A regional comparison of open innovation practices

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A REGIONAL COMPARISON
OF OPEN INNOVATION PRACTICES
BMOI REPORT

BMOI Report
A regional comparison of open innovation practices

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EUROPEAN COLLABORATIVE AND REGIONAL
OPEN INNOVATION STRATEGIES

Colophon

This report is part of the BMOI project which stands for 'Business Models for Open Innovation'.
This project aims to generate actionable insights to help firms transform their business model(s) to profit from open innovation. The project applies case-studies and a regional comparison to generate good practices, generic principles, training content, and policy recommendations. Other products of the project are a report identifying challenges of open business models and how to overcome them, a workshop methodology on open business models, and an integrated report with policy implications.

The BMOI project is part of EURIS, which is supported by the INTERREG IVC program financed by the European Union's Regional Development Fund (ERDF), helping regions of Europe to work together to share experience and good practices in the areas of innovation and the knowledge economy. The three project partners of the BMOI project are: Public University of Navarra (UPNa), University of Stuttgart (USTUTT), and Eindhoven University of Technology (TU/e).

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1. Introduction

Thanks to its impact on quality, price and sustainability, innovation is a topic that has been widely studied in business economics literature [31]. But, what is innovation? Drucker [14] defines it as the specific tool used by entrepreneurs to exploit change as an opportunity to initiate a new business or service. Additionally, innovation is driven by the ability to see connections, to spot opportunities and take advantage of them; also they stress that innovation is not just opening new markets but can also offer new ways of acting in established or mature markets.

Innovation matters at the firm level but also at the national level. Baumol [6] pointed out that the economic growth of the last century is ultimately attributable to innovation. At the firm level, Business Week magazine found that the median profit margin for the top 25 innovative firms was 3.4% for the period 1995-2005, whereas the average for non-innovative firms was only 0.4%. Similarly, the median annual stock return was 14.3% for innovators and 11.3% for non-innovators. According to Statistics Canada [30], innovation is the main factor in improving a company's market share, profitability and growth rate.

Traditionally, firms have innovated by looking within the firm for new ideas, technologies, products and processes that could give them a sustainable competitive advantage. The limitation of these exclusively internal activities is that firms might miss out on ideas, knowledge and technology that are located beyond their boundaries. However, some firms are aware of these limitations and have changed from the closed innovation strategy to the open innovation strategy (OI, hereafter). Table 1, based on Chesbrough [10], lists the main differences between closed innovators and those that have become open innovators.

1. Introduction

Table 1: Key differences between closed and open innovators

Closed Innovators	Open innovators
The smart people in the field work for us	Not all the smart people in the field work for us. We need to work with smart people inside and outside the company.
To profit from R&D, we must discover it, develop it, and ship it ourselves.	External R&D can create significant value; internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to the market first.	We don't have to originate the research to profit from it.
The company that gets an innovation to the market first will win.	Building a better business model is better than getting to the market first.
If we create the most and best ideas in the industry, we will win.	If we make the best use of internal and external ideas, we will win.
We should control our IP, so that our competitors don't profit from our ideas.	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our business model.

Source: Chesbrough [10]

As indicated, open innovators are conscious of knowledge that is located beyond the firm's boundaries and that internal knowledge plays a key role.

Chesbrough [10], who coined this terminology, argues that the change from closed to open innovation was enabled by growing mobility of high-skilled staff, knowledge spillovers and the increasing demand for shorter time to market for many products and services. These factors shorten the technology cycle, meaning that closed innovation is no longer sustainable. Under the contrasting open innovation approach, knowledge and technology flow is two-way: 1) inside-out and 2) outside-in. The flow goes from inside to out when the firm has internal ideas that can be taken to market through external channels, such as patents, licences, or start-up companies. The outside-in flow perspective stresses that firms may actively search for new technologies and ideas beyond the firm's boundaries and combine them with internal knowledge and technologies to achieve new products, processes and technologies and reduce time to market. It is important to highlight that the open innovation concept does not incentivise firms to solely trust in external knowledge but rather to combine their existent knowledge with external sources. Without internal knowledge, firms would not have the required absorptive capacity to integrate the external knowledge [13].

A key question is whether OI activities are beneficial for firms; that is to say, are there some tangible benefits from OI? The answer is… YES. Some studies have proven that OI practices enhance a firm's innovative performance. One example is the work of Tomlinson [32] which finds that intern-firm collaboration with suppliers, buyers and competitors fosters the realisation of product and process innovations. Laursen and Salter [21] also observed a

This study aims to analyse and compare OI practice in the regions of Eindhoven, Navarre and Stuttgart. Our results will allow understanding of why firms decide to adopt OI practices and the effects of these activities.

positive effect of OI on firm innovative performance. However, they discovered that too much OI has a negative effect on firm innovative performance. Some of the main consequences of OI, most widely discussed in innovation literature, are lower costs, shorter time to market and sales growth.

Some articles argue that firms engage in OI practices due to defensive or offensive reasons. The former assumes that a firm might want to reduce cost and risk, for example, and the latter considers that a firm's growth and innovation achievements might be other types of incentives. OI practices assume that the firm has changed the way it interacts with the environment in order to face it or defend against it. However, little is known about how firms profit from open innovation. A business model perspective, which shows how firms develop and capture value, may facilitate this analysis.

This is the context framing this study, which aims to analyse and compare OI practices in the regions of Eindhoven (Netherlands), Navarre (Spain) and Stuttgart (Germany). These regions are cooperating for the INTERREG IVC Programme funding for interregional cooperation across Europe, financed through the European Regional Development Fund (ERDF). The overall objective of the INTERREG IVC Programme is to improve the effectiveness of regional policies and instruments.

There are several specific objectives, listed below, that will contribute to the achievement of the INTERREG IVC Programme goal.

- Analysing the innovativeness in terms of innovation inputs and outputs.
- Observing trends in OI adoption in the three regions
- Studying the possible relationship between OI and firm size
- Observing the different OI trends across industries
- Examining the determinants of OI practices
- Determining the impact of OI on business model modifications
- Exploring the effect of OI activities on firm innovativeness

The comparison of these regions is made by means of the Community Innovation Survey (CIS) which is further explained in the next section. The structure of this study is based on the abovementioned objectives and finishes with the main conclusions and policy recommendations driven by the analyses performed.

1. Introduction

2. Description of the dataset used

This chapter introduces the survey used in this report, its characteristics and main features. Also, the differences across the surveys for each region are highlighted.

2.1 Community Innovation Survey

This study includes analysis of Open Innovation (hereafter OI) practices and the role that Business Models (hereafter BM) play in the firms that pursue OI. Three regions have been analysed and this report presents a general description and comparison of the three independent samples. The regions under analysis are Eindhoven (Netherlands), Stuttgart (Germany) and Navarre (Spain).

The data analysed has its origins in Community Innovation Statistics (CIS) which are produced in 27 Member States of the European Union, 3 countries of the European Free Trade Association (EFTA) and in EU candidate countries, based on Commission Regulation No 1450/2004. The first CIS was a pilot exercise, completed in 1993, while the second survey was carried out in 1997/1998, except for in Greece and Ireland where it was launched in 1999.

The CIS anonymised microdata refer to the data collected at national level. In order to ensure comparability across countries, Eurostat, in close cooperation with the EU Member States, developed a standard core questionnaire for the CIS 3, with an accompanying set of definitions and methodological recommendations. The CIS 3 is based on the Oslo Manual which gives methodological guidelines and defines the innovation concept.

2. Description of the dataset used

The National Statistical Office or a national Ministry is responsible for the CIS at a national level. In the Netherlands, the Statistics Netherlands (CBS)[1], in Germany the Centre for European Economic Research (ZEW)[2] and in Spain the National Institute of Statistics (INE)[3] provided the data for developing this study. CIS provides information about the structure of the innovation process and shows the relationship between this process and company technological strategy. It includes individualised firm data on technological innovation activities, like the main obstacles for achieving innovations, the main technological information sources, innovation and R&D expenditures, qualifications of the R&D personnel, cooperation in R&D activities classified by origin and type of partner, and the effects of the innovation achievements.

2.2 Sample selection

The sample selected corresponds to Manufacturing and Service firms that completed the CIS for the year 2008. For the Stuttgart sample, due to availability of variables, the years 2007 and 2008 were merged to create the final sample. Specifically, the variables that account for Business Models (BM) and public funds were taken from 2007; the remaining variables analysed in this study correspond to the 2008 CIS. Although the Eurostat gives guidance and recommendations on methodological issues and a standard core questionnaire, each National Statistical Office has the autonomy to introduce modifications to the CIS. Therefore, there are some variables that are not included in some of the CIS.

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[1] In the Netherlands, the responding companies are a reflection of the total business population in the Netherlands (ABR population of December 2008). Per stratum (defined by the business activity - sbi 2-digit - and size of the company) is a determined correction factor. For a given stratum: the number of responding companies (n), and total number (N) companies in the coordinated population estimate (see demographics of companies), become the multiplication factor WEIGHT08 = N / n. If, within a stratum, the number of responding companies is not sufficient or the stratum does not contain enough firms, strata are merged until the "problem" is solved. In doing so, first size classes are merged to publication size classes, and subsequently business activities are merged to publication activity classes. Please visit www.cbs.nl for further information on the compilation of the dataset.

[2] The sample frame consists of all firms with 5 or more employees in mining, manufacturing, energy, construction and a large number of service sectors. The surveyed sample is drawn as a stratified random sample. Stratification criteria are sectors (currently 40), size classes (8 in production sectors, 7 in service sectors) and regions (West and East Germany). Please visit www.zew.de.

[3] In the case of the INE, the survey by which the sample was collected is called the Technological Innovation Survey. It provides information about the structure of the innovation process and shows the relationship between this process and the company technological strategy. The survey collection is carried out according to methodological rules defined in the OECD Oslo Manual. The directory contains a comprehensive section including the companies that can potentially develop R+D activities and companies with over 200 employees; and another random section drawn from the Central Company Directory. Please visit the following site to obtain additional information on the sample collection: www.ine.es.

2. Description of the dataset used

Table 2. Comparison of the variables for each CIS within each region

Variable	Eindhoven	Navarre	Stuttgart
Firm size	small; medium; large	small; medium; large	small; medium; large
Industry	43 industries	80 industries	22 industries
Product Innovations	yes	yes	yes
Process Innovations	yes	yes	yes
Service Innovations	yes	yes	n.a.
Patents	yes	yes	yes
Internal R&D	yes	yes	yes
Internal R&D expenditure	yes	yes	n.a.
External R&D	yes	yes	yes
External R&D expenditure	yes	yes	n.a.
R&D intensity	yes	yes	yes
Information sources	9 sources	10 sources	n.a.
Cooperation partners	7 partners	8 partners	6 partners
Innovation objectives	10 objectives	13 objectives	n.a.
Innovation obstacles	n.a.	11 obstacles	13 obstacles
Public funds for R&D	3 types	3 types	n.a.
Organisational innovations	3 types	3 types	4 types
Commercial innovations	4 types	4 types	4 types

Note: n.a. stands for not available.

Table 2 shows the similarities and differences between the CIS for each region. The crucial differences are that a) the Stuttgart region does not have information about internal and external R&D expenditure, information sources, public funds for R&D and innovation objectives; b) the Eindhoven region does not include information about innovation obstacles. Some other differences are perceived in the number of industries considered in each region. While Navarre disaggregates the sample into 80 different industries, Stuttgart considers only 22. Therefore, detailed comparison of each industry is not feasible. Consequently, the remainder of the study is limited to the comparison of manufacturing and service firms.

Another significant difference is that the number of sources and the number of partners differ. Later, in section 5 where we proceed to describe the OI measures, these differences have to be taken into account in the interpretation of results. Although there is also a difference in the number of innovation objectives and innovation obstacles between Navarre and Eindhoven and Navarre and Stuttgart, this is not a significant problem due to the fact that the variables are reconverted into a single factor minimising this difference. The same logic applies to the difference in the number of organisational and commercial innovations.

In order to avoid any bias in the sample selection, we included all firms in the analysis, both innovative and non-innovative firms, and no discrimination was made for large or small firms, or for firms belonging to a certain industry. For the Navarre sample, the final sample consisted of 1,317 observations; there were 623 observations for Eindhoven and 2,836 observations for the Stuttgart region.

2. Description of the dataset used

3. Sample description

The main peculiarities and structural characteristics, such as firm size and industries, for the Eindhoven, Navarre and Stuttgart regions are presented in this chapter.

3.1 Industry structure

The starting point for describing the structural characteristics of the region is to present the percentage of firms classified as manufacturing or service. As observed in Figure 1, the composition of the industries is very similar. For Eindhoven, 59.16 per cent of firms are in manufacturing, this percentage is a little bit lower for Navarre, 54.21 per cent, and for Stuttgart, 53.99 per cent of the firms develop manufacturing activities. For the three regions, the majority of firms are classified as manufacturing and service firms represent less than half of the firms collected in the sample.
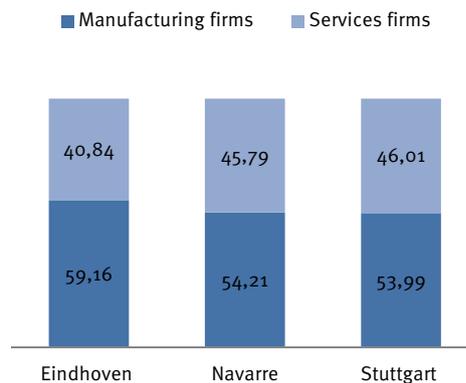
Figure 1. Industry composition

According to the NACE 2009 classification, the following industries were grouped as manufacturing firms: food (NACE code 10), beverages (11), tobacco (12), textile (13), clothing (14), tailoring (15), wood & cork (16), paper (17), graphic arts (18), chemistry (20), pharmaceutics (21), rubber and plastic (22), metallic non mineral (23), metallurgy (24), metallic manufacturing (25), informatics, electronic and optics (26), electric equipment (27), other machinery (28), motor vehicles (29), other motor vehicles (30), furniture (31) and other manufacturing activities (32).

Firms with activities in the following industries were coded as service firms: machinery and equipment repair (33), energy & water (35, 36), decontamination (37-39), construction (41-43), commerce (45-47), transport and warehousing (49-53), hotel (55), telecommunications (61), informatics service (62), other

information & communication services (58-60, 63), financing (64-66), real state (68), R&D services (72), other services activities (69-75), administrative activities (77-82), education (85), health (86-88), arts (90-93) and, other services (94-96). In order to gain deeper understanding of the structure of the regional industries, we think it is important to identify, for each region, the three industries in which there is the greatest concentration of firms. For the Eindhoven region, we observe a large dispersion of industries. The industry with the highest concentration is wholesale (17.68 %), followed by the building industry (8.68 %) and rental (8.03 %), all these are service firms. In Navarre, the highest concentration is in the commerce industry (12.18 %), followed by the food industry (10.47 %) and metallic manufacturing (8.69 %). Finally, the Stuttgart sample has its greatest concentration in technical services (9.33%), metallic manufacturing accounts for 8.69 per cent and transport equipment 8.23 per cent.

Following the European Commission classification of firm size[4], Figure 2 shows the distribution of firms by region according to firm size. In order to facilitate analysis, we classified firms as small (fewer than 50 employees) medium (between 50 and 250 employees) and large (more than 250 employees). Figure 2 shows that there is a similar distribution of firm sizes across the three regions. Small firms predominate and large firms represent the minority. In Eindhoven, there seems to be less difference between the number of large firms and other firms, as small firms represent 51.05 per cent. For Navarre and Stuttgart, the difference is bigger, 65.98 per cent in the Navarre region and 62.51 in Stuttgart are small firms. Conversely, a higher concentration of large firms can be found in Stuttgart (12.43%), compared to Navarre (6.61%).
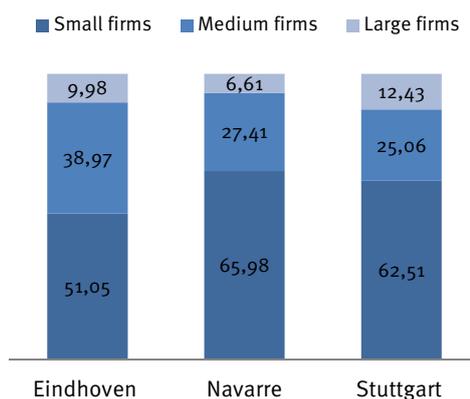
Figure 2. Firm size

Regarding the industry structure, it is important to highlight some differences in the mean number of employees. Stuttgart as a region has more large firms and the average number of employees is 221.44. Eindhoven and Navarre have a smaller average number of employees, 133.49 for the former and 120.48 for the latter. Breaking the sample down into manufacturing and service firms, the mean number of employees is considerable greater for manufacturing firms in Eindhoven and Stuttgart. Eindhoven has a mean of 108.59 employees for service firms and a mean of 169.18 employees for manufacturing firms. Stuttgart has a mean of 160.11 for service firms and a mean of 273.94 for manufacturing ones. Conversely, Navarre has the opposite industry structure, the larger firms are in the service industry, with a mean number of employees of 133.67 versus 108.11 for manufacturing firms. This is in line with the abovementioned data showing that the highest concentration of firms is in the commerce industry (12.18%).

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4 For more detailed information please visit: http://ec.europa.eu/enterprise/policies/sme/facts-figures-analysis/sme-definition/index_en.htm.

4. Innovation behaviour

The main innovation inputs and the main innovations outputs are described in this section. It is observed that some regions in this analysis are more committed to innovation activities than others. There are also visible variations across industries and firm size.

To gain a better understanding of innovation behaviour, it is important to define the different inputs and outputs that take place within the innovation process. With regard to the inputs, we could mention research and development activities (R&D)[5], firm creativity, leadership, willingness to innovate, etc. Technological innovations are generally dependent on R&D which is defined as the creative work undertaken on a systematic basis to increase the knowledge stock and use it to devise new applications [25]. In next section, we present some data on R&D activities for the three regions. With regard to the outputs, the OECD [24] has identified four types of innovations encompassing a wide range of changes in firm activities: a) product innovations; b) process innovations; c) organisational innovations and; d) marketing innovations.

In this section we pay special attention to technological innovations, since Bone and Saxon [9] claim that technological innovations, whether in the form of products or processes innovations, are the main source of competitive advantage and are crucial to business success.

4.1 Innovation inputs

The more traditional variable for measuring engagement in innovation activities is the Research and Development (R&D) carried out in-house by the firm. Internal R&D activities are crucial to gain a competitive advantage since it is through these activities that firms are able to generate unique knowledge and facilitate innovative responses to the real needs of the firm [35]. However, some authors suggest that internal R&D is more risky and less predictable than external R&D, defined as purchasing R&D services though a legal contract, and that product commercialization takes longer for those firms carrying out R&D in-house [27].

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[5] Research and experimental development (R&D) comprises 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 [24].

4. Innovation behaviour

Figure 3 shows the percentage of firms per region achieving internal R&D activities. The greatest engagement in in-house R&D can be seen in the Stuttgart region, where 35.66 per cent of the firms perform R&D internally. The Navarre region has the second highest level of involvement in these activities, having nearly 30 per cent of firms engaged in R&D. Eindhoven is the region where there are fewest firms performing R&D internally, 26.48 per cent.

Due to the fact that the innovation process is more dependent on R&D for manufacturing firms than for services firms, we consider it to be necessary to analyse these types of industries separately, and this disaggregation is also shown in Figure 3. It can be clearly observed that, in all regions, manufacturing firms are more involved in internal R&D activities than services firms. Eindhoven registers that 46.85 per cent of manufacturing firms are actively pursuing internal R&D, but only 12.46 per cent of service firms follow this pattern. In Navarre, a lower percentage of manufacturing firms achieve internal R&D, 37.44 per cent. For service firms, it can be observed that 20.51 per cent perform R&D internally. Considering this, it is observed that Stuttgart has a similar percentage of manufacturing firms engaged in R&D (45.98%) as Eindhoven but the percentage of service firms performing internal R&D is almost double that of Eindhoven (23.57%).
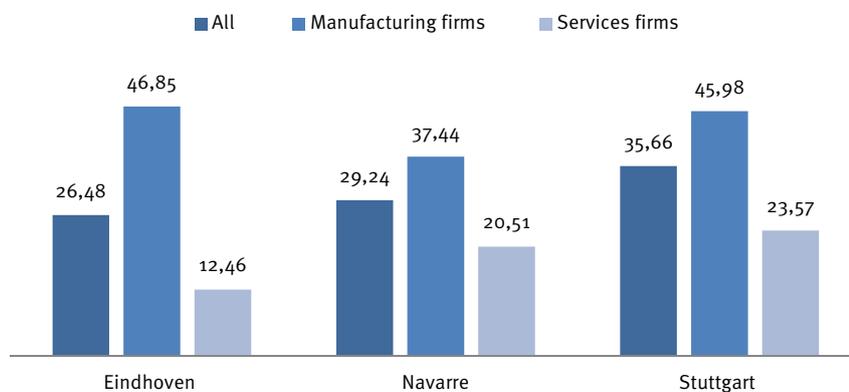
Figure 3. Percentage of firms engaged in internal R&D activities

Due to the increasing speed of development in new technologies, some firms prefer to outsource R&D activities since it is not feasible for them to develop everything in-house for such specific technology [28]. Additionally, Chesbrough and Crowther [11] stress that, due to the dramatic changes in technology, firms must source technology beyond their boundaries in order to provide the products and services demanded. Some authors argue that outsourcing R&D makes these activities less risky and more predictable, solves capacity problems, broadens the firms' knowledge base and speeds time to market [19, 20]. However, it increases transactional costs and, may result in firms becoming more dependent on their suppliers and losing technological expertise in the long run [8, 34].

Once the above considerations for outsourcing R&D have been made, Figure 4 shows the percentage of firms by region and industry that outsource R&D activities either in whole or in part. For Eindhoven, 16.05 per cent (10 per cent less than internal R&D) of firms outsource R&D activities. Conversely to the pattern of internal R&D, the percentage of Navarre firms engaged in external R&D (14.35 %) is lower than the percentage of firms based in Eindhoven. Again, firms in Stuttgart participate more actively in R&D activities than the other two regions with 27.31 of firms outsourcing R&D. In this sense, we could venture to say that Stuttgart firms rely more on open innovation activities than their counterparts, especially

By simultaneously analysing internal and external R&D activities, it can be observed that Stuttgart firms are more committed to R&D than their counterparts, internal R&D is still more preferred than external R&D by all firms in all regions and manufacturing firms have a greater commitment to, or requirement for R&D than service firms.

Navarre. With regard to the differences between manufacturing and service firms the pattern is similar to that of internal R&D. For all regions, the percentage of firms outsourcing R&D is considerably higher for manufacturing firms than for services; three times more for Eindhoven, twice for Navarre and almost twice for Stuttgart.
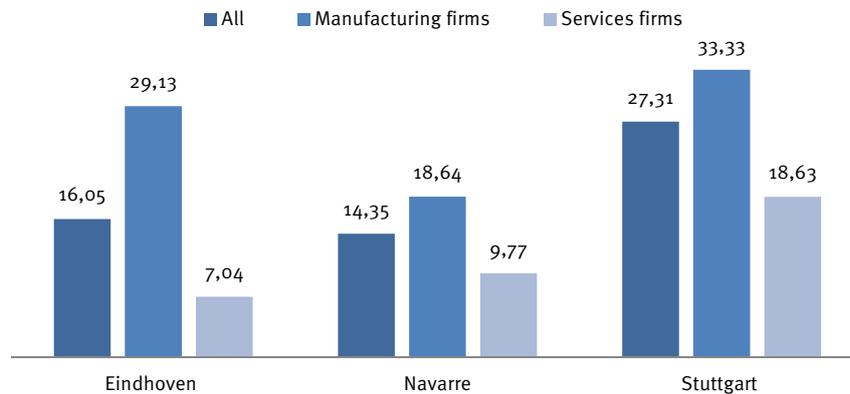
Figure 4. Percentage of firms engaging in external R&D activities

In order to gain a deeper understanding of the importance given to R&D activities, we present in Table 3 the R&D intensity (R&D expenditure/total sales) by industry type and firm size. Firm size is measured as the number of employees in the firm; small firms are those with fewer than 50 employees, medium between 50 and 250 employees and, large those with more than 250 employees. The first row, shows the mean R&D intensity for the regions. In the case of Eindhoven, the mean is 2.37; Navarre has the highest R&D intensity with a mean of 2.84, and the lowest intensity is for Stuttgart firms with a value of 1.34. Considering that Stuttgart firms were those with the highest involvement in R&D, it is surprising to observe in Table 3 that these firms have the lowest R&D intensity.

Table 3. R&D intensity by region

	Eindhoven	Navarre	Stuttgart
All	2.37	2.84	1.34
Manufacturing	4.20	2.43	1.54
Services	1.12	3.29	1.11
Small	1.38	3.48	1.46
Medium	2.02	1.74	1.14
Large	9.23	1.14	1.26

As mentioned previously, it is important to observe the industry effects. For Eindhoven, there is a large difference in the R&D intensity between manufacturing and service firms. Manufacturing firms, on

average, dedicate 4.20 per cent of their sales to R&D activities while service firms invest 1.12 per cent of their sales. Stuttgart manufacturing firms also invest more than service firms (1.54% and 1.11%, respectively) but the difference is smaller than that observed in Eindhoven. Interestingly, service firms in Navarre have a larger R&D intensity than their counterparts; they invest 3.29 per cent of their sales in R&D while manufacturing firms invest 2.23 per cent of their sales. Since percentages were used, this does not mean that service firms spend more on R&D, rather that they make a great effort in the investment[6]. By comparing the three regions, we can appreciate that, for manufacturing firms, Eindhoven leads the R&D intensity but, for service firms, Navarre firms invest more than double that of the other two regions.

Stuttgart has the largest percentage of innovative firms but they have the lowest commitment to these activities since their R&D intensity is the lowest.

When R&D intensity is disaggregated by firm size, see Table 3, interesting data emerge. The classical Schumpeterian [29] hypothesis, not always supported in the literature, argues that larger firms have higher R&D intensity as they can provide economies of scale in production and innovation. This hypothesis seems to hold for Eindhoven where there is a huge difference between the R&D intensity of large firms in comparison to small firms. The mean of this variable is 9.23% and this might be due to the fact that there are a couple of large international firms based in this region. Additionally, this extreme value might be dependent on the year 2008, in which the CIS survey was taken. In Navarre and Stuttgart, there is an opposite behaviour to that argued by Schumpeter. Navarre's small firms have more than the double the R&D intensity of the large firms, that is to say, 3.48 as opposed to 1.14 per cent. For this region, we can observe a negative relationship between firm size and R&D intensity. Finally, Stuttgart's small firms also have the highest R&D intensity (1.46%) compared to the other firms in the region, but it is considerably lower than for Navarre's small firms. Nevertheless, the R&D-size relationship seems to have a U formation as the medium firms have the lowest R&D intensity (1.14%).

4.2 Innovation outputs

As Griliches [16] argues, the innovation process is characterised as an input-output production process. In this sense, once we have observed some of the inputs used in this process we proceed to Figure 5 which presents the percentage of firms, by region, that achieved at least one of the innovation outputs presented: product, process, service and patents..

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[6] The mean of the R&D expenditures is higher for manufacturing firms (2.97e+7€) than for service firms (1.20e+7€) and the sales are lower for service firms (1.87e+7€) than for their counterparts (3.56e+7€).

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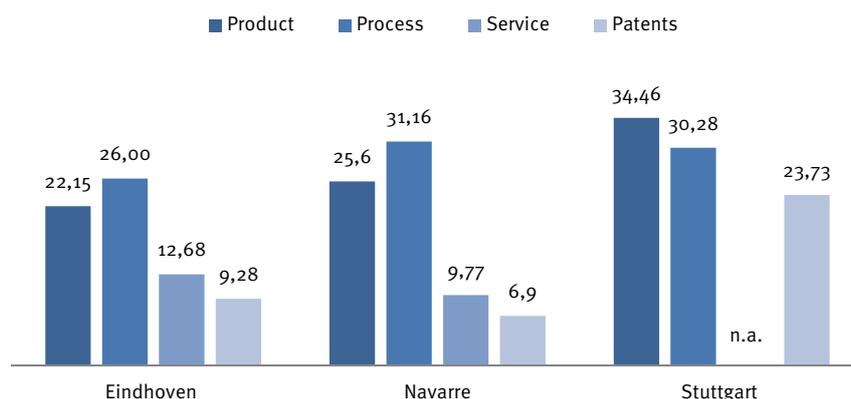
4. Innovation behaviour

Figure 5. Percentage of firms that achieved innovation outputs

Note: There is no information available for the number of firms that achieved service innovations in Stuttgart.

It can be seen that Stuttgart is the region with the highest percentage of firms innovating in products and obtaining patents (34.46 and 23.73 per cent, respectively). The major difference between Stuttgart and the other regions is in the percentage of firms patenting; while in Stuttgart 23.73 per cent of firms patent, in Eindhoven the percentage goes down to 9.28 and it is even lower for Navarre (6.9%). In the product innovation achievement, Eindhoven and Navarre have similar figures; Navarre is slightly higher, but almost 10 per cent below Stuttgart. Service innovations have a lower percentage than product and process innovations for Eindhoven and Navarre. In this case, Eindhoven has a larger value (12.68%) than Navarre (9.77%). One pattern that should be highlighted is the fact that in Eindhoven and Navarre the importance given to process innovations is higher than that for product innovations. However, Stuttgart seems to concentrate on product innovations rather than process innovations.

Consistent with the comparison between manufacturing and service firms in Table 4, the percentage of firms that achieve a certain innovation output is presented by industry type. At first glance, it can be appreciated that manufacturing firms are more innovative than service firms, as all figures are higher. This result is highly important for Navarre since service firms have a higher R&D intensity than manufacturing firms but they achieve fewer innovations. The origin of this problem might be in the inefficient use of innovation inputs. For Eindhoven and Stuttgart this is not distressing as the R&D intensity is lower for service firms. This table also shows that Eindhoven's manufacturing firms achieve more service innovation than service firms, which might be evidence for the shift towards firms offering product-service combinations. This new trend is known as servitisation, which is the innovation of an organisation's capabilities and processes to shift from selling products to selling integrated products and services that deliver value in use [4].

Table 4. Percentage of firms that achieved innovations

Innov. Outputs	Manufacturing			Service		
	Eindhoven	Navarre	Stuttgart	Eindhoven	Navarre	Stuttgart
Product	39.37	38.49	28.2	10.29	11.85	11.55
Process	40.15	49.47	33.04	16.26	26.12	20.07
Service	15.74	9.17	n.a.	10.56	10.41	n.a.
Patents	17.32	9.62	32.2	3.84	4	9.49

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4. Innovation behaviour

The number of manufacturing firms achieving product innovations is very similar for Eindhoven and Navarre, around 39 per cent. Stuttgart has a mean ten points lower for the same innovation output. With regard to service firms, the figures for the three regions for firms innovating in product are similar, around 11 per cent. Navarre is the region where both industries have the highest percentage of firms obtaining process innovations. Nearly 50 per cent of manufacturing firms achieved at least one process innovation, compared to 40.15 per cent for Eindhoven and 33.04 per cent for Stuttgart. 26.12 per cent of Navarre service firms came up with process innovations, 6 per cent more than Stuttgart and 10 per cent more than Eindhoven.

Regarding service innovations, Eindhoven has 15.74 per cent innovative manufacturing firms, while Navarre has 9.17 per cent; but the percentage is very similar for both regions for service firms. Finally, there is a clear predominance for Stuttgart in terms of patents,

When we compare the three regions, we observe that each region has a core competence: Eindhoven firms lead in terms of service innovations; Navarre has the highest percentage of firms achieving process innovations and Stuttgart's dominance is in the field of patents and product innovation.

as 32.2 per cent of manufacturing firms and 9.49 per cent of service firms patent. The percentages for Eindhoven and Navarre are considerably lower.

In conclusion we venture to identify that each region has focused on one comparative advantage. Figure 5 and Table 4 have helped to identify that Eindhoven's firms are more innovative in terms of service. On the other hand, Navarre registered the largest number of firms obtaining process innovations, both for manufacturing and service firms. The predominance of Stuttgart is clear in the field of patents.

5. Open innovation practices

This section is reserved for the analysis of open innovation practices within the three regions. Four types of open innovation models are considered:

- *Breadth of open innovation*
- *Depth of open innovation*
- *External R&D expenditure*
  Breadth of cooperation agreements

As defined by Chesbrough [10], firms have changed from a closed innovation paradigm to an open innovation approach, where firms open their boundaries and absorb external knowledge in order to create substantial innovation; outside-in knowledge flow. This new paradigm has been increasingly used by firms as the products and processes offered in the market require a variety of knowledge and technology making it very costly and difficult for a firm to do everything in-house [35]. The open innovation approach also defends the idea that the knowledge flow should be inside-out; that is to say, firms should make profits through licensing or patenting, for example, the knowledge developed internally. Figure 1 represents the graphical model proposed by Chesbrough. As observed, the boundaries of the firm are permeable and knowledge and information flow to and from the firm. Although the inside-out component of the open innovation model is essential, the CIS does not provide information about these practices. Therefore, we limit our analysis to the outside-in component and this section aims to observe to what extent firms based in the three regions of analysis implement these practices.
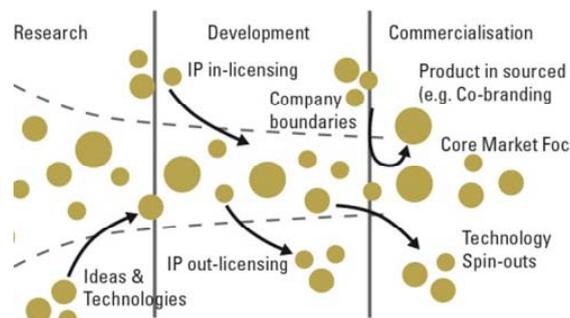
Source: http://www.openinnovation.eu   Figure 1. The open innovation model

5.1 Breadth and depth

Laursen and Salter [21] developed the concepts of open innovation breadth and depth to represent the use of a range of external actors as a source of information and new ideas. These concepts have been widely used in the literature to measure a firm's openness and the impact that open innovation strategy has on a firm's performance. Breadth accounts for the number of external information sources on which the firm relies in its innovative activity. The depth concept is defined in terms of the extent to which a firm relies on external information sources.

Based on the CIS survey, in Eindhoven we can identified nine different agents that serve as information sources: suppliers, clients, competitors, consultants or R&D private institutes, universities, public research centres, conferences, scientific journals and industry associations. Therefore, by adding up the number of sources used, the breadth variable ranges from 0, where no source is used (totally closed), to 9 when all sources of information are used (totally open).

The mean of the breadth variable obtained for Eindhoven is 1.23; this means that, on average, firms rely on more than one external information source for their innovative activity. Figure 6a shows how the percentage of firms with open innovation practices decreases as the degree of openness increases. As a result, 64.69 per cent of Eindhoven firms still follow the traditional closed innovator approach, while just 1.44 per cent of firms use all available external sources. Recoding the breadth as low (1 to 3 agents), medium (4 to 6 agents) and high (7 to 9 agents), it can be observed in Figure 6b that 65 per cent of Eindhoven firms (403 observations) are still following the traditional closed innovation model and do not interact with external agents. From the firms that are open, most of them have a low degree of breadth (124 observations); that is to say, they interact with a maximum of three external sources. Firms with medium breadth represent 12 per cent (74 observations). Those firms with a high level of breadth and openness represent only 3 per cent of the sample (22 observations)[7].
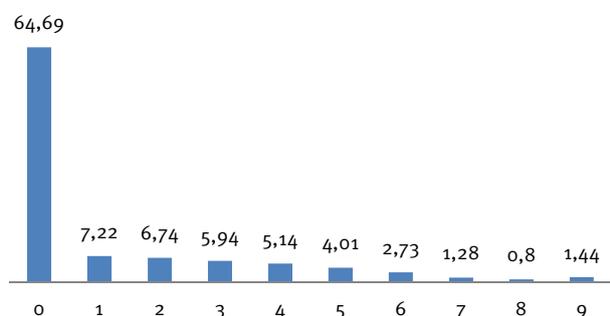
Figure 6a. OI breadth in Eindhoven
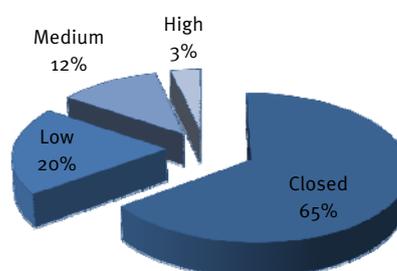
Figure 6b. OI breadth in Eindhoven

For the Navarre region, the CIS provided ten different external information sources. These are the same as for Eindhoven, but consultants and private R&D institutes are considered independently. Therefore, the breadth and depth range from 0 to 10. The mean breadth is 2.79, which indicates that open firms use almost three information sources for ideas. As observed, the mean breadth openness is higher for Navarre and this is due to the fact that there are fewer firms following the closed approach. The Figure 7a histogram shows the distribution of OI breadth across the sample. In contrast to Eindhoven, the

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[7] The reader needs to bear in mind the low number of observations for the high level of OI breadth while interpreting the percentages.

percentages do not decrease as the degree of openness increases. The second concentration of firms, after those that are closed, is for the highest OI breadth level (10 external sources) and there is no decreasing tendency as for Eindhoven. Figure 7b shows that 53 per cent of Navarre firms are closed[8] (12 per cent less than Eindhoven) and do not refer to external information sources for innovation. As Navarre has a breadth range from 0 to 10, the low level of breadth comprises 1 to 3 information sources, medium, 4 to 7 and, high, 8 to 10. These openness levels evenly embrace the remaining observations: 13, 17 and 17 per cent for low, medium and high, respectively. These results show that Navarre firms are committed to open innovation practices as most of the open firms have a medium or high degree of OI breadth. As appreciated, the opened firms have a considerably larger degree of openness than firms based in Eindhoven. Decoding these percentages for Navarre, there are 679 observations in closed-breadth level, 167 in low, 220 in medium and 223 in high. This number of observations needs to be borne in mind when interpreting the importance of the percentages.
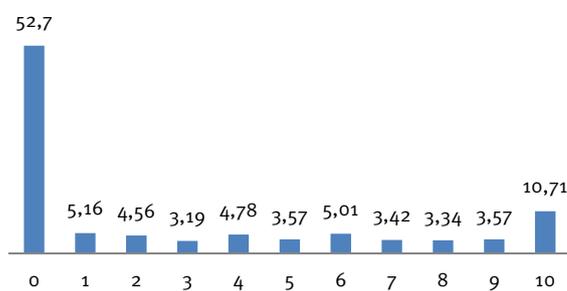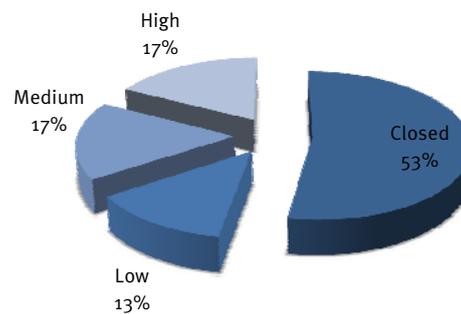

Figure 7a. OI breadth in Navarre   Figure 7b. OI breadth in Navarre

In the case of Stuttgart, the CIS only included six different sources of external information[9]: other firms (customers), consumers (customers), material suppliers, service providers, competitors, and universities and research institutes. Therefore, the highest degree of OI breadth is six. Results showed that the mean OI breadth is 1.59. Although the figure is smaller than that for Navarre (2.79%), if we consider the scale of the mean, taking into account the maximum number of external information sources, the figures are fairly similar but slightly higher for Navarre (1.4 per cent of difference). Figure 8a shows the distribution of the different levels of OI breadth in Stuttgart and, as for Eindhoven, the higher the level of OI breadth, the lower the percentage of firms. Unexpectedly, all the firms based in this region use at least one external agent as an information source for the innovation process. This is an immense difference compared with the other two regions. This clearly shows that firms in this region have shifted from closed innovation to an open innovation process. As Stuttgart recognises six external sources, the degrees of breadth range from 1-2 for low, 3-4 for medium and 5-6 for high. Figure 8b illustrates that more than half of firms have a low level of openness (60%, which accounts for 1107 observations); to be precise, they use one or two external sources of information. 11 per cent of firms have a medium breadth level of openness (303 observations). We can also see a large percentage of firms with a high degree of

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[8] The Stuttgart CIS do not include the variables of information sources as in the Navarre and Eindhoven regions. The breadth variable for Stuttgart was created using a proxy of the external information sources. The survey disaggregates the cooperation in the phases of the innovation process: 1) idea generation, 2) research, development and modelling, 3) form, design, 4) test/evaluation, production/distribution and 5) market introduction, implementation. As also the CIS in Germany indicates whether the cooperation was formal or informal, then we could filter those informal cooperation that were for the idea generation phase and calculate the breadth for each firm. As the cooperation variables do not indicate whether the cooperation during the idea generation where important or not, the depth variable could not be calculated.

OI breadth (29%, 826 observations). The striking finding that all firms in Stuttgart are open in breadth might be related to using a different measurement procedure to the other two regions.
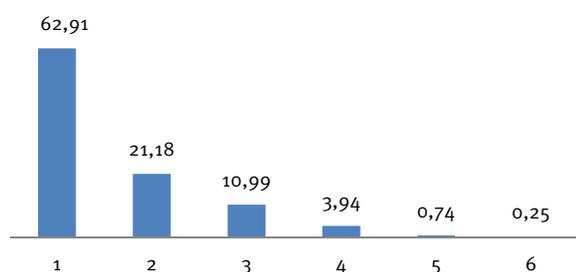

Figure 8a. OI breadth in Stuttgart
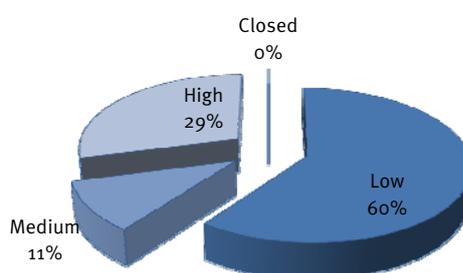
Figure 8b. OI breadth in Stuttgart

Respondents of the CIS also indicated the importance of the information source used on a scale of 0 (not used) to 3 (highly important). This rank was recorded as one when a firm reports that it uses the source to a high degree and zero otherwise. Similar to the breadth variable, the nine sources are totalled so that each firm obtains a score of 0 when no source is used extensively. Conversely, the firm gets a score of 9 when all sources are considered to be highly important. The resultant variable is named depth, representing the importance given to the external sources used. Unfortunately, the German CIS does not include this information and the depth variable could not be generated for Stuttgart.

With regard to the depth of OI practices, results show that the mean for Eindhoven is 0.38, that is to say, they consider, on average, that less than one information source is important for the innovation process. The mean for the depth variable is much lower than for breadth (1.23), indicating that, although firms use at least one of the available external sources, they are not committed to it. Observe in Figure 9a that 80 per cent of the firms are closed (500 observations) according to the OI depth definition and that the percentage of firms decreases as OI depth increases. From those firms that are open, 90 per cent registered a low level of openness depth, 18 per cent of the total sample (111 observations) (Figure 9b). Merely, 1.28 per cent recorded a medium level (8 observations) and 0.64 per cent a high degree of openness (4 observations)[10].

Figure 9a. OI depth in Eindhoven

Figure 9b. OI depth in Eindhoven

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[10] As mentioned earlier, this percentage should be interpreted considering also the number of observations it represents.

5. Open innovation practices

In Navarre, the mean obtained for OI depth is 0.54 showing that most of firms considered less than one external information source to be important. Observe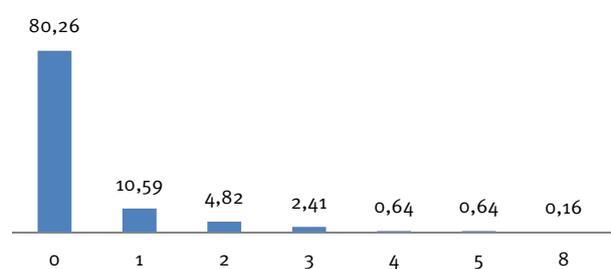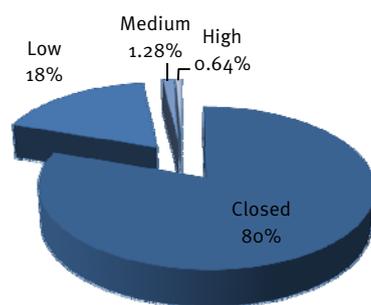 the distribution of OI depth in Figure 10a. Nevertheless, this percentage is very low as it also considers closed innovators. The mean of the depth exclusively for open innovators is 1.9 indicating that those firms with open boundaries have strong ties with almost two external agents. When reclassifying depth on three levels (Figure 10b), it can be observed that 73 per cent (921 observations) are closed –the discrepancy with the closed innovators according breadth is due to the fact that not all firms that used a certain source consider it as important- and, within the open innovators, most have a low OI depth (24 %, 328 observations), 3 per cent (38 firms) have a medium level and merely 0.1 per cent (2 observations) have a high degree of depth openness.
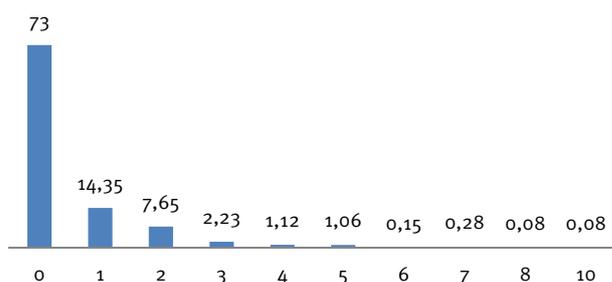
Figure 10a. OI depth in Navarre
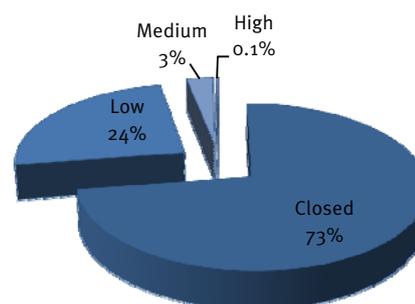
Figure 10b. OI depth in Navarre

From the above graphs, we can notice that the region with the most open firms is Stuttgart, as all of them use at least one external information source. Additionally, the percentage of firms with a high degree of OI breadth is notably high. Conversely, most of the firms in Eindhoven and Navarre are closed and, in the former, most of them have a low degree of openness. Moreover, the importance given to the information received from external sources seems to be extremely low for the regions under analysis. The "not invented here" (NIH) syndrome might be present within firms in those regions.

We also want to observe whether there are differences in OI practice across industries. Prior research seems to indicate that hypothesis. Atuahene-Gima [3] argues that service firms differ from physical goods in terms of intangibility, inseparability, heterogeneity and perishability. Therefore, given the distinct nature of offerings from manufacturing firms, it is plausible that there would be different behaviours in the adoption of OI practices. The logic behind this is that physical goods are more separable and homogeneous, making it easier to outsource part of the R&D process [33].

In order to observe whether there is an industry and size effect on the adoption of OI practices, we split the sample into manufacturing and service firms. Figure 11 accounts for the disaggregation of the levels of OI breadth across the different regions and Figure 12 the OI depth practices across industries. From Figure 11, we learn that there is an industry effect on OI practices as firms in service industries have a lower degree of OI breadth than manufacturing firms. This is in line with Van de Vrande et al.'s [33] arguments that manufacturing firms are more prone to engage in OI since they are characterised by globalisation, technology intensity, technology fusion, new business models and knowledge leveraging.

76.42 per cent of service firms in Eindhoven are closed, but this figure reduces to 47.64 per cent for manufacturing firms, almost 30 per cent less. Moreover, the firms with a high level of openness represent a lower percentage for service firms (0.81%) than for manufacturing firms (7.48%). Not only does the percentage of closed innovators vary across industries, but also the level of openness, since

5. Open innovation practices

Eindhoven and Navarre have larger percentages for all levels of openness within the manufacturing industry. Stuttgart, as mentioned before, has no closed firms and there are more manufacturing firms than service firms with a low level of OI, 61.19 and 59.02 per cent, respectively. Likewise, Figure 12 indicates that there is an industry effect on OI depth, as there are more closed innovations in the service industry than for manufacturing, both for Eindhoven and Navarre.
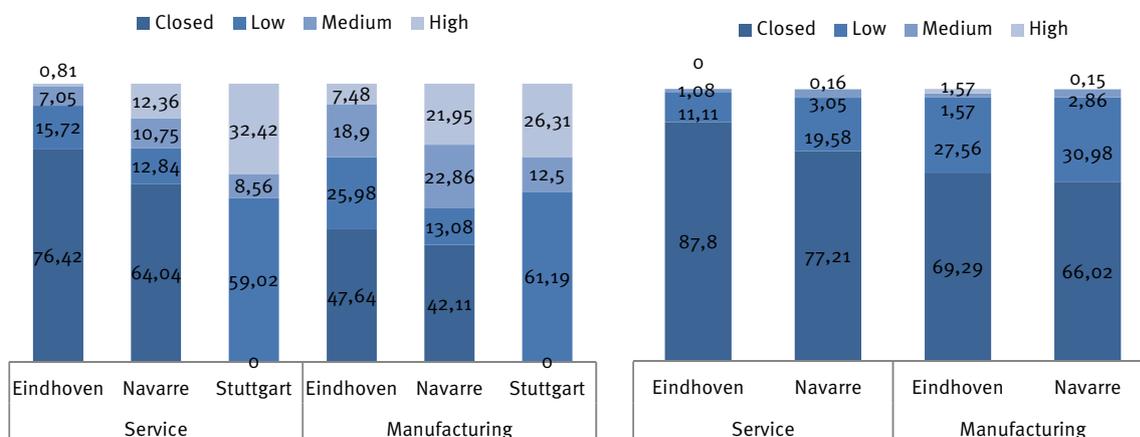
Figure 11. OI breadth by industry

Figure 12. OI depth by industry

Past research has shown that innovation strategies differ greatly between large firms and SMEs [1]. Large firms usually have a more structured and standardised innovation process and, due to their size, have developed the adequate structure for licensing IP, undertaking activities and external participations. Furthermore, large firms have greater resources to create a diversified innovation portfolio and to finance innovation activities.

On the basis of the above, Table 4 disaggregates the samples into three levels according to firm size. As observed, there is also a firm size effect on the practice of the OI approach. It is clear that the percentage of closed firms decreases as firm size increases, both for Eindhoven and Navarre and for both types of OI measure. Furthermore, firm size impacts not only on engagement in OI practices, but also on the OI breadth. That is to say, in the case of Navarre and Eindhoven, the percentage of firms with a high degree of OI breadth increases with the firm size. What calls our attention, is the fact that none of Eindhoven or Navarre's large firms have a high degree of OI depth. That is to say, large firms do not rely extensively on external information sources[11]. Stuttgart has a different pattern, as all firms look for information beyond the firm's boundaries no matter what size they are. Contrary to the other two regions, small firms seem to be more committed to OI breadth than their counterparts.

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[11] Bear in mind that the number of observations for OI depth is 4 for Eindhoven and 2 for Navarre.

Table 4. Firm size and OI practices

Region	Firm Size	OI breadth				OI depth			
		Closed	Low	Med.	High	Closed	Low	Med.	High
Eindhoven	Small	74.76	15.14	8.83	1.26	84.54	14.20	0.95	0.32
	Medium	57.44	23.14	14.46	4.96	75.62	21.49	1.65	1.24
	Large	40.32	32.26	17.74	9.68	75.81	22.58	1.61	0
Navarre	Small	57.95	13.19	15.31	13.55	74.68	22.73	2.47	0.12
	Medium	47.46	12.99	19.21	20.34	69.21	26.84	3.67	0.28
	Large	22.35	10.59	24.71	42.35	48.24	47.06	4.71	0
Stuttgart	Small	0	61.09	8.15	30.76	-	-	-	-
	Medium	0	62.50	11.12	26.38	-	-	-	-
	Large	0	50.95	21.25	27.79	-	-	-	-

There is an industry and a firm size effect on the adoption of OI practices. Manufacturing and large firms are more open.

5.2 Cooperation agreements

Besides the two dimensions of open innovation proposed by Laursen and Salter [21], breadth and depth, we also consider that formal collaboration agreements are a crucial component of open innovation that should be explored. These measurements are complementary, as open innovation breadth and depth account for an informal open innovation strategy while collaboration agreements represent formal, and usually long-term, open innovation practices.

Following the same methodology as the information sources, we generated the cooperation breadth variable. For Eindhoven, the range of cooperation breadth is from 0 to 7 (cooperation with: firms within the group; suppliers; customers; competitors; research institutes; universities and governmental institutions). For Navarre, the range is from 0 to 8 (the same cooperation partners as Eindhoven plus technological research centres) and, finally, for Stuttgart, it is from 0 to 6 (the same cooperation partners as Eindhoven minus governmental institutions). The corresponding means for cooperation breadth for the three regions is 0.54, 0.39 and 1.38; for Eindhoven, Navarre and Stuttgart, respectively. As observed, Stuttgart is again the region with the most formal OI practices.
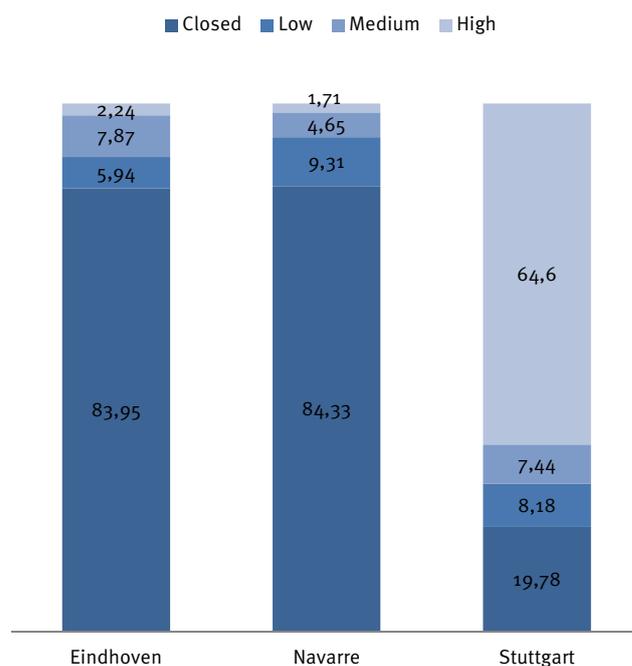
5. Open innovation practices

Figure 13. Cooperation breadth

Figure 13 shows the percentage of firms that have cooperation breadth as low, medium and high. These results are interesting and highlight the difference in open innovation practices between the three regions. Almost 84 per cent of Eindhoven firms do not have any formal cooperation agreement (523 firms), 5.94 per cent have a low degree (37 observations), 7.87 per cent a medium degree (49 observations) and only 2.24 per cent of firms cooperate with more than five external agents (14 observations)[12]. Navarre has similar figures to Eindhoven; 84.33 per cent of firms are closed but, among the open firms, most of them have a low degree of openness (9.31%). In Navarre, there are 1087 closed firms, according to the cooperation breadth, 120 with a low level, 60 with a medium level and 22 with a high level. On the other hand, Stuttgart has the lowest degree of closed firms, as only 19.78 per cent are closed. Interestingly, most of the firms have a high OI degree (64.6%) and there are a similar proportion of firms with a medium and low degree of cooperation breadth openness. These percentages translate into the following observations for breadth: 561 closed firms, 232 low level firms, 211 medium level firms and 1832 high level firms[13].

In order to observe whether there is an industry effect on formal open innovation practices, Figure 14 shows the distribution of firms according to industry type. As observed, there does seem to be an industry effect on formal open innovation practices. 91.87 per cent of Eindhoven service firms do not have contractual cooperation agreements while, for manufacturing firms, the percentage is reduced to 71.44 per cent. The same pattern is observable for Navarre, but with fewer differences across industries (87.64% vs. 81.2%). Once again, Stuttgart stands apart and the previous pattern is broken since the percentage of closed firms for manufacturing and service industries is practically the same, 19.7 and 19.88 per cent respectively. Furthermore, we observe that the commitment to open innovation practices, cooperation breadth, is similar in the two industries with around 64% of firms exhibiting a high degree of openness.

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[12] The reader needs to bear in mind the magnitude of these percentages in terms of number of firms.

[13] It must be borne in mind that the number of partners considered in the German CIS is the smallest from among the three regions. Therefore, interpretation of the results by the reader must be performed carefully.
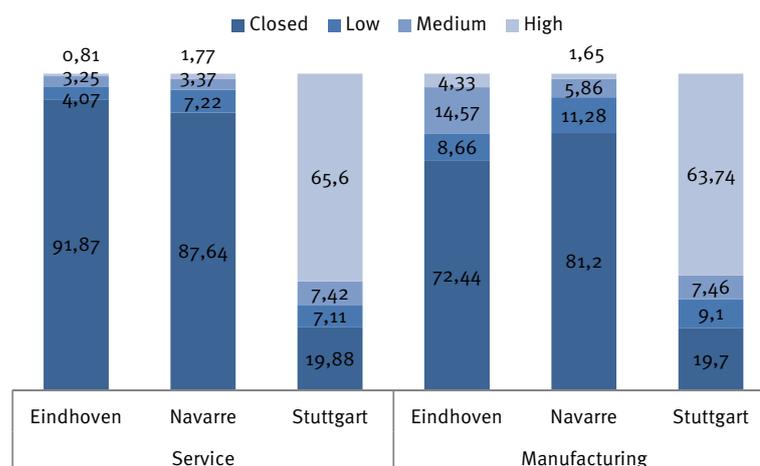
Figure 14. OI cooperation breadth by industry

The commitment with the formal open innovation form increases with firm size.

Similar to the effect of firm size and OI breadth and depth, in Table 5 it can be perceived that, for all regions, there seems to be a positive relationship between firm size and engagement in formal cooperation agreements. Observe how the percentage of closed firms decreases as firm size increases. For example, 88.57 per cent of Navarre small firms are closed but merely 58.8 per cent of large firms are closed. Furthermore, the degree of commitment to cooperation agreements also increases with firm size, that is to say, just 0.47 per cent of small firms have a high degree of OI cooperation breadth while this percentage increases to 11.76 for large firms in Navarre. From Table 5, we learn that Stuttgart firms are the most open in terms of cooperation agreements; it is evident that they have both the lowest levels of closed firms and the highest figures for highly open firms, for all sizes of firm. It is surprising that 61.69 per cent of small firms and 71.66 per cent of large firms have more than four collaboration agreements.

Table 5. Firm size and cooperation breadth

| Region | Firm Size | OI cooperation breadth | | | |
		Closed	Low	Med.	High
Eindhoven	Small	91.80	3.79	3.47	0.95
	Medium	78.10	8.26	11.57	2.07
	Large	66.13	8.06	16.13	9.68
Navarre	Small	88.57	8.13	2.83	0.47
	Medium	80.23	10.73	6.78	2.26
	Large	58.82	15.29	14.12	11.76
Stuttgart	Small	23.92	7.73	6.65	61.69
	Medium	15.88	8	8.62	67.5
	Large	9.26	10.63	8.45	71.66

5.3 External R&D expenditure and knowledge acquisition

Figure 4, section 3.1, presents the percentage of firms that partially or totally source R&D from external agents. The reader will recall that Stuttgart had the highest percentage of firms involved in this practice with a percentage of 27.31 per cent, followed by Eindhoven (16.05%) and Navarre (14.35%). For the three regions, Figure 4 also showed that manufacturing firms have a greater commitment to external R&D than their counterparts. In this section, we analyse the importance attached to these activities through the percentage of total innovation expenditure represented by external R&D. Figure 13 shows this OI measurement for Eindhoven and Navarre for the entire sample and for service and manufacturing firms. Due to the limitations of the data, this variable could not be generated for Stuttgart.
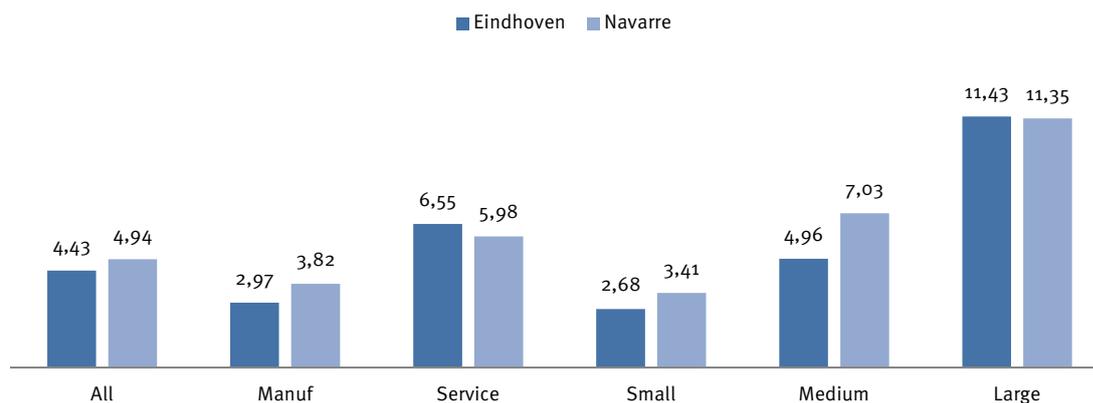
Figure 13. Percentage of external R&D relative to total innovation expenditure

As observed, Navarre firms are slightly more committed to this type of OI practice, as the percentage is higher, 4.94 vs. 4.43 per cent. From Figure 4, we learned that there were more manufacturing firms achieving external R&D, but Figure 13 indicates that their commitment is lower than service firms as they invest less in external R&D as a proportion of total R&D expenditure. It can also be noticed that large firms are more likely to trust in outsourcing R&D as they have an external R&D intensity around three times greater than small firms and around 50 per cent greater than medium firms. These results are in line with the open innovation breadth shown in Table 5.

As Chesbrough [10] argues, firms should open their boundaries and actively seek out new technologies, knowledge and ideas. Therefore, the CIS allows us to analyse a fifth component of OI practices: external knowledge acquisition. This variable accounts for the purchase or use, under license, of patents or other unpatented inventions and other types of technical knowledge. As shown in Figure 14, there is a large difference between the firms in Eindhoven and Navarre. 6.26 per cent of the former and merely 1.31 per cent of the latter acquire external knowledge. This difference increases for manufacturing firms but decreases for service firms. For Eindhoven, it seems that manufacturing firms are more prone to these activities than service firms but, for Navarre, there are no notable differences between the industries.

Figure 14. Percentage of firms acquiring external knowledge

There are more firms in manufacturing industries sourcing external R&D but their commitment is lower than that of service firms.

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6. Determinants of open innovation adoption

Discovering which are the determinants that make firms more open or closed than others is crucial. Following previous studies, we consider that offensive goals, such as innovation objectives, and defensive aims, innovation hampering factors, shape the firm's decision to engage in OI activities.

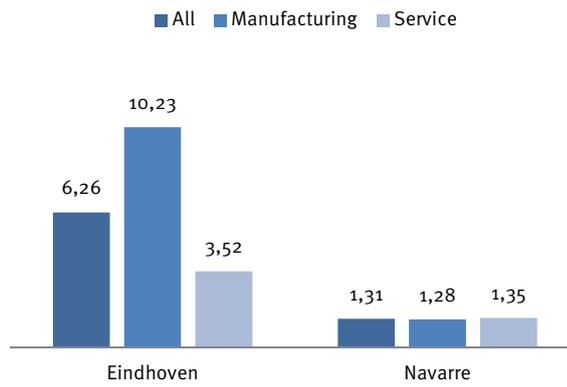*Additionally, the role of governmental actions in funding R&D activities is also analysed in this chapter. Three different types of public funds are examined: a) Regional, b) National and c) European.*

6.1 Offensive determinants

Chesbrough [10] argues that many firms started implementing OI practices as a necessary adaptation to developments in recent years as, due to the specificity and complexity of technology, firms can no longer do everything in-house. In his later work with Crowther [11], he observed that the most common determinant of OI adoption is a common belief among managers that it is critical to maintain growth. Some of the well-known reasons for why firms cooperate with external agents include a desire to acquire missing knowledge and complementary resources, spread risk and reduce costs [17,22]

The recent work of Van de Vrande et al. [33] identifies that the motives for configuring different inbound models of OI are similar. They observe that the most important motives are market-oriented and those relating to control, focus, cost and capacity are less frequently cited. In addition, Barge-Gil [5] states that internal R&D, firm size and firm sector are variables that explain OI engagement. He argues that, due to the fact that internal R&D enhances absorptive capacity, those firms that perform internal R&D are able to reduce the cost of OI practices.

In the case of the CIS, different motives may be found, offensive determinant, for developing innovation activities. Eindhoven registered ten different motives, while Navarre registered thirteen different goals for the innovation objectives. Unfortunately, this information was not available for Stuttgart. These different goals were aggregated[14] into three groups: a) objectives related to product innovation; b) those

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[14] The aggregation was made using the alpha methodology in Stata, which computes inter-item correlations (covariances) and Cronbach's alpha. All Cronbach's values were higher than .70.

related to process innovation; and, c) environmental effect. These variables range from 0, if the objective is not important, to 3, if the objective is very important. The objectives related to product innovation represent increasing the range of goods and services, replacing outdated products or processes, entering new markets or increasing market share and improving the quality of products. The objective related to process innovation makes reference to improved flexibility and capacity to produce and reduce the costs per unit output. Finally, environmental effect refers to improved health and safety.

Figure 15 shows the importance attached to each of the innovation motives. As shown, for Eindhoven and Navarre firms, the product goal is the most common innovation objective, but Navarre firms consider it to be more important, 0.84 out of 3. The second objective for both regions is the process goal and the environmental motive is the least important. The tendency is consistent across the industries but the importance attached is always higher for manufacturing firms.
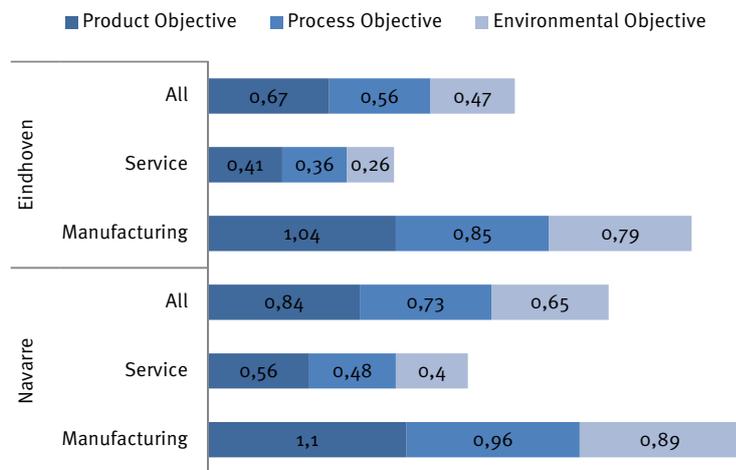
Figure 15. Motives for innovation activities

6.1.1 OI practices and offensive determinants

Next we present observations on the relationship which exists between innovation objectives and OI practices, that is, we aim to depict whether open firms are more prone to look for one specific innovation objective than closed firms. Figure 16 shows the relationship between the degree of OI breadth (closed, low, medium and high) and the innovation objectives described above.

6. Determinants of open innovation adoption
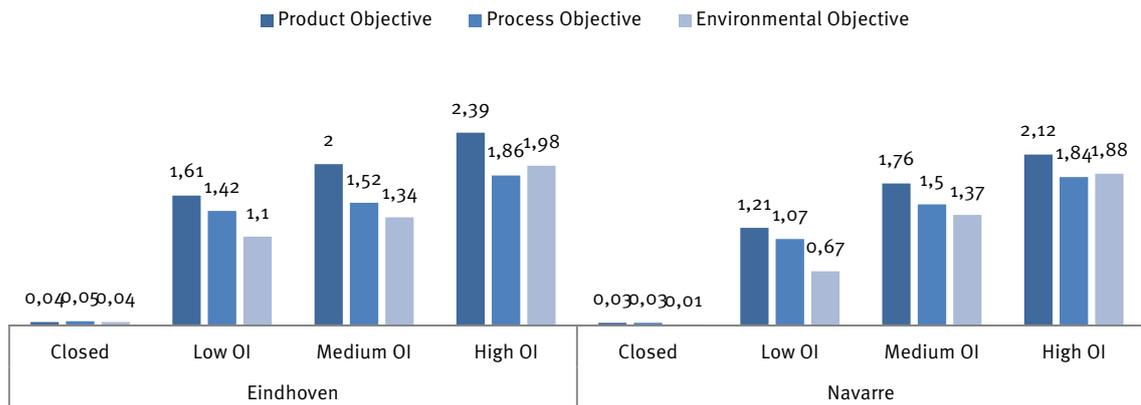
Figure 16. Degree of OI breadth and innovation objectives

As expected, the figure shows a positive relationship between these variables. In both the Eindhoven and Navarre regions, closed firms rank the innovation objectives at a lower level than open firms. Additionally, there seem to be differences in the valuation of innovation objectives among open firms.

For Eindhoven, for all innovation objectives, the more open the firm, the higher the importance it attaches to the innovation objective. As in Figure 15, the most important innovation motivation is product, followed by process and environmental. Navarre has a very similar composition, as the higher the openness breadth, the higher the importance of the innovation objective.

Figure 17 shows the relationship between OI depth and innovation objectives. Most of the tendencies observed for OI breadth remain similar but slight differences emerge. First, closed firms from both samples, according to OI depth, ranked innovation goals higher than closed OI breadth firms. The reason behind this fact is that some of the open firms according to the breadth definition (number of information sources) might be closed according to the OI depth definition (importance given to the information sources). Second, all highly depth-open firms in Eindhoven ranked all the innovation objectives, as very important; that is to say, open innovators are committed to all innovations[15]. Third, for medium open-depth Navarre firms, environmental innovation goals are more important than process innovation goals.
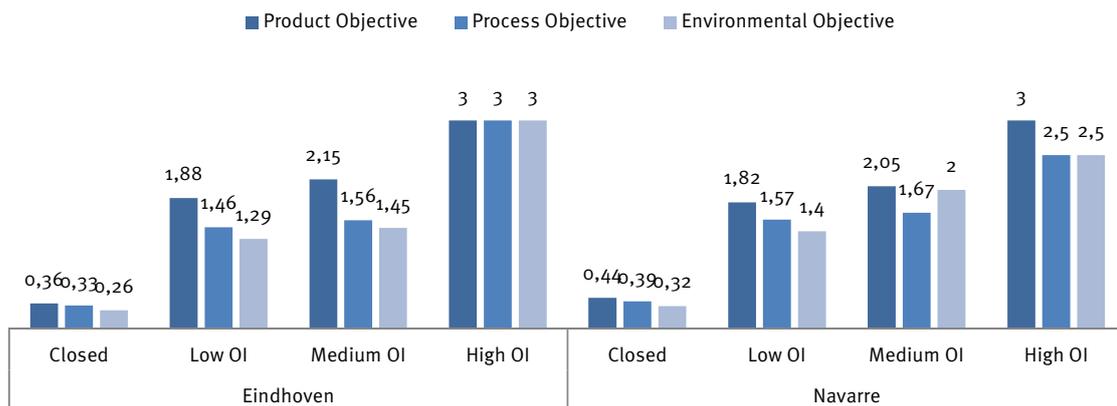
Figure 17. Degree of OI depth and innovation objectives

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[15] This statement has to be considered carefully due to the small number of observations in the high depth level.

Finally, Figure 18 represents the relationship between OI cooperation breadth and innovation objectives. As is the case for OI breadth and depth, there is a positive relationship between the degree of openness and the importance attached to the innovation objectives. The most important thing to mention here is that cooperation breadth-closed firms ranked the innovation objectives at a higher level than breadth-closed and depth-closed. Once again, the logic is that these closed cooperation-breadth firms might include open-breadth or open-depth firms.

Open innovators are more conscious of the importance of innovation objectives than closed innovators.

Product innovations outrank the rest of the innovation goals.
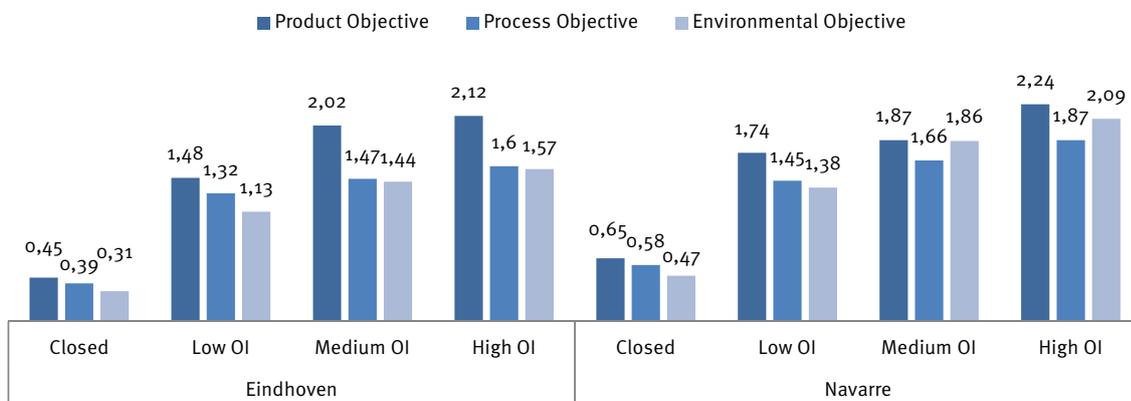
Figure 18. Degree of OI cooperation breadth and innovation objectives

6.2 Defensive determinants

Firms might not only have offensive incentives to embark on OI; they may also have defensive motivations that might incentivise or disincentivise them to engage in OI practices. One of the traditional barriers to the acquisition of external knowledge is the NIH syndrome [18]. The NIH syndrome and lack of internal commitment were the two main hampering factors for adopting OI identified by Chesbrough and Crowther [11]. In the recent work of Van de Vrande et al. [33] it is shown that the most important barriers that firms face when engaging in OI are organisational and corporate culture-related issues. Additionally, they found that availability of time and resources are other significant hampering factors.

The CIS for Navarre also gathers this information and contemplates eleven distinct hampering factors that were grouped into four categories: a) cost obstacle; b) knowledge obstacle; c) market obstacle; and, d) innovation obstacle. The cost obstacle represents the lack of funding and the high cost of innovation. The knowledge hampering factor represents a lack of information about the market, technology and partners. Market dominance by another firm and market demand uncertainty effects are grouped in the market hampering factor. Innovation obstacle makes reference to the lack of a need to innovate, either because the firm has already done so, or because there is no demand for it. The Stuttgart CIS considers

thirteen different obstacles that were also grouped into four categories. The first three categories are the same as for Navarre (cost, knowledge and market) but the fourth represents obstacles related to internal problems. For both regions, each variable ranges from 0 (not important) to 3 (highly important). Unfortunately, the CIS for Eindhoven does not include this information.

Figure 19 shows the hampering factors for developing innovation activities for Navarre and Stuttgart firms. In the case of the Navarre complete sample, the most important hampering factor is cost and it has a ranking of 1.42 out of 3. The second most important factor is market, with a value of 1.23, followed by the knowledge obstacle and finally innovation. When observing the industry effects some differences emerge. For both service and manufacturing firms, the main obstacle is cost but manufacturing firms consider it to be more important (1.58 vs. 1.24). The market obstacle is still second in importance for manufacturing firms but, for service firms, the innovation obstacle is seen to be more essential. Manufacturing firms considered the knowledge obstacle to be third in importance, while service firms ranked innovation higher. Finally, the knowledge hampering factor is the least important for service firms and the innovation factor has the lowest value for manufacturing firms.

The results for Stuttgart are similar to those for Navarre, in the sense that the most important hampering factor is cost (1.47) followed by the market obstacle (1.36). In third place, firms ranked the internal obstacle (1.34) and the least important is knowledge (1.31). Interestingly, the values for all hampering factors have a higher value than those for Navarre. Industry difference among Stuttgart firms is not evident, as both service and manufacturing firms ranked the hampering factors in the same order, but manufacturing ones are a little bit higher.
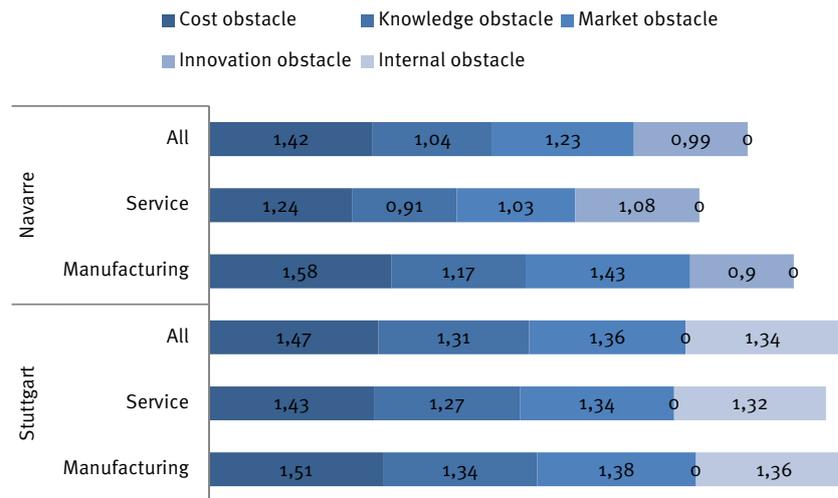
Figure 19. Hampering factors for innovation activities

6.2.1 OI practices and defensive determinants

As in section 6.1.1, we aim to observe whether there is a relationship between the importance of hampering factors and the adoption of OI practices. Figure 20 contains information showing how important firms, with differing levels of OI breadth degree, considered the hampering factors to be. Interestingly, there appears to be a positive relationship between OI breadth and how the hampering factors are perceived by firms. The cost obstacle has a mean of 1.14 for closed firms, 1.45 for low OI, 1.75 for medium and, 1.91 for high OI. That is to say, breadth-open firms consider that the high cost of innovation is the main hampering factors for innovation activities. In a certain way, one could expect that

those firms considering the high cost as a barrier would be the less innovative firms and closed firms. However, Navarre breadth-open firms are not discouraged for engaging in innovation activities due to the high cost, rather they are conscious of the problems they might face during the innovation process.

The knowledge and market obstacles follow the same pattern in Navarre as the cost hampering factor; that is to say, the more open the firm, the higher the importance it attaches to the factor. Nevertheless, knowledge is a minor obstacle compared to market and cost. The innovation obstacle, which stands for the lack of innovation need, has the inverse pattern. Closed firms ranked it as 1.23, while open firms ranked it as 0.8, 0.65 and 0.72. That is to say, few open firms consider that there is no need to innovate and they are willing to achieve permanent rediscovering.
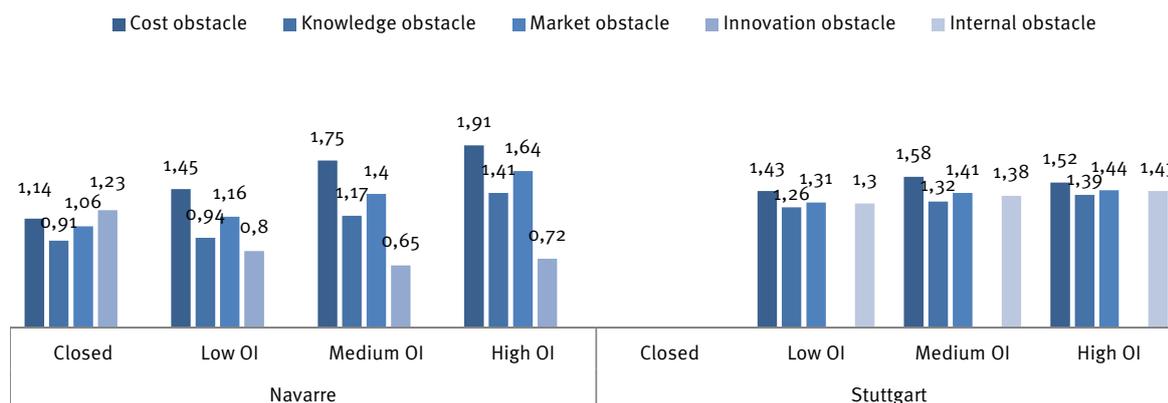
Figure 20. Degree of OI breadth and hampering factors for innovation

Navarre breadth-open firms are not discouraged from engaging in innovation activities due to the high cost, rather they are conscious of the problems they might face during the innovation process.

Stuttgart presents completely different behaviour to Navarre firms. As mentioned before, there are no breadth-closed firms, since all of them look for external information from at least two external sources. In this region, there is no evident relationship between OI breadth and the hampering factors. As observed, there is a slight difference in the importance attached to each factor but it always increases in accordance with the OI breadth degree.

As mentioned before, Stuttgart has no information for measuring OI depth; therefore Figure 21 only shows the descriptive for Navarre regarding hampering factors and OI depth. Similar to the behaviour for OI breadth, we perceived a positive effect of the hampering factor valuation and the OI depth-degree. We can observe how the cost obstacle has an increasing tendency: 1.27 for closed firms, 1.74 for low, 2.17 for medium and 3 for highly depth-open firms. The same trajectory is evident for the knowledge and market obstacles. The opposite direction is perceived for the innovation obstacle; that is to say, high depth-open firms always believe that innovations are needed[16].

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[16] Remember that there are 2 observations at this level.
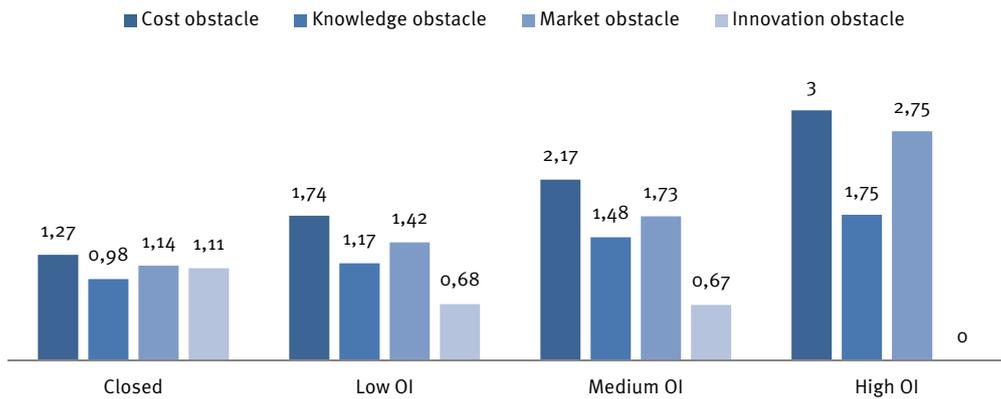
Figure 21. Degree of OI depth and hampering factors for innovation

Finally, Figure 22 shows the descriptive of the hampering factors and the OI cooperation breadth for Navarre and Stuttgart. The same positive relationship for the cost, knowledge and market obstacles can be perceived, as well as a negative relationship for the innovation obstacle in Navarre. It is interesting that Navarre firms attach a larger value to the cost and market obstacles than Stuttgart firms. That is to say, Navarre firms face these two hampering factors with more difficulty. Again, in Stuttgart, it seems to be a less clear relationship for the cooperation breadth degree and the evaluation of the hampering factors.
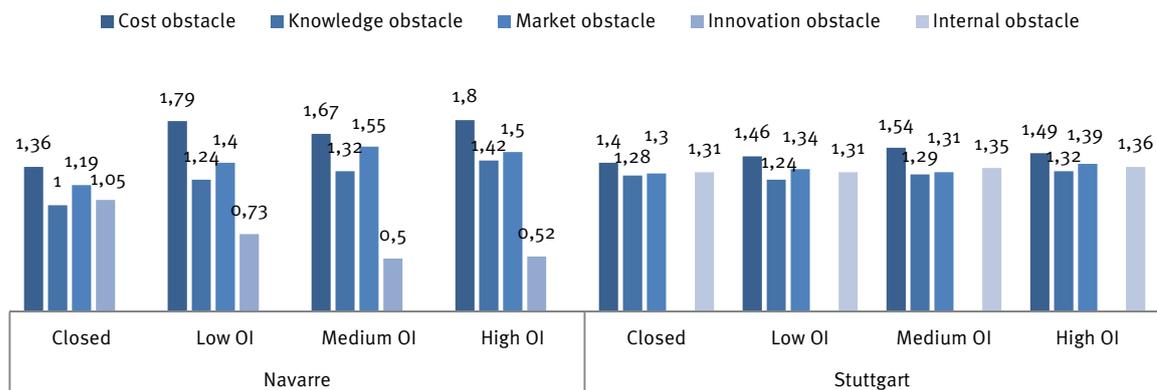
Figure 22. Degree of OI cooperation breadth and hampering factors for innovation

6.3 Public funds for R&D

Little evidence exists for the role that public financial aid plays in OI practices, but a recent study by Bayona-Sáez et al. [7] showed that an important factor conditioning the adoption of OI is whether the firms received public R&D funds and the provenance of those funds. They focus their analysis on R&D activities and explore whether the receipt of these funds conditions the selection of one specific type of R&D strategy. They consider three types of strategy: internal R&D, external R&D and the simultaneous combination of internal and external R&D. Results showed that national funding encourages firms to opt

the mixed strategy. Regional funding, the least significant in terms of the sums involved, presents a less obvious pattern, although there is some indication that it encourages selection of the mixed strategy.

In this sense, Figure 23 shows the percentage of firms that received public funds for R&D. Eindhoven and Navarre classifies the origin of the funds as Regional, National or Other, including those from the European Union. In the case of Stuttgart, the CIS does not have this disaggregation; rather it measures whether firms received a grant or a loan. It can be perceived that Navarre firms are the main recipients of public funds, considering the three different sources. Navarre firms mainly benefit from Regional funds (24.66%), followed by National (16.54%) and, finally, European (1.05%). As indicated, service firms are the main beneficiaries among Navarre firms. For both industries, Regional funds are the most granted. Interestingly, the highest percentage of recipients of European funds among Navarre firms is for manufacturers. Eindhoven demonstrates a distinct behaviour in the concession of grants. The main funds are National and 25.19 per cent of Eindhoven firms benefit from them. European funds are the second source of funds and 7.48 per cent of firms obtain these grants, a considerably higher percentage than for Navarre firms (1.05%). Similarly to Navarre, considerably more service firms, proportionally, than manufacturing firms receive public funds for R&D activities.

As argued, Stuttgart CIS has information on Grants and Loans for R&D activity. For the complete sample, 16.86 per cent of firms receive a grant and only 6.44 per cent a loan. Industry differences are apparent as more service firms than manufacturing firms benefit from grants and loans.
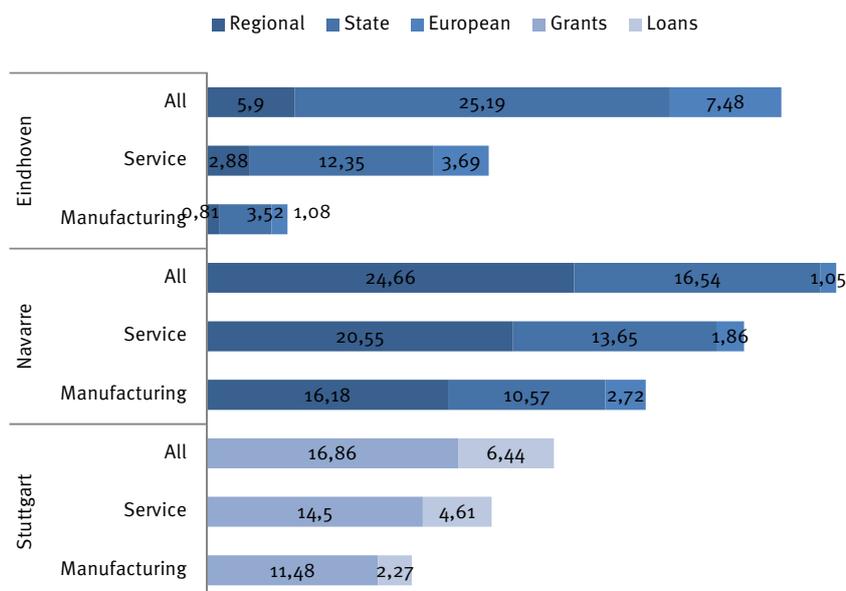
Figure 23. Percentage of firms benefitting from public funds

6.3.1 OI practices and public R&D funds

In line with the work of Bayona-Sáez et al.[7], this section aims to analyse whether there is a positive relationship between the receipt of public R&D funds and engagement in OI activities. The next Figure (Figure 24), shows the percentage of Eindhoven and Navarre firms that received public funds, classified according their OI breadth degree[17]. For both regions, it is observable that there is a higher concentration

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[17] Stuttgart firms are not shown in this table as they have a different variable than Eindhoven and Navarre.

of firms that received public funds for breadth-open firms than closed firms. In the case of Eindhoven, 50 per cent of firms with a high degree of openness received National funds, while 0.99 per cent of closed firms received a grant from the same institution[18]. Interestingly, closed firms did not receive funds either from the European Union or from the Regional government. In Navarre, there is also an evident relationship between OI breadth and public funding. More than 50 per cent of highly breadth-open firms received funding from the Regional government and this percentage decreases to 40.55 for medium, 22.75 for low breadth-open firms and merely 2.65 per cent for closed firms. This decreasing pattern is also observable for European and National funds.

Nonetheless, the above mentioned clear-cut positive relationship is not present for OI depth. Surprisingly, Figure 25 indicates that Eindhoven firms with high OI depth do

There is a positive relationship between the receipt of public funds for R&D and OI breadth and formal cooperation agreements.

not receive European and Regional funds[19]. Only 0.25 per cent of these firms received National funding. From medium OI to closed firms, we can perceive a positive relationship for European and Regional funds. Navarre also shows interesting figures. No firm with a high degree of depth received funds from the European or National government. However, 50 per cent received Regional funds for R&D activities[20]. The percentage of firms receiving grants has its main peak for medium depth-open firms and it decreases with OI degree level. Therefore, we can venture to argue that the relationship between public funds for R&D and OI depth has an inverted "U" form. That is to say, the highest level is perceived at the medium OI degree.

As for the last measure of OI, cooperation breadth, Figure 26 shows that, for Eindhoven, there is also a positive relationship between OI cooperation breadth and the receipt of public R&D funds. For example, 64.28 per cent of highly open firms received a National grant and the percentage decreases to 59.18 for medium OI firms, 27.9 for low OI and 5.35 per cent for closed firms. Navarre, on the contrary, appears to have an inverted "U" relationship between cooperation breadth and European funds. For the other funds, the trend is that more firms with a high degree of cooperation breadth received funds than closed firms.

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[18] Remember that the number of observation of firms in Eindhoven with a high breadth openness degree is 22.
[19] There are just 4 firms in Eindhoven with a high degree of OI depth.
[20] Remember that there are only 2 observations with a high level of OI depth.

6. Determinants of open innovation adoption

■ European ■ State ■ Regional

Eindhoven

High OI
- European: 31,81
- State: 50
- Regional: 18,18

Medium OI
- European: 13,51
- State: 39,18
- Regional: 10,81

Low OI
- European: 4,83
- State: 26,61
- Regional: 4,84

Closed
- European: 0
- State: 0,99
- Regional: 0

Navarre

High OI
- European: 5,38
- State: 38,11
- Regional: 53,81

Medium OI
- European: 4,09
- State: 24,54
- Regional: 40,45

Low OI
- European: 1,19
- State: 17,36
- Regional: 22,75

Closed
- European: 0,14
- State: 1,17
- Regional: 2,65

Figure 24. Degree of OI breadth and public R&D funding

■ European ■ State ■ Regional

Eindhoven

High OI
- European: 0
- State: 0,25
- Regional: 0

Medium OI
- European: 37,5
- State: 37,5
- Regional: 12,5

Low OI
- European: 9,9
- State: 36,93
- Regional: 9

Closed
- European: 1,8
- State: 6,4
- Regional: 1,4

Navarre

High OI
- European: 0
- State: 0
- Regional: 50

Medium OI
- European: 15,78
- State: 47,36
- Regional: 47,36

Low OI
- European: 3,65
- State: 30,18
- Regional: 46,03

Closed
- European: 0,65
- State: 6,4
- Regional: 10,31

Figure 25. Degree of OI depth and public R&D funding

European Union
European Regional Development Fund

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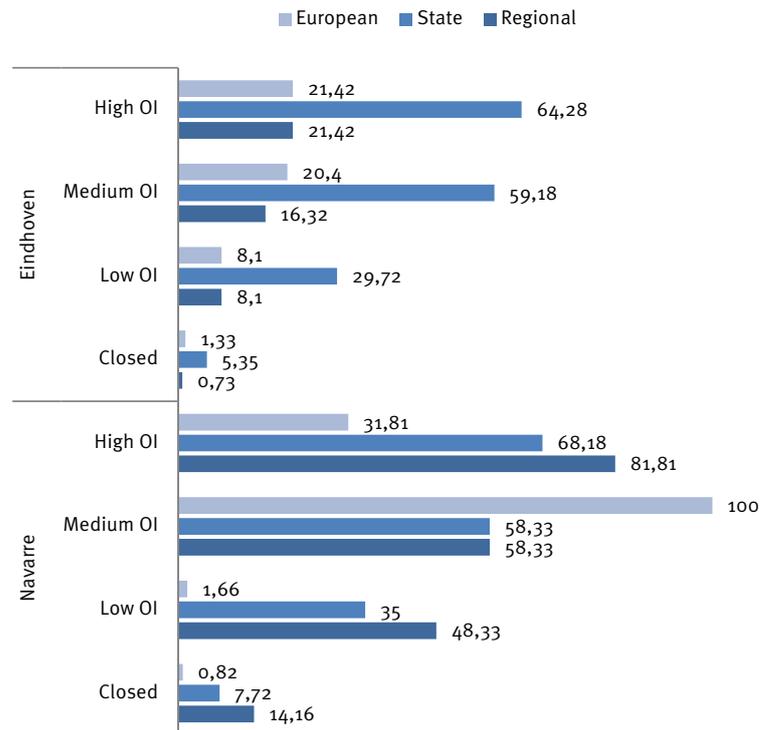
Figure 26. Degree of OI cooperation breadth and public R&D funding

6.4 Econometric analysis for OI determinants

Aiming to obtain a global picture of the factors that determine the adoption of OI activities, we have estimated Tobit models[21] simultaneously including the motivational and hampering factors, as well as public R&D funds. The model was also controlled by firm size and industry type; that is to say, manufacturing or service. The advantage of estimating these models is that we are able to observe whether the motives outperform the hampering factors or whether the industry effect is significant. Results for the estimated models for Navarre are shown in Table 6. Remember that Navarre was the only region where the CIS gathers information about innovation motives and innovation hampering factors. Each factor has three boxes for each type of OI and those filled in blue indicate that they have a positive and significant effect on engagement in that type of OI. The more boxes are filled for each variable by OI type, the more important they are[22]. For the red colour, the logic is the same but it represents a negative effect on the OI practices. Boxes in white show that the variable does not affect OI adoption.

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[21] A Tobit model was estimated for each type of OI. This model was selected as the variable under analysis ranged from 0 to 9.

[22] When estimating a model, the results give a coefficient and a significativity. The coefficient is a number that indicates the size of the effect but is conditioned to the measurement of the variable. The significativity reflects the probability that a certain variable will have an effect on the dependent variable (and the magnitude is the coefficent). The significativity could be at 99, 95 or 90 per cent of probability. In Table six, those variables filled with three blue boxes indicate with 99 per cent confidence, that specific variable will have an effect on the dependent variable. Two boxes indicate a significance of 95 per cent, and one box represents a significance of 90 per cent. Lower percentages are not considered in this type of analysis. We decided to represent the significativity rather than the size of the coefficient for two reasons; first, the coefficients are not comparable between variables as

6. Determinants of open innovation adoption

Table 6. Determinants of the OI practices for Navarre firms

	OI Breadth			OI Depth			OI Cooperation breadth		
Product objective	■	■	■	■	■	■	■	■	■
Process objective	■	■	■	■	■	■	□	□	□
Environmental objective	■	■	■	□	□	□	■	■	■
Cost obstacle	□	□	□	■	■	■	□	□	□
Knowledge obstacle	□	□	□	□	□	□	■	■	■
Market obstacle	□	□	□	□	□	□	□	□	□
Innovation obstacle	□	□	□	□	□	□	🟥	🟥	□
Regional funds	■	■	■	■	□	□	■	■	■
State funds	■	■	□	■	■	□	■	■	■
European funds	□	□	□	■	□	□	■	■	□
Manufacturing firms	□	□	□	🟥	🟥	🟥	□	□	□
Firm size	□	□	□	□	□	□	■	■	■

Table 6 highlights that, for all types of OI practices, looking to achieve product innovations is the main driver of engagement in OI activities. Process innovation is also an important factor that incentivises firms to look for informal sources of external knowledge. Firms that are willing to innovate in processes are not afraid to open their boundaries and to believe and trust in external sources of knowledge. Environmental goals for innovation activity incentivise firms to go beyond their frontiers to gain knowledge, but they do not have an important commitment (OI depth) to the external sources. However, firms aiming to achieve environmental innovations do look for formal collaborations to achieve their goals.

Hampering factors seem not to negatively affect engagement in OI activities as one might have expected. On the contrary, cost and knowledge obstacles prompt firms to open their boundaries and look for external knowledge and partners, maybe to reduce the impact that the hampering factor may have. The innovation obstacle is the one that has a negative effect on formal OI; that is to say, firms that do not consider it important to innovate, due to the fact that the market does not demand it or because they have already done it, avoid formal OI through collaboration.

As for public funds for R&D, it can be appreciated that, for Navarre, Regional and National funds are a key factor that highly incentivise firms to become open in an informal way, by sourcing ideas from outside the firm and in a formal way, through collaboration agreements. European funds also have a positive effect but with a minor impact, and principally on formal collaborations. This might indicate that this type of funding is intended to be accessed in collaboration with other external agents [7]. It can also be observed that manufacturing firms avoid OI depth. Finally, due to their larger resources, large firms have the possibility of maintaining several formal collaborations simultaneously. This is feasible since

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the variables have a different measurement; second, no matter how large the coefficient, it would be unimportant if the significativity were lower than 90 per cent.

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large firms might have a larger variety of products and are sometimes diversified and this may require collaboration to obtain the needed knowledge.

Table 7. Determinants of the OI practices for Eindhoven firms

	OI Breadth			OI Depth			OI Cooperation breadth		
Product objective	■	■	■	■	■	■	■	■	■
Process objective	□	□	□	□	□	□	□	□	□
Environmental objective	□	□	□	□	□	□	□	□	□
Regional funds	□	□	□	□	□	□	□	□	□
State funds	■	■	□	□	□	□	■	■	■
European funds	■	■	□	□	□	□	□	□	□
Manufacturing firms	■	□	□	□	□	□	□	□	□
Firm size	□	□	□	🟥	🟥	□	■	■	□

As for Navarre firms, the product innovation objective is a determinant of pursuing OI practices in Eindhoven. This variable has an important significance in the adoption of all OI forms. Interestingly, those firms that aim to pursue process and environmental innovations do not look for external information or collaborations outside the firm in order to innovate. This might indicate that Eindhoven firms are confident in their internal knowledge to achieve these innovation types. Contrary to Navarre, Regional funds do not have an influence on engagement in OI practices, but National funds do have an effect on OI breadth and cooperation breadth. One plausible explanation could be that the Netherlands is smaller, and regions are not the strong entities that they are in Spain. Although the percentage of firms receiving European funds is higher than that for Navarre, this variable is less important in determining the achievement of OI, since it only influences

Looking to innovate in products and reduce the high cost of innovations, and receiving National funds for R&D are the key drivers of open innovation engagement.

the OI breadth. Corroborating what was observed previously; manufacturing firms are more prone to open their boundaries than service firms. Finally, Table 7 indicates that large firms do not consider the external information received to be important, but they are able to support more collaboration agreements than small firms. In other words, the larger the firm, the lower the OI depth.

As for the Stuttgart sample, the information available to assess the determinants of open innovation are the offensive strategies, such as product, process, and environmental innovations. Stuttgart firms, in order to face the high cost of innovation and lack of funds, go beyond their borders and look for several sources of external information and formal cooperation agreements. This can be appreciated through the high effect of the cost obstacle on engagement in OI practices. On the other hand, the red colour for the knowledge obstacle shows how firms with limited knowledge avoid both sourcing external ideas and formal collaboration agreements. As shown in Table 8, market and innovation obstacles do not affect the

tendency to follow up the OI strategy. As in the case of Eindhoven, and contrary to Navarre, manufacturing firms are more open-breadth than service firms. We can observe the highly significant effect of this variable on OI breadth. Large firms, due to their large scale of resources, are able to have more simultaneous formal collaborations than small firms.

Table 8. Determinants of the OI practices for Stuttgart firms

	OI Breadth			OI Cooperation breadth		
Cost obstacle	■	■	■	■	■	■
Knowledge obstacle	□	□	□	▣(red)	▣(red)	□
Market obstacle	□	□	□	□	□	□
Innovation obstacle	□	□	□	□	□	□
Manufacturing firms	■	■	■	□	□	□
Firm size	□	□	□	■	■	■

Allowing for the limitations of comparing the results estimated using different models, we aim to make some general comparison across the regions. Navarre seems to be the region in which firms are most encouraged by offensive motives. While product, process and environmental innovation achievement goals positively affect OI breadth, in Eindhoven, firms are only incentivised by the goal of achieving product innovations. OI depth is encouraged in Navarre by the product and process innovations goals, while in Eindhoven this is true exclusively for the product goal. Similarly, cooperation breadth seems to be incentivised by the offensive product and environmental objectives in Navarre, but solely by the product goal in Eindhoven.

In reference to the defensive motives, the high cost of innovations highly incentivises Stuttgart firms to open their boundaries formally — collaboration breadth — and informally — breadth — but in the case of Navarre it only encourages firms to intensively rely on informal arrangements — i.e., depth. One interesting behaviour is the fact that the lack of knowledge encourages Stuttgart firms to cooperate with external agents, but in the opposite way, Navarre firms lacking knowledge look for collaboration in order to minimise this limitation.

Another interesting behaviour is the fact that Navarre firms seem to be more dependent on financial funds coming from governmental institutions. We observe in Table 6 how Regional and National funding affects the three types of OI evaluated; European funds encourage firms to deeply rely on external information sources and to collaborate formally. Eindhoven firms, differently, are not stimulated by Regional funds and National and European funding mainly affects OI breadth.

7. Business models and open innovation practices

The aim of this section is to examine the changes in business models and determine whether OI practices are related to, or lead, these changes in order to adapt the firm to the new philosophy. The two dimensions considered for the business models analysed here are the organisational and commercial modifications.

Chesbrough highlights that the OI approach has six fundamental principles:

- Not all the smart people in the field in which our firm is competing work for us.
- External R&D can create significant value and internal R&D is needed to absorb part of it.
- We don't need to generate the research to profit from it.
- Building a better business model is better than getting to the market first.
- If we make the best use of internal and external ideas, we will win.
- We should profit from others' use of our IP, and we should buy others' IP whenever it advances our business model.

Once the firms understand these principles and engage with the OI practices, they need to tailor their former closed business model, where the structure did not allow for interaction with external agents, to fit a new open business model that allows firms to interact constantly with the environment. Furthermore, only firms with a viable business model, in which revenue exceeds costs, can profit from applying open innovation. Although tailoring the business model to profit from OI is of high importance, little research has been carried out in this direction.

For the present study, the conceptualisation of a business model is: 'An heuristic logic, rationale, or representation of how an organisation or venture creates, delivers, and captures value [2, 12, 23].

Osterwalder and Pigneur [26] indicate that the most important components of a business model are:

1. Value proposition(s): Describes the bundle of products and services (offerings) that create value for specific customer segment(s).
2. Customer segment(s): Describes for whom the firm creates value and who are the most important customers.

3. Channel(s): Describes how a company communicates with and reaches its customers to deliver a value proposition.
4. Customer relationship(s): Describes the type of relationship(s) a company establishes with specific customer segments.
5. Revenue stream: Represents the cash (or exchange value) a company generates from each customer segment and the way it generates this revenue stream. (costs must be subtracted from revenues to create earnings)
6. Key resources: Describes the most important assets required to make a business model work. They can be physical (e.g. buildings, machines), financial, intellectual (e.g. brands, patents, copyrights, partnerships), or human. They can be owned or leased by the company or acquired from key partners.
7. Key activities: Describes the most important things a company must do to make its business model work.
8. Key partnerships: Describes the network of suppliers and partners that make the business model work.
9. Cost structure: Describes all costs incurred in operating a business model.

The CIS for the three regions capture information about three organisational modifications to a firm's business model, and four commercial changes to their business model. As for the organisational modifications, or innovations, the CIS identifies whether firms established: a) new business practices in the organisation of the work (e.g. supply chain, knowledge management, lean manufacturing, total quality management); b) new methods for organising work (e.g. responsibility distribution among employees, team work, decentralisation, department re-structuring) ; and, c) new methods for external relationships (e.g. alliances, partnerships, externalisation, outsourcing). These organisational innovations within the business model are represented in Figure 2 in blue circles. As observed, one key element of the business model is the key partner (external relationships) and also the key activities (the way the firm organises its business practices and methods of organising work)
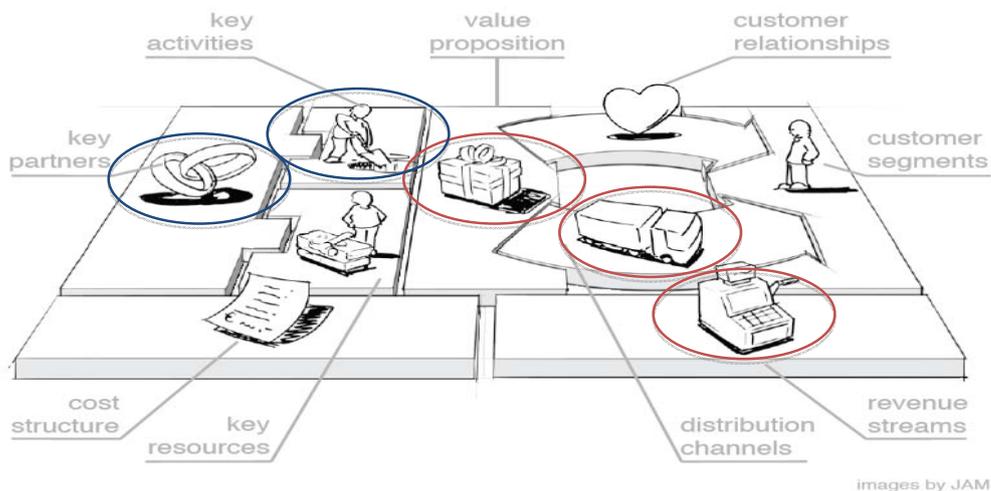

Figure 2: Business models canvas [26]

The commercial innovations analysed in this chapter are the 4Ps: a) product design; b) promotion; c) placement and; d) price. The product design accounts for significant modifications in the design of a

product or in the packaging of the goods and services. This business model change is represented by a red circle in the value proposition element in Figure 2. The promotion modification reports new techniques or channels for promoting the product or service. Placement modifications represent new ways by which the firm places their product in the market: franchises, licenses, direct sales, for example. The red circle in Figure 2 over the distributional channel component represents this commercial innovation. Finally, the red circle in Figure 2 over the revenue stream component accounts for the price business model modification. This component represents new methods used by the firm to establish the price of the goods and services (e.g. first time a firm uses a variable prices method based on demand, discount systems).

Table 9 shows the percentage of firms that achieved the different types of business model innovations for each of the three regions under analysis. Interestingly, for all three of them, the most pursued organisational innovation is new business practices. Observe how Eindhoven's value is 20.71 per cent, but that for Navarre is higher, at 25.13, and the highest is for Stuttgart, with a value of 38.35 per cent. The organisational work innovation is the second most popular for firms in the three regions. Again, the lowest value is for Eindhoven (18.44%) and the highest is for Stuttgart (35.86%). Navarre is positioned in the middle with a percentage of 24.2. In line with the previous analysis of the degree of OI practices, Stuttgart has the highest percentage of firms that modifying the way they interact with external agents. This organisational innovation is the least followed by firms in all regions.

For the three regions, the most pursued organisational innovation for the business model is the new business practice, followed by organisational work and external relations.

In reference to commercial innovations, Table 9 shows that Eindhoven and Stuttgart have a similar pattern for the achievement of commercial innovations. In these regions, firms mainly carry out promotion innovations; that is to, they use new techniques or channels for promoting the product or service. Innovations in the way the firms place their product or service is the second most popular commercial innovation adopted by Eindhoven and Stuttgart firms. Product design and price innovations have close percentages but the slightly difference favours the former. It is important to note that Stuttgart has larger figures for all four types of commercial innovations, indicating its large innovative culture. Navarre firms behave in a different way than their counterparts; 10.78 per cent of firms based in this region realise product design modifications looking for a new way to increase, or modify, the value proposition. Promotion is the second commercial innovation carried out by Navarre firms, followed by price and placement. We can observe the low figures for Navarre compared to Eindhoven and Stuttgart. An interesting observation is the fact that in Figure 5, Section 4, we can appreciate that Navarre firms are not less innovative in terms of product and process innovations, but there is a clear difference in the innovation commitment for commercial innovations when compared with Eindhoven and Stuttgart.

Table 9. Percentage of firms achieving different types of business model innovations

Organisational Innovations	Eindhoven	Navarre	Stuttgart
New business practices	20.71	25.13	38.25
Organising work	18.44	24.2	35.86
External relations	12.29	9.23	24.42
Commercial Innovations			
Product design	9.06	10.78	19.29
Promotion	14.84	8.84	23.43
Placement	10.74	5.74	20.91
Price	8.79	6.28	18.58

7.1 Relationship between BM and OI practices

As mentioned at the beginning of this chapter, we aim to assess whether open innovation activities lead firms to modify their business models. As described in the previous subsection, the CIS collects information on three organisational innovations and four commercial innovations. In order to achieve a comprehensible analysis of the effect on OI practices, these innovation types have been merged with the aim of obtaining one single organisational innovation variable and another single variable for commercial modifications to the business model[23]. The resultant variables are coded as binary variables, indicating whether a firm achieved at least one organisational or commercial innovation.

Figure 27 expresses the relationship between the level of OI breadth and the achievement of organisational and commercial innovations. In the case of Eindhoven, it can be corroborated that merely 7.87 per cent of closed firms achieved at least one organisational innovation. On the other hand, 75.77 per cent of highly breadth-open firms realised modifications in the way they interact with external agents, develop business practices or organise work. Additionally, 56.68 per cent of these highly open firms achieved commercial innovations. As observed, there is a positive relationship between the OI breadth level and the achievement of organisational and commercial innovations, with organisational innovations having a larger percentage. Navarre shows the same tendency as Eindhoven, in the sense that more firms accomplished organisational innovations and that there is a positive relationship between the breadth openness and the realisation of modifications to the business model. Nevertheless, the percentage of innovative firms is considerable lower for Navarre, mainly with regard to highly open firms.

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[23] The method for merging the variables was the alpha method, as in the case of the innovation obstacles and hampering factors. The Cronbach's Alpha was larger than 0.7 for both resultant variables.
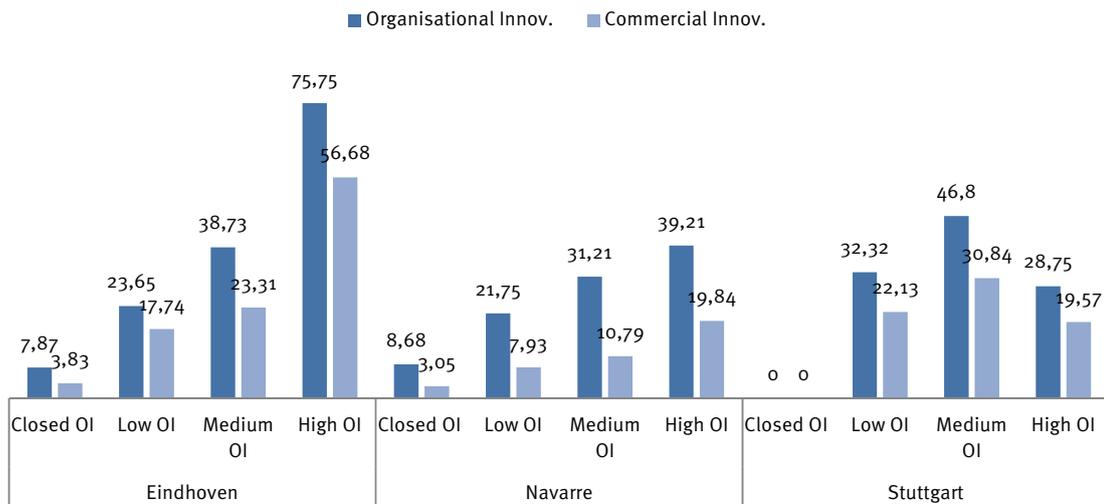
Figure 27. OI breadth and business models

In contrast to Eindhoven and Navarre, Stuttgart shows an inverted "u" relationship between OI breadth and commercial and organisational innovations. As evidenced, there are no closed firms in this region. With a higher percentage than the other regions, 32.32 per cent of the firms have accomplished new ways of organising themselves and, also with a higher percentage, 22.13 per cent achieved modifications to their business models in relation to product, placement, promotion and price. These percentages increase for firms with a medium level of OI breadth but decrease for firms with the highest level of OI breadth.

Figure 28. OI depth and business models

The relationship between the engagement of OI cooperation breadth and modifications to the business model is positive for Eindhoven and Navarre. Stuttgart illustrates the highest level of modification to business models with a medium level of OI.

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Figure 29. OI cooperation breadth and business models

Figure 28 represents the link which exists between the degree of OI depth openness and innovations within the business model. Similarly to OI breadth, Eindhoven and Navarre show a positive relationship between these two components. We can observe how just 12.79 per cent of Eindhoven closed firms modified their internal organisation and only 7.3 per cent modified commercial aspects, but 100 per cent of firms with a high degree of OI depth realised organisational innovations[24]. Most of the firms achieved organisational innovations and Navarre has a lower percentage of innovative firms than Eindhoven for both organisational and commercial innovations.
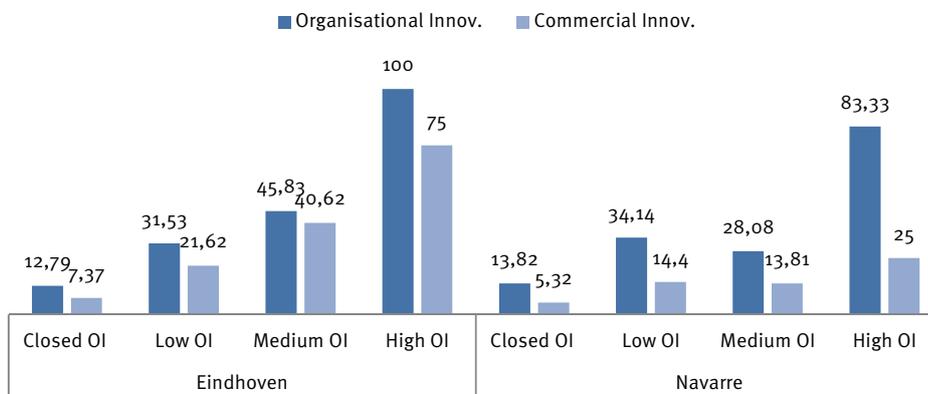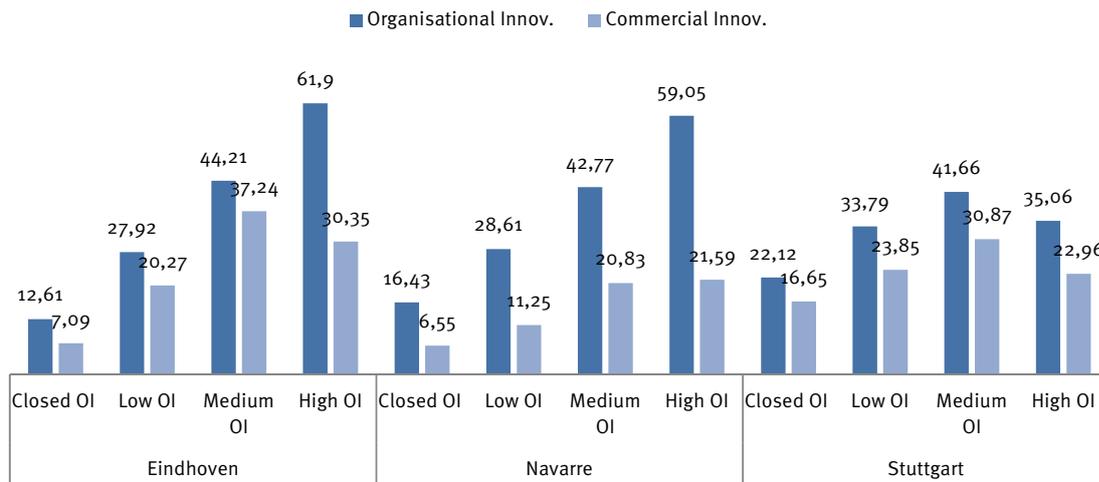
The relationship between OI cooperation breadth and business model innovations is captured in Figure 29. The data once again shows a positive relationship between OI cooperation breadth and the achievement of organisational innovations for Eindhoven and Navarre. In this case, the former difference in the percentage of innovative firms is reduced to minimum levels. Commercial innovations in Eindhoven grow in relation to OI cooperation breadth but, above the medium level, there is a small reduction in the percentage of firms achieving modifications in the 4Ps. As for Navarre, we can observe a constant growth of these innovations until the medium level for cooperation breadth, then it appears to stabilise between the medium and high degree of OI cooperation breadth. Similarly to OI breadth, in Stuttgart the relationship between the business model variables and OI cooperation variables seems to have the shape of an inverted "u". We can observe how the percentages for both business model innovations increase until the medium level and decreases for the high level.

7.2 Results of estimates

With the aim of obtaining more robust results; that is to say, simultaneously comparing which of the OI types has a greater effect on business model innovation, either in an organisational way or in a commercial one, we estimated two logit models, for each regions. The logit models are used since the dependent variables -organisational and commercial innovations- are dichotomous variables. The first model explains why some firms would achieve organisational innovations. The second one elucidates which effect OI practices have on the modification of the commercial component of the business model. The results of the model estimations are given in Table 10. As for Tables 7 and 8, the blue boxes indicate

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[24] Remember that the number of observations in this level of OI depth is four.

the positive impact of the variables on BM modifications. In Table 10, the grey boxes indicate that the variables were not available for the Stuttgart sample.

The first result that can be gleaned from Table 10 is the pronounced positive and significant effect of OI breadth in encouraging firms to modify their business practices, the organisation of their work or external relationships –organisational innovations. This result might indicate that a complementary activity to engaging in OI practices is the modification, update or innovation of the organisational component of a firm's business model in order to successfully profit from OI. This result leads us to believe that formal restructuring has to be performed inside the firm once it has moved from the closed innovator to the open innovator paradigm. The more external sources for innovation a firm uses, the more propensity it will have to modify the supply chain, knowledge management, decentralise, restructure departments or create alliances, partnerships and externalisation agreements.

Controversially, a firm will not be influenced to innovate within organisational activities by OI depth; that is to say, it does not matter how much a firm trusts or relies upon external information when deciding to carry out an organisational innovation.

Firms need to modify and innovate their business model in order to successfully profit from OI practices.

This statement is based on the fact that the depth variable has no significance in any region for organisational innovations. The cooperation breadth component does not have a significant effect for Eindhoven, but it does for Navarre and Stuttgart when achieving organisational innovations. Nevertheless, Stuttgart firms are much more affected by the cooperation breadth than Navarre firms (see the three blue bars for Stuttgart and the single blue bar for Navarre.)

As for the control variables, it seems that there is no industry effect on the achievement of organisational innovations, but firm size appears to be a highly important determinant for business model modification, since this variable has a highly significant and positive effect for all three regions. That is to say, large firms engage more in organisational innovations.

The commercial innovation determinants are also presented in Table 10 and the results again show the clear and positive effect of OI breadth on the achievement of these innovations, though the effect is slightly smaller for Stuttgart. Once again, the OI depth does not affect the firms' decision to modify any of the 4Ps. That is to say, what incentivises firms to innovate in commercialisation is the number of external sources they use, not the extent to which they are used. The cooperation breadth does not incentivise Navarre firms but it pushes Eindhoven firms and, to a greater extent, Stuttgart firms to achieve commercial innovations. That is to say, to make significant modifications to the design of a product or its packaging, to use new techniques or channels for promoting goods or services, establish franchises, concede licenses, or establish the price of goods and services based on new methods.

Based on the positive and significant effect of the manufacturing variable, it can be observed that for Navarre, there is an industry effect when adopting a new commercial business model. Firm size is once again a determinant of achieving commercial innovations but only for Eindhoven and Stuttgart. In Navarre, firm size seems not to affect the firms' decision to embark on the modification of at least one of the 4Ps.

Table 10. Effects of OI practices on the achievement of business models modifications

	Eindhoven	Navarre	Stuttgart
Organisational innovations			
OI breadth	■ ■ ■	■ ■ ■	■ ■ ■
OI depth	□ □ □	□ □ □	▨ ▨ ▨
OI coop. Breadth	□ □ □	■ □ □	■ ■ ■
Manufacturing	□ □ □	□ □ □	□ □ □
Firm size	■ ■ ■	■ ■ ■	■ ■ ■
Commercial Innovations			
OI breadth	■ ■ ■	■ ■ ■	■ ■ □
OI depth	□ □ □	□ □ □	▨ ▨ ▨
OI coop. Breadth	■ ■ □	□ □ □	■ ■ ■
Manufacturing	□ □ □	■ ■ ■	□ □ □
Firm size	■ ■ ■	□ □ □	■ ■ □

8. Effects of OI practices on firm innovativeness performance

A crucial analysis within this report is to find whether OI practices have a positive impact on firm innovativeness performance and, if so which of the different types of open innovation would be recommended for each of the regions. Therefore, in this section, we observe the relationships between each of the OI practices and two measures of firm innovative performance:

- *Percentage of sales due to radical innovations*
- *Percentage of sales due to incremental innovations*

8.1 OI and innovative performance

As explained in the introductory section, due to the complexity of the technology, high customer requirements, and the high level of competition, every day it becomes more difficult to achieve all innovations in-house. The open innovation approach breaks most of the paradigms under which firms used to innovate. For example, the fact that there is a lot of knowledge stock outside the firm, and the fact that firms should combine their internal abilities and knowledge with external technology, ideas and knowledge. But, do the activities proposed by the OI approach pay? Are open firms more innovative than closed firms? Are they more able to profit from innovations than closed innovators?

In order to answer these questions, in this section we observe and develop the existing relationship between OI activities and firm innovative performance. Some previous studies have measured firm innovative performance based on the number of patents achieved or the achievement of product and/or process innovations. The main limitation of these variables is that they do not include the quality of the patents and innovations. In order to avoid this handicap, we use the percentage of sales due to radical innovations (PSRI, hereafter) and the percentage of sales due to incremental innovations (PSII) as measures of innovation performance. The CIS defines radical innovations as those that are new to the market and incremental innovations as those that are new to the firm. The advantage of considering these variables is that it controls for the firm strategy; that is to say, those firms with a leadership strategy will tend to achieve mainly radical innovations. On the other hand, those firms with a follower

strategy might be prone to achieve incremental innovations. In this way, we are able to observe whether OI is positive for accomplishing the leader or the follower strategy.

In addition, the percentage of sales due to innovations, radical or incremental, controls for the quality of the innovations achieved. That is to say, the market will not accept those innovations with low quality and/or utility and the percentage of sales due to these innovations will be low. On the other hand, high quality products will triumph in the market and the percentage of sales will be higher.

These PSRI and PSII variables are measured as a percentage for Eindhoven and Navarre but, for Stuttgart, they are measured on a Likert scale from 0 to 8, where 0 equals 0, 1 represents a percentage between 0 and 5, 2 between 5 and 10, 3 between 10 and 15, 4 between 15 and 20, 5 between 20 and 30, 6 between 30 and 50, 7 between 50 and 75 and 8 larger than 75 per cent. Therefore, these values have to be taken into account when interpreting the results for Stuttgart.

On the basis of the above, Figure 30 shows the average PSRI and PSII achieved by firms with a certain level of OI breadth. The left of the Figure represents the sales due to radical innovations while the right shows the percentage of sales due to incremental innovations. First of all, we can detect a positive relationship between the OI breadth openness and the PSRI for Eindhoven and Navarre. Eindhoven is the region with the highest average PSRI for low, medium and high levels of OI breadth. Navarre closed innovators are the closed firms with the highest PSRI, attaining an average of 0.88 per cent. Low and medium OI breadth firms in Eindhoven and Navarre have similar figures but highly open firms within these regions show an important difference in favour of Eindhoven. We can observe that the average PSRI for Eindhoven is 21.04 and 11.9 for Navarre.

As previously observed, there are no breadth-closed firms in Stuttgart. Firms with a low level of OI breadth have an average PSRI of 0.61, which represents a value between 0 and 5 per cent, slightly lower than the percentages for Eindhoven and Navarre. The average PSRI for medium breadth-open firms is 1.12, or between 5 and 10 per cent. Interestingly, we can again observe an inverted "u" shape relationship between OI breadth and firm innovative performance for Stuttgart, since the value for highly open firms is 0.39, much lower than for firms with a low level of OI breadth.
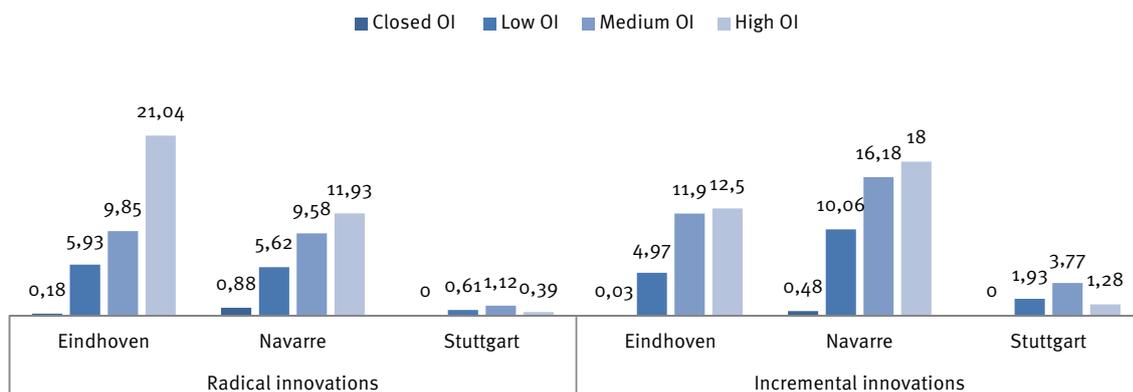

Figure 30. OI breadth and innovative performance

Continuing with Figure 30, the PSII shows a similar pattern to that for PSRI, but the protagonist this time is Navarre. We can observe that, for all levels of OI breadth, Navarre has the largest values for the PSII. We can clearly distinguish large differences in the PSRI between Navarre and Eindhoven for low (10.06

vs. 4.97), medium (16.18 vs. 11.9) and high (18 vs. 12.5) levels of OI breadth. Another interesting thing to highlight is that, for both Eindhoven and Navarre firms, PSII is higher than PSRI, except in the case of Eindhoven firms with high level of openness. Moreover, we can distinguish a positive relationship between the PSII and the level of OI breadth for Eindhoven and Navarre. Conversely, Stuttgart again shows an inverted "u" shape relationship, as the highest level of PRII is achieved by firms with a medium OI breadth and the minimum PSII is achieved by highly open firms. For Stuttgart, the PSII outperforms the PSRI, which indicates that producing and marketing a radically new product is not an easy task.

Figure 31 shows the relationship between OI depth and the percentage of sales due to radical and incremental innovations. As discussed in earlier sections, the OI depth is not available for Stuttgart. As shown in the Figure, the positive

Under high level of OI breadth, Eindhoven firms obtain higher levels of percentage of sales due to radical innovations while Navarre firms profit by the incremental innovations.

relationship between OI breadth and the PSRI and PSII is no longer present for OI depth. Eindhoven exhibits an inverted "u" shape for the relationship between OI depth and PSRI, which indicates that those firms that attach great importance to external sources of information register a lower PSRI. Navarre does not show a clear-cut relationship as the lowest PSRI is registered for firms with a medium level of OI depth (6.79%). As for the PSII, Eindhoven firms with high OI depth register a considerably higher PSII than firms with a high level of OI breadth. That is to say, for Eindhoven, the key to increasing PSII is not to have several external sources of information but to have a high degree of trust in them. Conversely, Navarre exhibits the opposite behaviour, as the key to increasing the PSII is to source ideas from several sources and not commit to them[25].
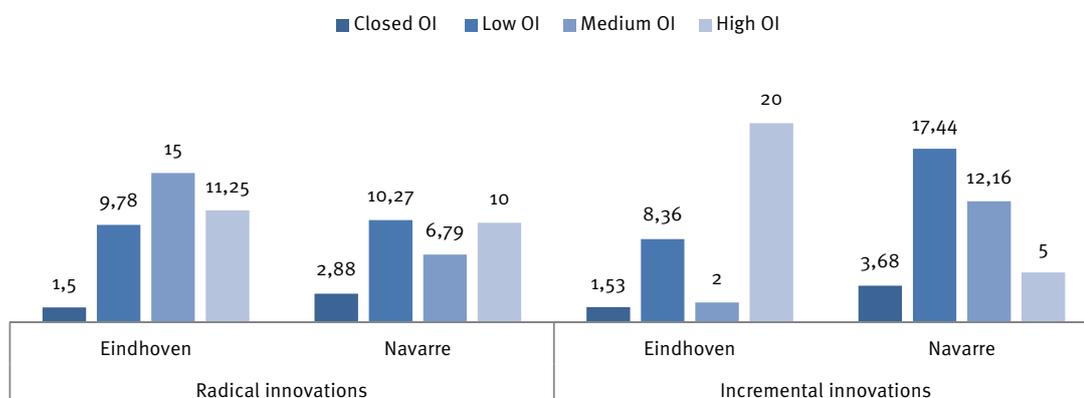
Figure 31. OI depth and innovative performance

Finally, Figure 32 shows the link which exists between formal OI practices -cooperation breadth- and the percentage of sales due to radical and incremental innovations. This time, a positive relationship between these two components seems to be present for Eindhoven and Navarre. The most important thing to mention is the fact that those firms with a high level of OI cooperation breadth for Eindhoven and Navarre have the largest PSRI compared to firms with high levels of OI breadth and depth. This might indicate that it is through formal collaboration agreements that firms achieve successful radical

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[25] Remember the limited number of observations in Navarre and Eindhoven for high levels of OI depth.

innovations. This table again shows that Eindhoven has higher levels of PSRI than Navarre and Stuttgart, but Navarre has the largest values for the PSII. As in the two previous graphs, Stuttgart presents an inverted "u" relationship.

Figure 32. OI cooperation breadth and innovative performance

8.2 Results

In section 8.1, we presented the descriptive of the percentage of sales due to radical and incremental innovations for the different levels of openness, but they have the limitation that you cannot make simultaneous comparisons between the different levels by type of OI practice; that is to ask the question, which type of OI activities are more likely to increase the percentage of sales due to innovations? Moreover, the descriptive presented does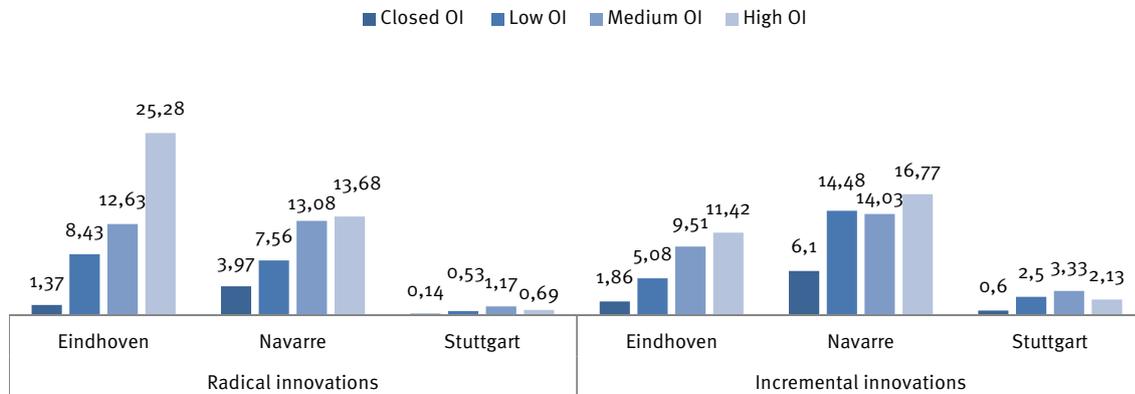n't allow us to detect whether the differences mentioned are vary significantly from one to another. Furthermore, it is hard to discern whether the perceived differences between the PSRI and PSII are the result of the OI practices or whether there are other effects that are not perceived. Therefore, in the aim of obtaining robust results we developed this section to estimate a regression to explain the percentage of sales due to innovations based on the different OI practices.

Chesbrough's concept of OI emphasises that firms that combine internal and external knowledge will win. The absorptive capacity approach also indicates that firms need internal knowledge and their own technology to be able to absorb and integrate the knowledge and technology acquired beyond the firm's boundaries. As a consequence, in this section we will evaluate the effect of internal knowledge as a determinant of the PSRI and PSII.

The CIS for Eindhoven and Navarre also included "internal" in the section on information sources. Firms were asked to respond as to whether they use internal information as a source for developing innovations and also to what extent that information is important. Following the same logic as for the OI, we generated the variable internal breadth that represents the use of this source and also the internal depth that represents the importance attached to internal information as a source of ideas for innovation. Both variables are binary; for innovation breadth, o indicates that firms do not use internal information and 1 otherwise. Innovation depth takes the value of 1 if the firm values internal information as being highly important and o otherwise.

The absorptive capacity approach denotes that one of the main sources for generating the ability to scan and integrate external knowledge and technology is the accomplishment of internal R&D activities. Therefore, we also consider the achievement of internal R&D as a determinant of the percentage of sales due to innovations. However, we believe that what would really have an impact is not the fact that firms carry out internal R&D but the extent to which the firm is committed to this activity. Therefore, we consider the relative expenditure on internal R&D as another determinant of the PSRI and PSII[26].

Table 11 shows the results of the model that explains the PSRI. As evidenced, this table shows the results of the models for each region and the explanatory variables are OI breadth, depth, cooperation breadth, internal R&D expenditure, external R&D expenditure, internal information breadth and internal information depth and the regression also controls for the industry effect and firm size.

Table 11. Effects of OI practices on the percentage of sales due to radical innovations

	Eindhoven			Navarre			Stuttgart		
OI breadth	■	■	■	■	■	□	□	□	□
OI depth	□	□	□	□	□	□	▨	▨	▨
OI coop. Breadth	□	□	□	■	□	□	■	■	□
Internal R&D expenditure*	■	■	■	■	■	■	■	■	■
External R&D expenditure*	■	■	■	□	□	□	■	■	□
Internal information breadth	■	■	■	■	■	■	▨	▨	▨
Internal information depth	■	■	□	□	□	□	▨	▨	▨
Manufacturing	■	□	□	■	■	□	□	□	□
Firm size	□	□	□	□	□	□	□	□	□

* For Stuttgart the variable is categorical and represents whether firms achieve the type of R&D mentioned

The results in Table 11 indicate that, in Eindhoven, OI breadth is very important; we can observe how the three boxes are filled in blue. In Navarre, OI breadth also has a positive and significant effect but not as significant as for Eindhoven. On the other hand, Stuttgart firms do not increase their percentage of sales due to radical innovations even if they have OI breadth. This result is very interesting since, as shown in Figure 8, all Stuttgart firms are breadth-open, they use at least one external source of information. That is to say, in the region where all firms are breadth-open, performing this activity does not make a difference in terms of increasing the PSRI. One reason might be that this activity is so commonplace that the competitive advantage it might generate disappears in this context.

Since the depth variable is not significant for either Eindhoven or Navarre, we can learn from Table 10 that no matter how much firms trust external sources, or consider them to be important, what really matters for increasing the PSRI is the variety of sources used to innovate. This makes a lot of sense since it is through the combination of different ideas that major innovation occurs [15].

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[26] For Eindhoven and Navarre this variable was introduced into the model as the percentage of total innovation expenditure that was used for internal (or external) R&D. Stuttgart does not have this information. Therefore, for this region, the variable was introduced as a dummy variable where 1 presents that the firm achieves internal (or external) R&D and 0 otherwise.

The reader will recall that the results from Figure 13 indicated that Eindhoven and Navarre have more than 80 per cent closed firms in terms of formal collaboration, while Stuttgart has less than 20 per cent of cooperation breadth-closed firms. The effort made by Stuttgart firms in achieving these collaborations pays by significantly increasing the PSRI. On the other hand, Navarre receives a benefit from these activities but at a lower level than Stuttgart. Eindhoven firms do not see the benefits of

While Eindhoven and Navarre are able to increase the percentage of sales due to radical innovations based on the informal OI, Stuttgart benefits from the formal OI

cooperation breadth in terms of increased PSRI. Based on this, we can argue that Eindhoven and Navarre are able to increase the percentage of sales due to radical innovations on the basis of informal OI, while Navarre and Stuttgart benefit from formal OI practices.

Interestingly, the relative internal R&D expenditure variable is positive and highly significant for the three regions. Additionally, the internal information breadth is very significant for Eindhoven and Navarre and, for Eindhoven, the importance of this internal information also fosters increased PSRI for firms. This indicates that internal R&D activities and internal information sources are crucial components in the creation of successful radical innovations.

Relative external R&D expenditure is also positive and highly important for Eindhoven, slightly less important for Stuttgart and not at all important for Navarre.

Table 11 demonstrates that manufacturing firms in Eindhoven and Stuttgart are more prone to have higher levels of PSRI than service firms. Finally, we can appreciate that there are no significant differences between large firms and their counterparts.

The effect of OI and closed innovation practices on the percentage of sales due to incremental innovations is presented in Table 12. At first glance, we can appreciate that the effect of these activities is much less important than they are to the realisation of successful radical innovations. The OI breadth has a positive and significant effect on PSII for Eindhoven and Navarre, which indicates that this form of OI promotes both radical and incremental innovations. Stuttgart firms are not affected by this variable. Again, OI depth is not significant for either Eindhoven or Navarre.

Table 12. Effects of OI practices on the percentage of sales due to incremental innovations

	Eindhoven			Navarre			Stuttgart		
OI breadth	■	■	■	■	■	■	□	□	□
OI depth	□	□	□	□	□	□	▨	▨	▨
OI coop. Breadth	□	□	□	□	□	□	■	■	■
Internal R&D expenditure*	□	□	□	□	□	□	■	■	■
External R&D expenditure*	□	□	□	□	□	□	□	□	□
Internal information breadth	■	■	■	■	■	■	▨	▨	▨
Internal information depth	□	□	□	□	□	□	▨	▨	▨
Manufacturing	□	□	□	■	■	□	□	□	□
Firm size	□	□	□	□	□	□	□	□	□

* For Stuttgart the variable is categorical and represetns wheter firms achieve the type of R&D mentioned

Stuttgart firms receive a positive and significant effect on the PSII for cooperation breadth but Navarre and Eindhoven are not able to profit from this type of OI. Interestingly, internal R&D expenditure is no longer significant for Eindhoven and Navarre as it was for the PSRI. This shows that, for these regions, internal R&D activities are reserved for the achievement of radical innovations, while incremental innovations are less dependent on these activities. On the other hand, internal R&D activities do increase the PSII for Stuttgart. This time, external R&D expenditure does not increase the PSII for Stuttgart or Eindhoven.

Internal information breadth is again positive and highly significant for Eindhoven and Navarre, but not the depth in which this information is used. Once more, the importance of internal knowledge as a complement to OI practices is emphasised.

In the case of Navarre, it seems that manufacturing firms are more able than service firms to achieve successful incremental innovations. In Eindhoven and Stuttgart, there is no significant difference in the industry type. Finally, firm size effects are non-existent.

OI breadth has a positive and significant effect on both radical and incremental innovations for Eindhoven and Navarre.

8. OI and innovative performance

9. Conclusions

This final chapter is devoted to the conclusions of the study. We expose the regions' behaviour in terms of OI practices and the industry and firm effect. A revision of the main drivers of OI and their impact on business model modifications and firm innovative performance is discussed. This chapter ends with some recommendations for policymakers on fostering OI practices within each region.

Traditionally, firms used to innovate in a closed manner; that is to say, by relying exclusively on their internal resources and capabilities, such as knowledge and technology. However, the products and services offered in the market need to embody a specific set of technologies and knowledge, with the result that firms can no longer hope to do everything in-house, and must therefore draw on external sources of technology and knowledge [10].

In this context, Chesbrough [10] argues that firms have changed from closed to open innovation. This modification to the innovation strategy has been motivated by the growing mobility of high-skilled staff, knowledge spillovers and the increasing demand for shorter time to market for many products and services. These factors shorten the technology cycle, making closed innovation no longer sustainable. The OI approach states that the knowledge and technology flow is two-way: 1) inside-out and 2) outside-in. The flow goes from inside to out when the firm has internal ideas that can be taken to market through external channels, such as patents, licences, or start-up companies. The outside-in flow exists when firms source ideas, knowledge and technology beyond their boundaries and integrate them with external knowledge. This integration is easier for those firms that have generated the required absorptive capacity through the development of internal R&D.

In this context, the aim of this research is to gain a better understanding of inbound OI practices, their determinants and consequences in the regions of Eindhoven, Navarre and Stuttgart. This study is the result of close collaboration between these regions, and has been promoted and financed by the INTERREG IVC Programme. Within this study, we have been able to compare the OI practices of the three regions based on the CIS, which is a survey that gathers information about the innovation inputs, outputs, goals, hampering factors and performance for innovative and non-innovating firms that compete in manufacturing or service industries. Unfortunately, there were some differences in the content of the CIS for each region that make it difficult to perform a perfect comparison of the inbound OI practices.

The innovation input analysis exhibited interesting innovative behaviours and differences across the industries. First, for all three regions, internal R&D activities are preferred over external R&D activities. This fact could indicate two key aspects: a) most of the firms are still more closed than open, and b) those firms that practice open innovation activities are aware that internal R&D is a source of knowledge that helps in scanning, valuating and integrating external knowledge and technology. Second, as expected, manufacturing firms more actively develop internal and external R&D than service firms. Third,

9. Conclusions

Stuttgart firms are more committed to R&D than their counterparts. Fourth, Navarre is the region where firms make the largest effort to achieve R&D activities since their R&D intensity is the largest. Moreover, an unexpected result is the fact that service firms in Navarre have a larger R&D intensity than manufacturing firms. That is to say R&D activities are more important for service firms than for manufacturing firms, even though there are fewer service firms developing R&D. Fifth, in line with the Schumpeterian hypothesis, large firms in Eindhoven have a greater average R&D intensity, but in Navarre and Stuttgart small firms are more devoted to R&D. One possible explanation for this unusual result is that the concentration of knowledge intensive firms in this industry is very high in these regions. It is important to point out that neither Navarre service firms nor small firms in Navarre and Stuttgart invest more than their counterparts, but the investments represent a higher proportion of their sales.

Something that the Eindhoven and Navarre regions should take into account is the efficiency with which firms are developing the innovation process. Stuttgart seems to have a significant ability to efficiently transform innovation inputs into innovation outputs, as this region has the lowest commitment to R&D but the highest proportion of innovative firms.

In terms of innovation outputs, the results indicate that each region has its own core competence since there is a notable tendency to focus on a certain type of innovation output. The Eindhoven region leads the pack in service innovations, Navarre has paid more attention to process innovations and Stuttgart has a clear dominance in the achievement of patents and in the field of product innovations. This aspect is crucial for each region since they might base their competitive advantages in the field in which they dominate.

In order to measure OI practices, we have considered five dimensions: OI breadth, which accounts for the number of external sources for innovation ideas; OI depth, which measures the importance attached to the external sources of information; OI cooperation breadth, which includes the number of formal collaboration agreements in which the firm is engaged; external R&D expenditure; and external knowledge acquisition, which represents the purchase of patents, licences, or inventions. Based on these measures, we have observed that open innovation practices in the three regions are not a sporadic activity. Nevertheless, there are some OI innovation types which are less pursued and some industries that remain more closed than others.

When cross-referencing the results of the different types of OI activities, interesting concepts can be observed:

1. *Stuttgart has the greatest level of OI breadth and OI cooperation breadth. In fact, all Stuttgart firms use at least one external source of information and 80 per cent of firms have formal collaboration agreements.*
2. *Eindhoven is the most closed region in terms of OI breadth, depth and external R&D expenditure.*
3. *In all three regions, service firms are more closed than manufacturing firms, in terms of OI breadth, depth and cooperation agreements.*
4. *Small firms are more closed than large firms, both in terms of formal and informal OI practices*
5. *Although service firms are more closed in terms of formal collaboration and information sources (breadth and depth) they spend almost double that of manufacturing firms on external R&D.*

Point number five might indicate that service firms are less open to seeking external information sources and formally cooperate, but they lead external R&D activities because they are technology users, rather than technology developers.

9. Conclusions

In this study, we were able to analyse the determinants of OI activities and these determinants were grouped into offensive and defensive motives and whether the firms received financial funding for R&D from the Regional or National governments, or from the European Union. Offensive motives are those that motivate firms to achieve innovation, such as product, process or environmental objectives. Defensive motives are the barriers perceived by firms when engaging in innovation activities, like the high cost of innovation, lack of knowledge, lack of market demand or internal obstacles. Based on the results we are able to conclude that:

6. *Government funding for R&D activities incentivises firms to look for external sources of information to innovate (breadth and depth) and to establish formal cooperation agreements.*

However, within in each region, there is one source which has a greater effect; National funding for Eindhoven and Regional and National funding for Navarre[27].

Some other important conclusions that could be derived from the offensive and defensive determinants of OI practices are:

7. *The quest for product innovation achievement is the main offensive reason for developing innovation activities within the three regions. This innovation goal incentivises firms both to look for external sources of information and to establish contracts for collaboration agreements.*
8. *There is a positive relationship between innovation objectives and firm openness.*
9. *The lack of financial funding, and the high cost of innovation, is one of the main factors in incentivising firms to engage in OI practices.*
10. *Navarre seems to be the region in which firms are most encouraged to engage in OI activities by offensive motives.*
11. *While Stuttgart firms avoid cooperation with external agents faced with a lack of knowledge, Navarre firms lacking the same resources are keen to forge formal collaboration agreements.*

Open innovation practices modify the way in which firms interact with their customers, suppliers, competitors and other external agents. Therefore, we believe that it is important to analyse the effect that OI has on business model innovations. The information gathered by the CIS allowed us to observe innovations in the internal organisation of the firms –organisational innovations-, like the way in which the firm interacts with agents, and innovations in the way the firm interacts with customers, basically, the 4Ps (product, price, placement and promotion). Based on analysis of the data we are able to conclude that:

12. *Most of the firms are focused on organisational innovations rather than commercial innovations.*
13. *For Eindhoven and Navarre, there is positive relationship between OI practices and the organisational and commercial innovations achieved.*
14. *Stuttgart presented an inverted "u" shape for the same relationship. That is to say, low levels of OI practices positively affect business model innovations, medium levels still have a positive effect but, at the highest level of OI, business model innovations are reduced.*
15. *OI breadth and formal collaboration agreements demand that firms modify their organisational and commercial business model.*

A crucial part of this research is to observe whether OI practices do increase firm innovative performance and which of them is more valuable for increasing the percentage of sales due to radical and incremental

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[27] There is no information available for Stuttgart about public funds for R&D.

innovations. This analysis was essential to discover whether the new trend of innovation strategy pays off and also to determine which direction open innovation policy should follow. We have selected two variables to measure innovative performance, the percentage of sales due to radical innovations and the percentage of sales due to incremental innovations (PSRI and PRII, respectively) since, rather than just measuring the amount of innovation achieved, they represent the quality of the innovations achieved. These two variables additionally allow us to observe whether one type of OI fosters successful radical or incremental innovations[28].

Based on the previous analysis, some conclusions can be drawn in the area of OI effects on firm innovative performance.

16. *For Eindhoven and Navarre, there is a linear relationship between the PSRI, the PSII and open innovation breadth and OI cooperation breadth; that is to say, the more breadth-open, or cooperation breadth-open, the firm, the higher the percentage of sales due to radical and incremental innovations.*
17. *Stuttgart registered an inverted "u" relationship with the PSRI, PSII and both the OI breadth and OI cooperation breadth; that is to say, higher levels of OI breadth and cooperation breadth produce negative effects on firm innovative performance.*
18. *Eindhoven and Navarre are able to increase the percentage of sales due to radical innovations based on informal OI, but Stuttgart benefits from formal OI practices.*
19. *Internal R&D activities and the additional use of internal information sources for innovation are also important drivers, and complement OI, in increasing the percentage of sales due to radical and incremental innovations.*
20. *External R&D has positive effects exclusively for radical innovation.*

In point number 20, it is expressed that external R&D activities produce a positive effect on the percentage of sales due to radical innovations, but has no effect on incremental innovations. This fact gives extra support to the benefits of OI practices, since the main innovations occur with a combination of internal and external ideas, knowledge and technology.

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[28] The problem is that innovation performance measures may favour those firms that are more prone to obtaining product innovations than those that look for process innovations.

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