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Working Paper Series

#2009-013

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Keywords: Knowledge flows, innovation, dynamic equations, sectoral innovation, CIS.
JEL: C34, O32, O31

Abstract

This paper tries to quantify the effect of diffusion of informal knowledge on the innovative performance of European firms using data derived from the 3rd Community Innovation Survey. When firms are asked whether or not they have introduced new products or processes, they were also asked to which degree such innovations were developed in-house. These degrees were captured by the CIS variables InPdtW and InPcsW. These variables ranged from 1 (Mainly done by the firm) to 3 (Mainly done by other enterprises).

The focus of this paper is to investigate the impact of diffusion of informal knowledge. We combine the previous variables with another variable which reflects firms that were not doing any formal collaboration with other institutions. If an innovative firm has no formal collaboration arrangements and the innovation has not been done mainly by the firm, then diffusion of informal knowledge is considered to be the main driver of the innovation.

The idea is that informal channels are accessible to all firms. This paper tries to quantify the impact of such flows of knowledge on firms' innovation performance.
To do this, a two step procedure is followed:

- *In a first step, a latent variable for diffusion of informal knowledge is defined and estimated based on firms' characteristics.*
- *In a second step, the latent diffusion variable is introduced as a regressor in a probit/tobit model.*

UNU-MERIT Working Papers
ISSN 1871-9872

Maastricht Economic and social Research and training centre on Innovation and Technology, UNU-MERIT

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Table of Contents

1. Introduction

This paper tries to quantify the effect of diffusion of informal knowledge on the innovative capacity of firms. Our assumption is that the diffusion of informal knowledge plays an important role in introducing new products and new processes. The effect of this flow has, to our knowledge, not been studied before.

When a firm decides on its innovation strategy, it can choose to innovate using a variety of possibilities: a.o. by increasing its R&D expenditures, by investing in human capital, by cooperating with universities. However it is also possible to base its innovation strategy on the intensive use of existing knowledge generated by innovation activities in a specific sector. This knowledge can be acquired through scientific publications, attendance to trade fairs, and communication with providers and customers. In this way firms might be able to combine pieces of existing knowledge to innovate.

It is our understanding, that it is not only possible to be an innovator based purely on these flows of informal knowledge, but also that the diffusion of informal knowledge has an impact on the overall innovation performance of a sector. This flow contains information about applications and future products and processes. The flow of informal knowledge is being constantly renewed and it is accessible to all firms. Some firms might rely only on this flow to innovate, while others might combine it with other forms of innovation strategies.

The innovation literature points out that many factors may affect the successful innovation performance of a firm, as for example the amount of R&D, human capital, networks and size. However, the total effect of these factors is most likely overestimated because none of them take into account the diffusion of informal knowledge.

In this paper, we empirically investigate the effect of the diffusion of informal knowledge on the innovative performance of firms. We do this by taking into account firms' characteristics. We estimate a function of the intensity in which the diffusion of informal knowledge affects the innovation performance of firms. We follow a sectoral approach as the sector is relevant. Consequently, we will be neglecting national dynamics.

The rest of the paper is organized as follows: section 2 describes the data used; section 3 focuses on the methodology and presents the econometric model used in the paper; section 4 presents the results for all industries; section 5 focuses on main sectors as analysed in the Systematic project: Automotive, Food, Machinery, Textiles, Chemicals, Energy, ICT, Eco-innovation and Gazelles; the last section concludes.

2. Data and definitions

2.1 Data

The analysis is based on the micro-data of the third Community Innovation Survey (CIS 3) for 18 countries: Belgium, Bulgaria, Czech Republic, Estonia, Germany, Greece, Hungary, Island, Latvia, Lithuania, Norway, Portugal, Romania, Slovakia, Spain, Finland, Italy and Slovenia. The questionnaire covers the innovation activity of firms during the years 1998-2000. The population studied comprises a total of 61649 firms.

2.2 Definition of diffusion of informal knowledge flows

The CIS is structured in such a way that questions can be divided in two groups: one set of questions answered by all firms, and another set only answered by firms considered to be innovators[1]. After a few identifying questions, respondents were faced with the following questions:

- During the period 1998-2000, did your enterprise introduce onto the market any new or significantly improved products? (InPdt)

If the answer was positive, the firm was asked to grade its innovation according to who developed these new products:

- Mainly your enterprise or enterprise group. (InPdtW=1)
- Your enterprise in co-operation with other enterprises or institutions. (InPdtW=2)
- Mainly other enterprises or institutions. (InPdtW=3)

Another relevant question for our study concerns co-operation agreements. If a firm had introduced an innovation, it was asked the following question:

- Did your enterprise have any co-operation arrangements on innovation activities with other enterprises or institutions during 1998-2000? (Co)

A combination of these two sets of questions gives us the definition of diffusion of informal knowledge: if the firm answered to have introduced an innovation mainly in co-operation with other enterprises or institutions or mainly done by other enterprises or institutions (InPdtW= 2 or InPdtW=3), and also answered that there were no co-operation arrangements with other enterprises or institutions (Co=0), then we consider that the main driver of the innovation was the diffusion of informal knowledge. If there was a formal arrangement like a research contract between the firm and an institution – e.g. a university – we consider that the knowledge came from a formal channel. If the firm answered that the innovation was mainly done by

[1] In the CIS a firm is considered to be an innovator if it had introduced a new process, a new product, or had had some ongoing or abandoned innovation activities during the period 1998-2000.

itself (InPdtW=1), we can not be sure that the firm's innovative performance was based only on diffusion of informal knowledge. It could also be that it was purely based on intramural R&D. However if the firm had acknowledged to have introduced an innovation and at the same time the innovation was not developed by the firm alone, this combination comes closer to our definition of informal channels of knowledge through scientific publications, trade fairs, providers and customers. Our definition of diffusion of informal knowledge is very close to Arundel (2007)[2], however ours is more restrictive as we exclude formal means of co-operation arrangements[3].

Table 1 illustrates our definition of diffusion of informal knowledge, based on the questions as asked in the CIS 3 survey.

Table 1: Definition of diffusion of informal knowledge – CIS 3

1.1 During the period 1998-2000, did your enterprise introduce onto the market any new or significantly improved products (goods or services) <u>for your enterprise?</u> *InPdt*

Yes ☐ I

Who developed these products? (*InPdtW*)

Mainly your enterprise or enterprise group ☐ (1)

Your enterprise in co-operation with other enterprises or institution ☐ (2)

Mainly other enterprises or institutions ☐ (3)

No ☐

8.1 Did your enterprise have any co-operation arrangements on innovation activities with other enterprises or institutions during 1998-2000? *Co*

Yes ☐ (1)

No ☐ (0)

From Question 1.1: InPdtW (2) or InPdtW (3) and From Question 8.1: Co=0

Definition: Intersection between InPdtW = 2 or InPdtW = 3 and Co = 0

	Co = 0	Co =1
InPdtW = 1		
InPdtW = 2	(shaded)	
InPdtW = 3	(shaded)	

[2] According to Arundel (2007), an interim indicator for knowledge diffusion based on the CIS-4 survey could be constructed from the percentage of firms that give a positive response to introducing either a product or process innovation that was developed by "your enterprise together with other enterprises or institutions" (option 2) or developed mainly by "other enterprises or institutions" (option 1). As this concept would miss firms that mainly innovate in-house, but which also develop innovations together with other firms, the definition also includes firms that give a positive response to the CIS-4 question on any form of collaboration: "Did your enterprise co-operate on any of your innovation activities with other enterprises or institutions?" (Co=1).

[3] An interesting case is the following one: there are firms which answer to have introduced a new product basically by co-operating with other firms (InPdtW=2) and at the same time report not to have any collaboration arrangements (Co=0). If this is the case, we consider that co-operation involves some kind of formal contract while InPdtW=2 captures informal collaboration, basically talking without any joint formal research. A firm can work with a university in the R&D process; however it can also collaborate by delivering information about the new technology which might be enough for coming up with a new product.

Our dependent variable will be defined as a successful product innovation mainly based on the diffusion of informal knowledge ($KnDif_{pdt}$):

$KnDif_{pdt}$= 1 if (InPdtW= 2 or InPdtW=3) and Co=0.

A parallel definition[4] is constructed for the case of process innovation, and we also define $KnDif_{pcs}$, as a successful process innovation which was mainly based on the diffusion of informal knowledge:

$KnDif_{pcs}$ = 1 if (InPcsW= 2 or InPcsW=3) and Co=0.

Based on these definitions, we find 2459 firm in the CIS-3 survey that report having successfully introduced a new product purely based on the diffusion of informal knowledge, and 3169 firms that have done the same for process innovation.

[4] For process innovations, firms are faced with the following questions:

- During the period 1998-2000, has your enterprise introduced any new or significantly improved production processes including methods of supplying services and ways of delivering products? (InPcs)

If the answer is positive, firms are asked to grade their innovation according to who developed these new processes:

- Mainly your enterprise or enterprise group. (InPcsW=1)
- Your enterprise in co-operation with other enterprises or institutions. (InPcsW=2)
- Mainly other enterprises or institutions. (InPcsW=3)

3. Methodology

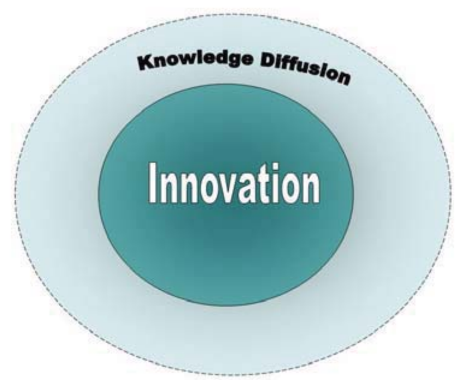

Figure 1. Innovation and Knowledge Diffusion

If we look at the innovation activities of a sector, then surrounding the innovation performance of a sector, we observe a certain amount of "knowledge diffusion" that affects innovation and its applications. Figure 1 illustrates this idea. The access that firms have to this knowledge, could determine their ability to come up with more innovations. The following example helps to clarify this idea: In the space sector, the Galileo project will provide a superior signal to the current GPS technology. Firms which operate close to the knowledge related to this innovation will be able to generate more innovations using the improvement of quality provided by the new signal. These innovations should not be seen as radical ones, but rather as incremental innovations. Also compared to basic improvements of technologies which rely more on R&D, we are considering innovations that apply this knowledge to more "down to the market" applications. We now discuss how firms access this knowledge and then how this knowledge impacts the innovation process.

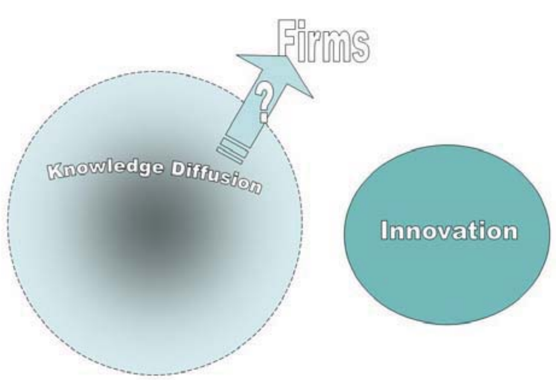

Figure 2. Firms characteristics and knowledge diffusion

In a first stage, this study focuses on analyzing which firms' characteristics determine their exposure to the diffusion of informal knowledge (Figure 2). Depending on these characteristics, firms will be capable of using this stream of knowledge to successfully innovate. For example, size, as measured by a higher number of employees, means that more people are able to access knowledge thus increasing the probability of a firm to innovate. At this stage we exploit the information on a sub-sample of firms. As explained before, we distinguish between three kinds of firms: general innovators, innovators only based on diffusion of informal knowledge and non innovators. At this first stage, we work with a sub-sample formed by the sum of innovators "only based on the diffusion of informal knowledge" and "non innovators". The purpose here is to determine why some firms are able to access this free knowledge and become successful innovators while others are not capable of accomplishing the same. In the next section we define a latent variable that determines the exposure of a firm to the flow of informal knowledge.

Later, in the second stage, this latent variable will be used to analyze which are the effects of the underlying diffusion of informal knowledge on the general innovation process. This idea is graphically represented in Figure 3. The information obtained in the first stage will be used on the total population of firms. The basic assumption is that all firms are exposed to the stream of knowledge diffusion. The latent variable will give us information on the intensity of the flow of informal knowledge. In our analysis, we focus on the effect of this latent variable on total innovation performance.

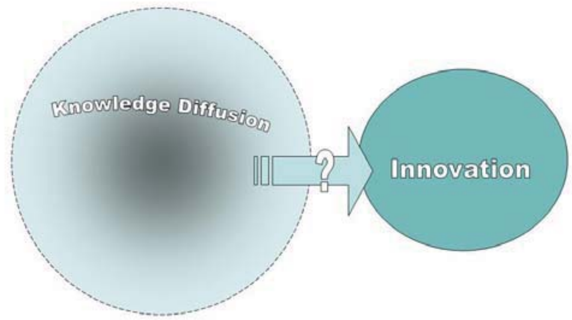

Figure 3. Effect of Diffusion of knowledge on innovation.

We distinguish between two streams concerning the diffusion of knowledge: one for product innovation and another one for process innovation. This distinction is based on the fact that the dynamics of diffusion of informal knowledge for product and process innovations are different as they are based on different firms' characteristics. Therefore we generate two latent variables; one that informs us about the diffusion of informal knowledge in each sector for product innovation and another for process innovation.

Econometric Model

The econometric model is based on the assumption that there is a group of firms which basically rely on flows of informal knowledge to innovate. We also assume that the intensity in which these firms benefit from these flows can be estimated based on firm characteristics and that diffusion of informal knowledge is equally affecting all firms with the same characteristics.

All the estimations will be performed introducing the latent variable that captures the effect of diffusion of informal knowledge. The same regressions will be performed without this variable. The intention is to clearly show that these flows are relevant, even though they have been neglected by other empirical studies up until now.

The model equations are presented in Table 2. We make a couple of simultaneous equations, which are analyzed in sets of two. In this way we take care of endogeneity, since some of the control variables are in both sets (z_1 and z_2). First we analyze the effect of diffusion of knowledge for product innovation on the probability of being a successful innovator. If firms are aware of what is happening in their sector, and are informed of the last changes in products, then these firms might have a better chance to come up with a new product. We do this by estimating a probit model on product innovation in which we introduce the latent variable for diffusion of informal knowledge that affects product innovation. Then we analyze the effect that this diffusion has on innovative sales. Innovative sales are calculated by multiplying total turnover by the percentage of innovative sales and then taking logarithms. Since a substantial amount of firms report zero innovative sales, we use a tobit equation in the estimation of the effect. As a result of how the variables are defined, the coefficient can be interpreted as an elasticity. We proceed the same way for process innovation, studying how the probability of being a successful innovator is affected by the flow of informal knowledge.

Table 2. Model equations

Product	Process
$KnDif_{pdt} = 1$ if $KnDif^{*}{}_{pdt} = \alpha_{kd1} z_1 + \varepsilon_{kd1} > 0$ = 0 otherwise	$KnDif_{pcs} = 1$ if $KnDif^{*}{}_{pcs} = \alpha_{kd2} z_1 + \varepsilon_{kd2} > 0$ = 0 otherwise
$Pdt = 0$ if $Pdt^* = \beta_{i1} KnDif^{*}{}_{pdt} + \beta_{i2} z_2 + \varepsilon_{i1} \leq 0$ = 1 if $Pdt^* > 0$ $Inno = 0$ if $Inno^* = \beta_{i3} KnDif^{*}{}_{pdt} + \beta_{i4} z_2 + \varepsilon_{i2} \leq 0$ > 0 if $Inno^* > 0$	$Pcs = 0$ if $Pcs^* = \beta_{j1} KnDif^{*}{}_{pcs} + \beta_{j2} z_2 + \varepsilon_{j1} \leq 0$ = 1 if $Pcs^* > 0$
Where ε_{kd1}, ε_{kd2}, ε_{i1}, ε_{i2}, ε_{j1} are normally distributed error terms with zero means and resp. σ_{kd1}, σ_{kd2}, σ_{i1}, σ_{i2} and σ_{j1} are standard deviations, z_1 is the array of firms' characteristic identifying the intensity of the diffusion process and z_2 is the array of control variables, $KnDif_{pdt}$ (diffusion of informal knowledge for product innovation), $KnDif_{pcs}$ (diffusion of informal knowledge for process innovation), Pdt (new product) Inno (ln(innovative sales)) and Pcs (new process). The star superscript indicates a latent variable.	

The estimation procedure follows the following steps: From the population of all firms we have distinguished three relevant and exclusive theoretical samples: innovators, innovators purely based on diffusion of knowledge, and non-innovators. The first step is to make a probit using the innovators purely based on diffusion of knowledge and non-innovators. We are looking for firms' characteristics that capture the diffusion of knowledge. The set of characteristics (z_1) is based in the general questions that are answered by all firms in the CIS 3 survey no matter whether they are innovators or non-innovators. This first step generates a vector of coefficients (α_{kd1}); this vector is used to define a latent variable over the total population of innovators. The probability of being a successful product innovator is then studied using the effect of the latent variable for the diffusion of knowledge. In this second stage we concentrate only on innovators as defined by the CIS (see footnote 1)[5]. In

[5] A Heckman selection model will allow us to use the population all firms instead of concentrating only in firms considered to be innovative by the CIS. This process was considered in a first stage of the research, however it was observed that if the selection was done on the fact of belonging to the Innoact population (those firms considered as innovator by the CIS) was predicting a proportion of

order to be able to compare the effects of knowledge diffusion we repeat the estimations with and without the effect of knowledge diffusion.

Array of characteristics and control variables

In this subsection we introduce a description of the variables used in the model. In the first stage, these variables represent the firms' characteristics which inform us about the intensity of the diffusion of informal knowledge. In the second stage, these variables are used as control variables, trying to isolate the effect of diffusion of informal knowledge from the other effects that have an impact on innovation performance. The selection of variables is not a trivial one, and is done partially motivated on theoretical grounds and partially on empirical ones (based on the significance of the estimated coefficients and on availability of data). The description and definition of the variables is as follows:

- **Industry dummies**: The idea of introducing industry dummies is to control in the general process of innovation for some sector specificities. We define the following sectors grouping them according to the two digit NACE codes:
  - [Mining] Mining: includes mining, extraction of petroleum, uranium, metals and quarrying activities. From NACE code 10 to 14.
  - [ManufHighTech] High-Technology Manufacturing includes manufacture of electrical and optical equipment (NACE 30), manufacture of radio, television and communications equipment and apparatus (NACE 32) and manufacture of medical, precision and optical instruments, watches and clocks (NACE 33).
  - [MediumHighTech] Medium-High Tech manufacture consists of five sectors: manufacture of chemicals (NACE 24), machinery and equipment n.e.c (NACE 29), electrical machinery n.e.c (NACE 31), motor vehicles (NACE 34) and other transport equipment (NACE 35).
  - [MediumLowTech] Medium-Low Tech manufacture includes manufacture of fuel (NACE 23), rubber and plastic products (NACE 25), other non metallic mineral products (NACE 26), basic metals (NACE 27) and fabricated metal products (NACE 28).
  - [LowTech] low tech manufacture includes the manufacture of the following sectors: food and beverages (NACE 15), tobacco (NACE 6), textiles (NACE 17), wearing apparel (NACE 18), tanning and dressing of leather and derivates (NACE 19), wood and cork (NACE 20), paper (NACE 21), recorded media (NACE 22), furniture (NACE 36) and recycling (NACE 37).
  - [Utilities] Energy sectors; which includes two sectors electricity, gas, steam and hot water supply (NACE 40) and the collection and purification of water (NACE 41).
  - [MarketServLow] Market services consider to be related to low tech services which includes: wholesale trade (NACE 51), land transport (NACE 60) and supporting of auxiliary transport activities (NACE 63).

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right observations higher than 90% none of the coefficients was significantly altered. Therefore for the sake of simplicity and clarity this estimation process was disregarded.

- [FinancialServices] Financial services are formed by the following sectors: financial intermediation (NACE 65), Insurance and pension funding (NACE 66) and activities auxiliary to financial intermediation (NACE 67).
- [HighTechServices] High-tech services include the following sectors: post and telecommunications (NACE 64), Computer and related activities (NACE 72) and research and development (NACE 73).

- **[Size]** Large firms might be more exposed to flows of informal knowledge. They are also known for having a more active innovation activity and higher R&D expenditures. This variable is defined as the logarithm of the number of employees.

- **[Higher Education]** If there is a larger stock of higher educated human capital in the firm, it might be easier for the firm to absorb diffusion of informal knowledge. We measure higher education as the logarithm of the number of employees with higher education.

- **[Group]** We expect firms belonging to a group to be more exposed to the diffusion of informal knowledge. First because they might be closer to innovation activities of other firms from the same group, and second, because they might be closer to the diffusion of knowledge from within their group.

The CIS gives us information about factors hampering innovation activities. This information is given for innovators and non innovators. Since information on hampering factors is available for all firms, these factors can be used as firms' characteristics related to the successful use of diffusion of informal knowledge. We make use of three of them:

- **[Innovation costs]** If a firm reports having problems in its innovation capacity due to perceiving innovation costs as being too high, it is expected that this firm will try to compensate by being closer to the innovation activity of other firms in the same sector, and therefore to the diffusion of informal knowledge in the sector.

- **[Lack of personnel]** If a firm reports having problems in its innovation capacity due to a lack of qualified personnel, it is expected that this firm will try to compensate by making more intensive use of the diffusion of informal knowledge.

- **[Lack of customers]** A perceived lack of customers' responsiveness to new goods or services means a weak demand for that specific innovation. We expect this variable to be negatively related to the diffusion of informal knowledge.

The CIS also offers information about instruments that firms use to protect their innovations. In this paper, our interest is on firms that innovate mainly based on diffusion of informal knowledge. Such firms are likely not to rely mainly on intramural R&D activities. Probably these R&D activities would be too costly for these firms. We are concentrating on a secondary type of innovation: firms might not choose to protect their innovations using patents since they might be more costly. Instead, they would make use of alternative forms of intellectual property protection. We exploit the following variables:

- Registration of design patterns
- Trademarks
- Copyright
- Secrecy
- Complexity of design
- Lead-time advantage on competitors

Next we look at a set of questions which inform us about important strategic and organizational changes in the enterprise. Information about these changes gives us an idea about the dynamism of the firm. A firm which is very active in strategic and organizational changes, should also be a firm which is more active when close to flows of informal knowledge. Firms are asked whether they have undertaken any implementation of the following activities:

- New or significantly improved Corporate strategies
- Advanced Management techniques
- New or significantly changed Organizational structures
- Significantly changes Marketing concepts or strategies
- Significant changes in the Aesthetic appearance or design of products

In a second stage, once we have created the latent variable which informs us about the intensity in which diffusion of informal knowledge is accessible to the firm, we concentrate on the effect that this diffusion has on the general performance of the firm. As we are in particular interested in isolating this effect from other known effects, we introduce a number of control variables. Besides the sectoral and size dummies we consider the following variables:

- **Fund.** If a firm receives any kind of financial support from either its local or regional or national government or the EU it might be easier for this firm to innovate. We are interested in isolating the effect that this public funding might have on the general performance of the innovation activity of the firm. The variable is a dummy that takes the value one if the firm reports to have received any kind of public funding and zero if it reports not to have received any kind of public funding.

- **Information sources.** Since we are interested in general knowledge which is generated by the sector, we would like to control also for pure sources of information. We introduce these control variables with the objective to isolate the effect of diffusion of informal knowledge from other sources of knowledge including suppliers, clients and universities. All three of them are dummies taking the value zero or one.

4. Results

To investigate the dynamics of the flows of knowledge and their interactions with firms' innovative performance, we study two parallel effects: the flows of knowledge related to product innovation and those related to process innovation. Therefore, we create two latent variables, each of them explaining the intensity in which these flows affect firms' innovative performance. In order to do this, we perform three estimations and analyse how they are affected by the diffusion of knowledge:

- The probability of coming up with a new product (InPdt), and its relation with the diffusion of knowledge related to new products ($KnDif_{pdt}$).
- How the innovative sales (ln(total innovative sales)) are affected by the diffusion of knowledge related to new products ($KnDif_{pdt}$).
- The probability of introducing a new process (InPcs) and its relation with the diffusion of knowledge generated in the sector concerning the introduction of new processes ($KnDif_{pcs}$).

Our main interest is the innovative activity and its dynamics. In addition to the control variables introduced in the previous section, we also control for R&D expenditures. Exploiting the information collected by the CIS survey, and with the objective of better understanding sectoral dynamics, in a first estimation, we control for total innovation expenditures (INNOVTotal) and then introduce several sub-categories of total innovation expenditures according to the five specifications given in the CIS: intramural R&D ($R\&D_{Internal}$), extramural R&D ($R\&D_{External}$), expenditures in machinery and equipment ($INNOV_{Mach}$), acquisition of other external knowledge ($INNOV_{ExtKnw}$) and other innovation expenditures ($INNOV_{Other}$))[6]. For all types of expenditures, we take natural logarithms.

All the estimations are done with and without the latent variable related to the diffusion of informal knowledge. The intention is to understand the effect that this diffusion process has on the general performance of the firm, and what are the effects of neglecting the diffusion process. An important case, from a theoretical point of view, is the effect that innovation expenditures have on the diffusion of knowledge. Innovation expenditures could be only related to this diffusion instead of affecting the successful innovation. We will explain this idea in more detail:

A firm's innovation expenditures influence its innovation performance in two different dimensions:

- The capacity of a firm to generate innovations, which is considered the main goal of any innovation activity.

[6] In theory if in a regression we introduce the total of a sum of a variable and in another the different parts of a variable sum ceteris paribus, the sum of the coefficients of the different parts should be the total coefficient given by the first estimation. In the research process we observed that in innovation expenditures there were errors. Out of all the data, only in one-third of the observations of the Innoact population the total innovation expenditures were equal to the sum of the different parts. In the other two-third of the observations we always found a calculation error; not knowing if the total was right and the different part wrong or the other way around we decided to use both of them in two alternative settings.

- The ability to bring the firm closer to the flow of knowledge generated by the sectoral innovation activity.

Assume two theoretical sectors, A and B. In sector A, R&D is used to generate innovation and to bring the firm closer to the sectoral diffusion of informal knowledge, while in sector B, it only brings the firm closer to the diffusion of informal knowledge. When we run the regressions with and without the latent variable, for sector A, R&D will be significant in both cases while for sector B only in the first case (with the latent variable). In the regression for sector B where the latent is introduced R&D expenditure is thus expected to lose its explanatory power.

We start comparing the two probits over the diffusion of knowledge for product and process innovations. This information is given in Table 4.1, where we report the coefficients of the estimations. The symbol "Δ" refers to the marginal effect of the coefficient for the probit estimation. The number of stars is related to the significance of the coefficient. We use one star for a coefficient which is significant at the 10% level; two at the 5%, and three at the 1% level.

Table 4.1 Diffusion for product and process innovations

	Product innovation (InPdt)	Process innovation (InPcs)
Δ ManufHighTech	0.10176 ***	0.07219 ***
Δ MediumHighTech	0.04935 ***	0.02416 *
Δ MediumLowTech	0.05715 ***	0.0342 ***
Δ LowTech	0.01097	0.00861
Δ Utilities	0.00535	0.04161 ***
Δ Market Serv Low	0.03178 **	-0.00012
Δ Financial Services	0.11638 ***	0.08874 ***
Δ Market Services	0.03858 **	0.02228
Δ High Tech Services	0.08268 ***	0.04379 ***
Size	0.00359 ***	0.01421 ***
Higher Education	0.00489 ***	0.00077
Δ Group	-0.00042	0.01046 ***
Δ Innovation Costs	0.03058 ***	0.03858 ***
Δ Lack of Personnel	0.01151 ***	0.02338 ***
Δ Lack of Costumers	-0.00593 **	-0.01787 ***
Δ Registration Design	0.04463 ***	0.04383 ***
Δ Trade Marks	0.0105 **	0.01745 ***
Δ Copyright	-0.00931	-0.00364
Δ Secrecy	0.01412 ***	0.01281 ***
Δ Complex Design	0.01486 ***	0.00714
Δ Time Advantage	0.06693 ***	0.08026 ***
Δ Corporate Strategy	0.01781 ***	0.02051 ***
Δ Management	-0.00173	0.0138 ***
Δ Organization	0.01917 ***	0.01963 ***
Δ Marketing	0.00454	0.01258 ***
Δ Aesthetic Change	0.04703 ***	0.03999 ***

The coefficients given by the industry dummies inform us about how the diffusion of informal knowledge differs across sectors. For product innovation, the diffusion of informal knowledge is most intense for the financial services sector, followed by high-tech manufacturing, high-tech services, medium-low-tech manufacturing, medium-high-tech manufacturing and market services. We found no sectoral significant distinction for the low-tech manufacturing or the utilities sector.

As for process innovation, the diffusion of informal knowledge is highly dynamic for the financial services sector, followed by high-tech manufacturing, high-tech services, the utilities sector, medium-low-tech manufacturing, and medium-high-tech manufacturing. For the other sectors we did not find any significant statistical difference.

For both product and process innovation, the size of the firm is a relevant variable. The larger the firm, the higher the capacity it has to be exposed to or to be able to make use of the flow of informal knowledge generated around the innovation activities of its sector. However we observe that the coefficient is higher in the case of process innovation.

The quality of human capital is an important variable for the diffusion of informal knowledge related to product innovation. A higher number of educated workers implies an increased capacity for firms to introduce new products. However, in the case of process innovation, we find no significant results.

The fact that a firm belongs to a group is not relevant to the capacity of the firm to make use of informal knowledge to introduce a new product. For process innovation it is an important variable, explaining the capacity of the firm to introduce a new process by making use of the diffusion of informal knowledge present in the sector.

The next three variables are related to factors that hamper innovation. If a firm has difficulties to innovate due to costs or lack of personnel we expect this firm to make a more intensive use of the diffusion of informal knowledge. Firms which find that innovation costs are too high are firms more capable to innovate both in process and in product with very little difference between the two coefficients. Moreover, firms that report a lack of qualified personnel are firms that are closer to the diffusion process, even though the effect is higher in the case of process innovation. If a firm reports lack of customers' responsiveness to new goods or services, this results in a lower capacity to innovate. Maybe the entrepreneur has developed an idea or invention but it never materializes into an innovation due to a lack of demand.

The next set of variables is related to strategies used by firms to protect their innovations. Innovation based on the diffusion of informal knowledge can be considered as an innovation of "second order". These firms are trying to be innovative by benefiting from the informal knowledge generated by the innovative activities in the sector. We have seen that the most successful firms based on diffusion report innovative costs being too high. Consequently, methods chosen to protect their innovations would also be the less costly[7]. The CIS offers three formal

[7] Having applied for a patent is a not significant variable therefore we neglected it in the estimation. Considering innovation based on diffusion of informal knowledge as innovation of second order, which

methods of protection: registration of design patterns, trademarks and copyrights. Out of the three, the one with the largest effect for product and process innovation is the registration of design patterns. If a firm reports to have used registration of design patterns, it increases the probability of being able to profit from the diffusion of informal knowledge related to new products. In the case of profiting from process innovation, the coefficient is almost as high. When we compare this coefficient to that of trademarks, the coefficients for both estimations drop significantly, although they are still significant. Using copyrights as a way to protect innovation has no effect on firms' innovative performance. Out of the three informal methods – secrecy, complexity of design and lead-time advantage on competitors – lead-time advantage has the highest impact, although the use of secrecy and complexity of design are also significant. Strategic instead of formal methods for protecting ideas and innovations are more effective for increasing the change of successfully introducing a new product or process.

For being a successful user of diffusion of informal knowledge, the most important strategic and organizational changes are aesthetic or other subjective changes. For process innovation changes in strategy, management, organization and marketing are all relevant and have significant coefficients. All of them point to a more intensive use of sectoral diffusion of informal knowledge. For product innovation, we only find a significant variable for firms that have introduced a corporate strategy or organizational innovation. Surprisingly, management and marketing changes are not connected to being close to the sectoral flow of informal knowledge.

With these two probits, we build the latent variables as explained in section 3.1. This will allow us to study the relation between the diffusion of informal knowledge and the innovation performance of a firm. In this second stage, we concentrate on the probability of introducing a new product, of increasing the proportion of innovative sales, and of successfully introducing a new process.

Table 4.2 presents the results of the diffusion of informal knowledge on the probability of being a successful product innovator. Columns 1 and 3 are estimated including the latent variable, while columns 2 and 4 are estimated without the latent variable. A first observation based on the results illustrated in table 4.2 is that after including the effect of diffusion of informal knowledge, the total effect of the other variables tends to reduce. This is observed by comparing the coefficients before and after introducing the latent variable. Coefficients are smaller when diffusion is considered, as reflected by the presence of the latent variable.

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would be costly, the protection used by these firms would also be less costly as shown in the regression results.

Table 4.2 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.17011 *****		**0.14749 *****	
$INNOV_{total}$	0.01289 ***	0.01827 ***		
$R\&D_{Internal}$			0.01156 ***	0.01547 ***
$R\&D_{External}$			0.00099	0.00219 **
$INNOV_{Mach}$			-0.00178 **	-0.00034
$INNOV_{ExtKnw}$			0.00219 **	0.00371 ***
$INNOV_{Other}$			0.02601 ***	0.02829 ***
Size	-0.02332 ***	-0.00299	-0.03078 ***	-0.01527 ***
Δ Fund	-0.02864 ***	-0.00955	-0.01664 *	-0.00445
Δ ManufHighTech	0.10134 ***	0.21131 ***	0.07625 **	0.17195 ***
Δ MediumHighTech	0.16469 ***	0.24351 ***	0.13937 ***	0.20367 ***
Δ MediumLowTech	0.07095 **	0.15762 ***	0.06618 **	0.13771 ***
Δ LowTech	0.12644 ***	0.16631 ***	0.11807 ***	0.14879 ***
Δ Utilities	-0.09204 **	-0.10206 **	-0.10705 **	-0.11585 ***
Δ Market Serv Low	0.04074	0.10769 ***	0.02466	0.07944 **
Δ Financial Services	0.08021 **	0.19753 ***	0.07423 **	0.17499 ***
Δ Market Services	0.01666	0.09863 ***	-0.01931	0.04882
Δ High Tech Services	0.13312 ***	0.22323 ***	0.09778 ***	0.17793 ***
Δ Suppliers	-0.00906	0.00991	0.0111	0.03162 ***
Δ Clients	0.21821 ***	0.24517 ***	0.20216 ***	0.22413 ***
Δ Universities	0.04533 ***	0.06298 ***	0.01577 *	0.0244 ***

We find a negative and statistically significant coefficient for size whenever diffusion is taken into consideration. The idea behind this finding is that a higher number of new products are introduced by firms which are small. We find a negative and significant coefficient for the variable that controls for public funding. The profile of an innovative firm, after controlling for the diffusion of informal knowledge, is a firm for which using clients and universities as sources of information is more effective for being innovative. One could think that the introduction of sources of information might interact with the concept of diffusion of informal knowledge, however, the idea of diffusion of informal knowledge reflects the capacity of a firm to be close to the knowledge generated by the innovation capacity of the sector, and to use the influence of this flow of specific knowledge in the innovation process. If a firm reports to have used clients as a source of information, this effect can be disentangled from the diffusion of the informal knowledge process. We observe that clients and universities are the relevant sources of information for product innovation.

The comparison between columns 3 and 4 shows the dynamic process of the innovative performance of firms. Expenditures on extramural R&D are not statistically significant when the diffusion process is included, which might imply that what external R&D is capturing is a second best solution to the estimated knowledge diffusion. This means that extramural R&D is not really affecting the innovative performance, but instead it is bringing the firm closer to the diffusion of knowledge. When the latent is present, we find a negative relation between expenditures in machinery and equipment and the probability of introducing a new product. This effect might be explained by the competitive nature of innovation expenditures, where firms have a diversified innovation strategy of engaging in both product and process innovation. Whatever is spent in machinery affects negatively the probability of introducing a new product. The expenditures devoted to the acquisition of other external knowledge and other innovation expenditures have a positive impact on the successful introduction of a new product.

Table 4.3 Effect of knowledge diffusion on innovative sales

KnDifpdt	**2.49247 *****		**2.52076 *****	
$INNOV_{total}$	0.41611 ***	0.51327 ***		
$R\&D_{Internal}$			0.17685 ***	0.25452 ***
$R\&D_{External}$			0.02029	0.03995 ***
$INNOV_{Mach}$			0.05467 ***	0.07655 ***
$INNOV_{ExtKnw}$			0.04419 ***	0.07503 ***
$INNOV_{Other}$			0.30922 ***	0.3367 ***
Size	0.12062 ***	0.42022 ***	0.0518	0.31298 ***
Fund	-0.26674 **	0.022	0.1436	0.35232 **
Mining	2.45525 ***	-4.39678 ***	4.1591 ***	-2.27407 ***
ManufHighTech	4.43026 ***	0.2022	5.6122 ***	1.53734 ***
MediumHighTech	5.43655 ***	0.29518	6.7208 ***	1.81635 ***
MediumLowTech	4.11488 ***	-1.21166 ***	5.56936 ***	0.57665 **
LowTech	5.20669 ***	-0.977 ***	6.66974 ***	0.84744 ***
Utilities	-0.19101	-7.23802 ***	1.35292 **	-5.23638 ***
Market Serv Low	3.69088 ***	-2.06668 ***	4.81993 ***	-0.60915 **
Financial Services	4.49668 ***	0.05883	6.17131 ***	2.11217 ***
Market Services	2.6904 ***	-2.87285 ***	3.99446 ***	-1.31901 ***
High Tech Services	4.25896 ***	-0.33485	5.38755 ***	0.99723 ***
Suppliers	0.67886 ***	0.97976 ***	1.10934 ***	1.4747 ***
Clients	3.51441 ***	3.93124 ***	3.69667 ***	4.12869 ***
Universities	0.2027	0.44471 ***	-0.02356	0.09672

Table 4.3 shows the effect of the diffusion of informal knowledge on innovative sales. These are defined as the logarithm of total innovative sales; therefore the coefficients can be interpreted as elasticities. The first interesting result, when compared with those in Table 4.2, is the effect of size on innovative sales: small firms introduce more new products. However, large firms are able to gain higher profits out of product innovation. The effect of size disappears when we disaggregate the innovation expenditures. This might be due to measurement errors (see footnote 4). We also observe that innovation expenditures in machinery and equipment, which have a negative effect in Table 4.2, have a positive effect in Table 4.3, even after considering the effect of diffusion. This means that these expenditures reduce the capacity of firms to come up with a new product, even though they increase total sales, probably through the reduction of costs, and the impact they have in process innovation. As explained before, extramural R&D is not really affecting the innovative performance, but instead it is bringing the firm closer to the diffusion of knowledge. Once we allow for the diffusion effect, its significance disappears. Another interesting difference is the effect of sources of information. As seen in Table 4.2, firms reporting using clients as sources of information have higher chances to increase their innovative sales. However, information coming from suppliers seems to be relevant for sales (Table 4.3) which was not the case for product innovation (Table 4.2) and the effect does not depend on including the effect of knowledge diffusion.

Universities, which were an important source of information for product innovation, are not a relevant source of information when considering innovative sales.

We now consider the effects for process innovation. Table 4.4 shows results considering the latent variable that captures the diffusion of informal knowledge related to process innovation ($KnDif_{pcs}$). A first comparison with Table 4.2 shows that the effect of diffusion is smaller in size for process innovation, with a magnitude of the coefficient ranging between 0.07-0.08.In Table 4.2, the magnitude of the diffusion was within 0.14-0.17. Size is no longer relevant when we take into account the effect of knowledge diffusion. The effect of size is overtaken by the introduction of the diffusion variable which already takes size into account. Public funding is a relevant variable: the effect on process innovation is statistically significant in all cases.

Intramural R&D seems to have a positive impact which disappears when we include the diffusion process. This is an interesting result, meaning that a firm that is involved with intramural R&D might be closer to process innovation. However these expenditures do not affect the probability of being a successful process innovator if we consider the diffusion of informal knowledge. The external R&D seems to have a positive impact even after considering diffusion, which implies that firms doing external R&D are more capable of introducing new processes when compared to those firms that do not outsource R&D. The expenditures in machinery and equipment are the most relevant for process innovation, and are positively related with the probability of being a successful process innovator. The same observation applies for expenditures for acquiring other external knowledge and other innovation expenditures.

Table 4.4 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.07549 *****		**0.0837 *****	
$INNOV_{total}$	0.02623 ***	0.02887 ***		
$R\&D_{Internal}$			-0.00018	0.00229 ***
$R\&D_{External}$			0.00179 *	0.00243 **
$INNOV_{Mach}$			0.02292 ***	0.02365 ***
$INNOV_{ExtKnw}$			0.0062 ***	0.00716 ***
$INNOV_{Other}$			0.00378 ***	0.00476 ***
Size	-0.00385	0.01142 ***	0.00215	0.01785 ***
Δ Fund	0.06298 ***	0.07107 ***	0.07408 ***	0.08031 ***
Δ ManufHighTech	-0.22972 ***	-0.16486 ***	-0.24003 ***	-0.17829 ***
Δ MediumHighTech	-0.14728 ***	-0.11076 ***	-0.14005 ***	-0.1073 ***
Δ MediumLowTech	-0.04191	-0.00893	-0.05183	-0.01944
Δ LowTech	-0.0195	-0.00131	-0.03745	-0.02078
Δ Utilities	0.01025	0.02706	-0.00944	0.01031
Δ Market Serv Low	-0.08371 **	-0.07296 *	-0.11687 ***	-0.10907 ***
Δ Financial Services	0.03381	0.09184 **	0.01698	0.07833 *
Δ Market Services	-0.15012 ***	-0.12351 ***	-0.14484 ***	-0.12251 ***
Δ High Tech Services	-0.18827 ***	-0.14034 ***	-0.17036 ***	-0.1259 ***
Δ Suppliers	0.21463 ***	0.22176 ***	0.21294 ***	0.22299 ***
Δ Clients	-0.01515	-0.00326	0.01606	0.02878 ***
Δ Universities	-0.03002 ***	-0.02228 **	-0.01845 *	-0.01414

As for sources of information and their effects on process innovation, suppliers are the most relevant source, instead of clients and universities. The negative significant sign found for universities can be explained considering firms' characteristics. In general, firms closer to universities are engaged with product instead of process innovations.

Conclusion 1: Diffusion and innovative performance
Diffusion of informal knowledge has a positive impact on firms' overall innovative performance. Once we acknowledge the effect of diffusion, the effect of the other variables diminishes. *When total innovation expenditures are analyzed we can say that in general they are always relevant, even after considering diffusion of knowledge. However when we analyze the different parts which innovation expenditures are composed of, and we introduce them as separate variables, we observe that in combination with diffusion, extramural R&D does not affect product innovation, that these expenditures are only an indirect measure for the effect of diffusion and that they are only significant when the latent is not present. The same can be said for innovative sales. In the case of process innovation, intramural R&D has a diffusion effect over the introduction of a new process but it disappears with the introduction of the latent variable that controls for diffusion of informal knowledge across sectors.*

5. Results at sector level

In this section we focus our analysis on the following nine sectors: Food, Machinery, Textiles, Chemicals, Energy, ICT, Automotive, Eco-innovation and Gazelles. These sectors can be studied given the available information in the CIS 3 database. Aerospace was disregarded because the number of observation was too small to pass the EUROSTAT threshold of a minimum number of firms to ensure confidentiality.

For each of the sectors we have repeated the second stage of the estimation for a sample containing only firms that belong to each of the specific sectors. The first stage of the definition of the latent variables could not be done because for most sectors we did not have enough observations in the group of firms that innovate only based on diffusion of informal knowledge.

Food

The estimation results for the effect on knowledge diffusion on product innovation for the Food industry (defined as NACE 15+16) are presented in Table 5.1.1. The first challenging result is that total expenditures in innovation are not relevant when we introduce knowledge diffusion. However, when comparing the last two columns of the table we observe that some of the expenditures in innovation have a negative impact on the probability of successfully introducing a new product. When the expenditures in innovation are added then the total effect is not significant. Intramural R&D is positively related to product innovation, while the expenditures on the acquisition of new machinery and equipment decrease the capacity of the firm to innovate with a new product. Size, when significant, points to the fact that small firms introduce a higher number of new products in the Food sector. Governmental support has no positive effect on product innovation in the Food sector. Firms in the Food sector benefit from clients and universities as relevant sources of information.

Table 5.1.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.11715 *****		**0.08995 *****	
$INNOV_{total}$	0.00362	0.00668 **		
$R\&D_{Internal}$			0.01071 ***	0.01378 ***
$R\&D_{External}$			-0.00147	-0.00092
$INNOV_{Mach}$			-0.00485 **	-0.00427 *
$INNOV_{ExtKnw}$			0.00827 **	0.00868 **
$INNOV_{Other}$			0.02083 ***	0.02183 ***
Size	-0.01422	0.00486	-0.03098 ***	-0.01905 *
Δ Fund	-0.06887 **	-0.0564 **	-0.07129 **	-0.06096 **
Δ Suppliers	-0.03114	-0.00767	-0.00641	0.01464
Δ Clients	0.14829 ***	0.16757 ***	0.11765 ***	0.13117 ***
Δ Universities	0.08019 ***	0.08698 ***	0.04256	0.04299

When comparing Table 5.1.1 with the general results obtained by Table 4.2, we observe that for innovative firms in the Food sector governmental support has a smaller effect on their innovativeness. Firms in this sector are also less capable of using the information from clients and transforming it into new products.

Table 5.1.2 presents the relation of the diffusion of informal knowledge for product innovation with innovative sales. Large firms are normally more capable of translating product innovation into higher sales, despite the fact that smaller firms have a higher probability of introducing new products. Intramural R&D is relevant for increasing the amount of innovative sales. Clients are important sources of information for increasing innovative sales. Suppliers are not a relevant source of information, contrary to what we have seen for the general results for all industries. Universities are not a relevant source of information for this sector; a similar result was obtained for all industries.

Table 5.1.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**2.00835 *****		**1.81457 *****	
$INNOV_{total}$	0.21789 ***	0.28468 ***		
$R\&D_{Internal}$			0.17016 ***	0.23958 ***
$R\&D_{External}$			0.0011	0.02014
$INNOV_{Mach}$			-0.0123	0.00111
$INNOV_{ExtKnw}$			0.08113	0.09688 *
$INNOV_{Other}$			0.20082 ***	0.21449 ***
Size	0.38841 **	0.7482 ***	0.27255	0.52274 ***
Δ Fund	-0.03197	0.19405	0.18765	0.3365
Constant	8.53288 ***	3.13435 ***	9.11825 ***	4.63806 ***
Δ Suppliers	-0.35702	-0.02002	0.09022	0.44295
Δ Clients	1.73997 ***	2.01016 ***	1.53161 ***	1.79261 ***
Δ Universities	0.54428	0.63984	0.25388	0.22501

Table 5.1.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.07681 *****		**0.0757 *****	
$INNOV_{total}$	0.03002 ***	0.0322 ***		
$R\&D_{Internal}$			0.00735 **	0.01049 ***
$R\&D_{External}$			0.00762 *	0.00814 *
$INNOV_{Mach}$			0.02308 ***	0.02344 ***
$INNOV_{ExtKnw}$			0.0083 *	0.00879 *
$INNOV_{Other}$			0.00568	0.00624
Size	-0.04859 ***	-0.02866 **	-0.04208 ***	-0.02527 *
Δ Fund	0.20935 ***	0.21549 ***	0.21539 ***	0.21948 ***
Δ Suppliers	0.18447 ***	0.1991 ***	0.18309 ***	0.20046 ***
Δ Clients	-0.02348	-0.01269	-0.00347	0.00648
Δ Universities	-0.01696	-0.01446	-0.01477	-0.01753

An interesting result when comparing the Food sector results with Table 4.3 (general picture) is that expenditures in machinery and equipment do not increase innovative sales. In the Food sector large firms doing process innovation are more successful than small firms. Both intramural and extramural R&D expenditures are relevant. However, the most important innovation expenditures are those related to the acquisition of new machinery and equipment. Public funding and information from suppliers have a positive effect on process innovation.

When comparing with the general results of Table 4.4, firms in the Food sector benefit more from intramural R&D for process innovation; also small firms are more likely to introduce a new process innovation.

Conclusion 2: Diffusion and innovative performance in the Food sector

Even though the diffusion of informal knowledge shows a positive impact in all three dimensions of innovative performance, the impact is lower than that for all industries.

Smaller firms are more likely to introduce product and process innovations. However, larger firms are the ones that seem to benefit most from innovative sales. In this sector, public funding has a negative effect on product innovation but a positive effect on process innovation.

Machinery

Table 5.2.1 presents the results for product innovation and knowledge diffusion for the Machinery sector (defined as NACE 29). Diffusion of informal knowledge has always a positive and significant value for the firms in this sector. After including diffusion related to product innovation, the impact of total innovation expenditures is marginal. This is mostly due to the different sign of the different innovation expenditures. The expenditures in extramural R&D are significant at the 5% level, intramural R&D however is not significant. The most relevant expenditures are expenditures related to other activities which include expenditures in training of personnel, market introduction of innovations and designs and other preparations for production and delivery. Size is not relevant for explaining product innovation in the Machinery sector and the main source of information comes from clients.

Table 5.2.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.10025 *****		**0.08458 *****	
$INNOV_{total}$	0.00146	0.00575 **		
$R\&D_{Internal}$			0.00139	0.00427 **
$R\&D_{External}$			0.0051 **	0.00608 ***
$INNOV_{Mach}$			-0.00384 **	-0.00319 *
$INNOV_{ExtKnw}$			0.00238	0.00389
$INNOV_{Other}$			0.01135 ***	0.01293 ***
Size	-0.0016	0.01378 *	-0.00649	0.00368
Δ Fund	-0.02352	-0.00924	-0.02525	-0.01753
Δ Suppliers	-0.0398 *	-0.03214	-0.0461 **	-0.03717 *
Δ Clients	0.28047 ***	0.31458 ***	0.27291 ***	0.29641 ***
Δ Universities	0.01967	0.02573	0.01184	0.01298

When these results are compared with Table 4.2, firms in the Machinery sector make more intense use of the information from clients as represented by the coefficients 0.28 and 0.27 (compared to the overall results of 0.21 and 0.20 respectively). This sector does not benefit from the knowledge generated by universities, as shown by the non significant coefficient.

Table 5.2.2 focuses on the effect of diffusion of informal knowledge on the innovative sales of the Machinery sector. We observe that the larger firms are more likely to have a higher proportion of innovative sales. Public funding has no significant effect on innovative sales. The main source of information, as in product innovations, comes from clients and this information is more effective when compared with the general results presented in Table 4.3. When total innovation expenditures are broken down into different components, internal R&D is relevant for the sale of new products. Expenditures in extramural R&D, other external knowledge and other innovation expenditures are also important.

Table 5.2.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**1.97723 *****		**1.95373 *****	
$INNOV_{total}$	0.19328 ***	0.2835 ***		
$R\&D_{Internal}$			0.07287 **	0.14198 ***
$R\&D_{External}$			0.05756 *	0.07206 **
$INNOV_{Mach}$			0.01181	0.02288
$INNOV_{ExtKnw}$			0.08857 **	0.12101 ***
$INNOV_{Other}$			0.11119 **	0.12314 **
Size	0.60151 ***	0.86308 ***	0.53522 ***	0.75408 ***
Δ Fund	-0.19475	-0.01712	-0.1316	-0.0332
Constant	5.27201 ***	0.90969	6.16103 ***	2.27282 ***
Δ Suppliers	-0.11874	0.08102	-0.12216	0.13774
Δ Clients	4.26694 ***	4.68388 ***	4.33785 ***	4.69824 ***
Δ Universities	-0.04189	0.21424	-0.144	0.02682

Table 5.2.3 explains the relation between diffusion of informal knowledge and process innovations. Small firms are more likely to introduce process innovations. Innovative process firms do not seem to benefit from government support. The amount of money devoted to the acquisition of new machinery and equipment increases the probability of introducing a new process. We observe that information from suppliers or from universities have a positive effect on process innovation, thus indicating a closer connection between process innovation and basic research.

Table 5.2.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.11595 *****		**0.11887 *****	
$INNOV_{total}$	0.02439 ***	0.02953 ***		
$R\&D_{Internal}$			0.00022	0.00419
$R\&D_{External}$			-0.00311	-0.00195
$INNOV_{Mach}$			0.02456 ***	0.02519 ***
$INNOV_{ExtKnw}$			0.00573	0.00757 **
$INNOV_{Other}$			0.00459	0.00496
Size	-0.02765 **	-0.00221	-0.02343 *	0.00024
Δ Fund	0.00284	0.01413	-0.00335	0.00345
Δ Suppliers	0.07925 **	0.08795 **	0.08525 **	0.09877 ***
Δ Clients	-0.04755	-0.02732	-0.02745	-0.01015
Δ Universities	0.07227 **	0.0826 ***	0.07668 **	0.08356 **

Conclusion 3: Diffusion and innovative performance in the Machinery sector

The effect of diffusion of informal knowledge in the Machinery sector is below the general average when we consider product innovation and innovative sales. However, the use made of diffusion of informal knowledge in this sector is higher when we consider process innovation.

Overall, government support is not essential for successful product and process innovation in the Machinery sector. Smaller firms are more likely to introduce new products and processes. However, large firms are more likely to have higher innovative sales. There is a strong connection with basic research for being successful in process innovation.

Textiles

Table 5.3.1 shows the relation between the diffusion of informal knowledge and the innovative capacity of firms to introduce new products. In the Textiles sector (defined as NACE 17+18), size is a relevant variable to explain successful product introduction where the negative sign shows that small firms are more likely to introduce product innovations. There is no statistical relation between receiving funds and increasing the probability of innovating. Total expenditures in innovation are relevant even after the diffusion of informal knowledge is included. When we look at innovation expenditures at the disaggregate level, we observe that intramural R&D and other innovation expenditures increase the capacity to introduce new products. The most relevant source of information when introducing new textile products is clients. When we compare these results with those of Table 4.2, the Textiles sector presents a similar behaviour as that for all industries.

Table 5.3.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.21065 *****		**0.17457 *****	
$INNOV_{total}$	0.02219 ***	0.02836 ***		
$R\&D_{Internal}$			0.02129 ***	0.0275 ***
$R\&D_{External}$			0.00465	0.00388
$INNOV_{Mach}$			-0.00127	0.00039
$INNOV_{ExtKnw}$			0.00159	0.0031
$INNOV_{Other}$			0.03842 ***	0.04009 ***
Size	-0.03515 **	-0.00556	-0.05556 ***	-0.03471 **
Δ Fund	-0.0676	-0.03021	-0.04825	-0.02315
Δ Suppliers	-0.09736 **	-0.05721	-0.05809	-0.01855
Δ Clients	0.29541 ***	0.30646 ***	0.28064 ***	0.28704 ***
Δ Universities	0.09111 **	0.09516 **	0.06224	0.05945

Table 5.3.2 shows the relations with innovative sales. The amount of total innovation expenditures is relevant but size is not a significant variable, which means that the innovative sales of the sector are equally distributed among all firms, independently of their size. When we consider disaggregated innovation expenditures, we see that intramural R&D and other innovative expenditures are significant variables. Public funds are not relevant and clients are the main source of information.

Table 5.3.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**2.58671 *****		**2.35179 *****	
$INNOV_{total}$	0.56412 ***	0.66956 ***		
$R\&D_{Internal}$			0.3783 ***	0.47436 ***
$R\&D_{External}$			0.03302	0.03037
$INNOV_{Mach}$			0.05867	0.0779
$INNOV_{ExtKnw}$			0.08549	0.11145
$INNOV_{Other}$			0.34202 ***	0.36965 ***
Size	-0.18242	0.10303	-0.3675	-0.15733
Δ Fund	-0.44736	-0.00253	-0.22119	0.09962
Constant	3.92392 **	-2.49569 **	5.41057 ***	-0.05222
Δ Suppliers	-1.05991	-0.48231	-0.07015	0.50811
Δ Clients	6.1441 ***	6.4316 ***	6.10148 ***	6.3726 ***
Δ Universities	0.62098	0.62064	-0.01952	-0.16423

The comparison of this table with Table 4.3 shows that the expenditures in machinery are not relevant to increase innovative sales in Textiles, whereas they are relevant for the average industry. Neither suppliers nor universities are important sources of information.

The relations between process innovation and diffusion are presented in Table 5.3.3. Size is not relevant when explaining process innovation in the textile sector. Process innovations are introduced by both small and big firms. Total innovation is an important variable which explains the increase in the probability of doing process innovation. When we disaggregate these expenditures, we see that it is the money spent on the acquisition of new machinery and equipment that is the most relevant component of innovative expenditures. Suppliers are the main source of information for the Textiles sector when doing process innovation.

Diffusion of informal knowledge is not relevant when explaining process innovation activity in this sector. Public funding is very relevant in this sector for a successful process innovation. Suppliers are the most relevant source of information.

Table 5.3.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.0302**		**0.07237 ****	
$INNOV_{total}$	0.02679 ***	0.02796 ***		
$R\&D_{Internal}$			-0.00766 *	-0.00453
$R\&D_{External}$			0.00436	0.00392
$INNOV_{Mach}$			0.02514 ***	0.02586 ***
$INNOV_{ExtKnw}$			0.00557	0.00633
$INNOV_{Other}$			0.00168	0.00209
Size	0.0011	0.0075	0.00872	0.0228
Δ Fund	0.09243 **	0.09723 **	0.10641 **	0.11446 **
Δ Suppliers	0.30451 ***	0.3094 ***	0.32847 ***	0.34107 ***
Δ Clients	-0.06798	-0.06606	-0.03211	-0.02537
Δ Universities	-0.02037	-0.01884	-0.02584	-0.02691

Conclusion 4. Diffusion and innovative performance of the Textiles sector

Diffusion is relevant and positively correlated with all innovative dimensions considered in the analysis. Although product innovation and innovative sales make use of diffusion, in both cases the effect is below the average effect for all industries. Diffusion is not significant for process innovation.

For process innovation, information given by suppliers is very relevant and is public funding. Product innovators and the innovative sales of the sector make intensive use of information provided by clients.

Chemicals

Table 5.4.1 shows a positive relation between diffusion of informal knowledge and successful product innovation in the Chemicals sector (defined as NACE 24). As in the general picture, small and medium sized firms are more likely to introduce a new product. Total innovation expenditures are not significant, although when we disaggregate innovation expenditures, we see that intramural R&D and other innovation expenditures are significant. The other expenditures in innovation seem to have no impact on successful innovation. Clients are the best source of information when introducing new products in this sector.

Table 5.4.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.0972 *****		**0.07662 *****	
$INNOV_{total}$	-0.00206	0.00046		
$R\&D_{Internal}$			0.00516 **	0.00634 ***
$R\&D_{External}$			-0.00264	-0.00243
$INNOV_{Mach}$			-0.00197	-0.0014
$INNOV_{ExtKnw}$			0.00033	0.00076
$INNOV_{Other}$			0.01592 ***	0.01814 ***
Size	-0.0201 **	-0.00699	-0.03409 ***	-0.02478 **
Δ Fund	0.00743	0.01399	0.01275	0.01728
Δ Suppliers	-0.02419	-0.00432	-0.02803	-0.01278
Δ Clients	0.13132 ***	0.14831 ***	0.10982 ***	0.12033 ***
Δ Universities	0.0087	0.02658	-0.00085	0.01075

Table 5.4.2 considers diffusion and innovative sales. Even though total expenditures in innovation is not an important variable to generate a new chemical product, it is relevant for increasing innovative sales. In this case, intramural R&D is very important. Larger firms have a higher probability to get higher profits. Clients are the main source of innovation.

Comparing Tables 5.4.1 and 5.4.2 it seems there are two different kinds of innovation: small and medium sized firms are more likely to introduce a new product but the sales revenues are more limited than those of large firms which are less likely to introduce a new product. New product innovations by large firms are economically of more importance than those of small firms.

Table 5.4.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**1.21271 *****		**1.13549 *****	
$INNOV_{total}$	0.12479 **	0.15672 ***		
$R\&D_{Internal}$			0.13296 ***	0.14816 ***
$R\&D_{External}$			-0.02834	-0.02632
$INNOV_{Mach}$			0.01984	0.02759
$INNOV_{ExtKnw}$			0.03094	0.04386
$INNOV_{Other}$			0.12871 **	0.14533 ***
Size	0.53648 ***	0.70899 ***	0.391 **	0.54242 ***
Δ Fund	0.09953	0.20555	0.07156	0.17413
Constant	9.0146 ***	6.56285 ***	9.56241 ***	7.41021 ***
Δ Suppliers	-0.24856	0.01961	-0.31105	-0.07158
Δ Clients	0.92868 **	0.97939 **	0.70161	0.72456
Δ Universities	0.34301	0.54422	0.26289	0.43398

For process innovations (Table 5.4.3), the first important result is that in the Chemicals sector, larger firms are more successful in introducing a new process innovation. General expenditures in innovation are relevant. However, if we disaggregate these innovation expenditures, we see that expenditures in machinery and equipment are positively correlated with the increase in the probability of introducing a process innovation, whereas other expenditures are negatively correlated, explaining why the total aggregation is not significant when the diffusion latent variable is included in the regressions.

Table 5.4.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.08652 *****		**0.07761 *****	
$INNOV_{total}$	0.00798	0.01017 **		
$R\&D_{Internal}$			-0.00359	-0.00239
$R\&D_{External}$			-0.00146	-0.00147
$INNOV_{Mach}$			0.02 ***	0.02051 ***
$INNOV_{ExtKnw}$			0.00537	0.00643
$INNOV_{Other}$			-0.01152 **	-0.01043 **
Size	0.04244 ***	0.06075 ***	0.05988 ***	0.07582 ***
Δ Fund	0.09133 **	0.09747 ***	0.06621 *	0.07189 *
Δ Suppliers	0.06968	0.08824 **	0.05687	0.07272 *
Δ Clients	0.03409	0.04299	0.03532	0.03991
Δ Universities	-0.01311	0.00323	-0.00279	0.00926

In general, for firms engaged in process innovation in the Chemicals sector public support is relevant. None of the information sources are relevant for increasing the chance of introducing a process innovation.

Conclusion 5. Diffusion and innovative performance of the Chemicals sector

The diffusion of informal knowledge is positively related to the innovation performance of Chemical firms. The closer they are to these flows of knowledge, the higher their capacity to successfully introduce a new process or product or to increase their innovative sales.

Total expenditures in innovation seem to mainly affect innovative sales, public funding is only relevant for process innovation and small firms are more likely to introduce a product innovation whereas large firms are more likely to introduce a process innovation.

Energy

Table 5.5.1 shows the relation between the diffusion of informal knowledge and the introduction of new products in the Energy sector (defined as NACE 10+11+12+23+40). The effect of diffusion of informal knowledge is about two times higher in the Energy sector than for the average industry as shown in Table 4.2. However, this effect is so strong that it nullifies most of the other variables. When innovation expenditures are considered as a total, the only significant variable is information from clients. When innovation expenditures are broken-down into different components, we find that intramural R&D is the most important investment in innovation for being a successful innovator. An interesting result is the fact that successful Energy firms do not use universities as a source of information for product innovation.

Table 5.5.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.3169 *****		**0.26803 *****	
$INNOV_{total}$	0.01106	0.02044 ***		
$R\&D_{Internal}$			0.0174 ***	0.02715 ***
$R\&D_{External}$			-0.00187	-0.00271
$INNOV_{Mach}$			0.00069	0.00141
$INNOV_{ExtKnw}$			0.00771	0.01375 **
$INNOV_{Other}$			0.0152	0.01329
Size	-0.01675	0.01769	-0.03121	-0.00574
Δ Fund	-0.01399	0.04351	-0.04084	-0.01385
Δ Suppliers	0.04543	0.02117	0.05914	0.0606
Δ Clients	0.19963 ***	0.25572 ***	0.18812 ***	0.22508 ***
Δ Universities	-0.09809	-0.07231	-0.09811	-0.09902

When we consider innovative sales in the Energy sector, we see that size is not a relevant factor. This is different compared to all sectors, where larger firms are more related to innovative sales. However, innovation expenditures are important and firms' spending on innovation has on average innovative sales 0.41 larger than firms not investing in innovation. Especially important in this sector is intramural R&D and other innovation expenditures. Clients are the most relevant source of information and the effect is above that of the average industry (cf. Table 4.3).

Table 5.5.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**7.30449 *****		**6.0086 *****	
$INNOV_{total}$	0.41263 **	0.72056 ***		
$R\&D_{Internal}$			0.49066 ***	0.79355 ***
$R\&D_{External}$			-0.09684	-0.15613
$INNOV_{Mach}$			-0.01098	-0.02073
$INNOV_{ExtKnw}$			0.25783	0.42522 **
$INNOV_{Other}$			0.60722 **	0.61782 **
Size	-0.15137	0.69952	-0.7243	-0.11719
Δ Fund	0.97959	2.418	0.69479	1.24692
Constant	4.14039	-15.12804 ***	4.67556	-9.49586 ***
Δ Suppliers	2.09236	2.10653	1.88972	2.30824
Δ Clients	5.09348 **	6.70929 ***	4.85055 **	5.90645 ***
Δ Universities	-2.31264	-1.72938	-1.45397	-1.44096

When we consider process innovation in the Energy sector we observe that the diffusion of informal knowledge is not relevant. The sector might rely on other methods to disseminate knowledge. In this case the results of columns 1 and 2 and columns 3 and 4 are almost identical. Total innovation expenditures is important for process innovation, especially expenditures on acquiring machinery and equipment and other expenditures. Firms which are engaged in process innovation are able to benefit from public support and their best source of information is suppliers.

Table 5.5.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.02481**		**0.041**	
$INNOV_{total}$	0.02489 ***	0.02561 ***		
$R\&D_{Internal}$			-0.00154	-0.00027
$R\&D_{External}$			0.00035	0.00016
$INNOV_{Mach}$			0.02351 ***	0.02347 ***
$INNOV_{ExtKnw}$			0.00204	0.00318
$INNOV_{Other}$			0.02762 ***	0.0279 ***
Size	0.00012	0.00503	-0.0016	0.00547
Δ Fund	0.20159 ***	0.20521 ***	0.21505 ***	0.2191 ***
Δ Suppliers	0.34444 ***	0.34471 ***	0.34691 ***	0.34753 ***
Δ Clients	-0.08282	-0.07938	-0.09829	-0.09394
Δ Universities	-0.0616	-0.05971	-0.03536	-0.03269

Conclusion 6. Diffusion and innovation performance in the Energy sector

When we analyze the Energy sector and its relation with the diffusion of informal knowledge we find some extreme results; for product innovation and innovative sales, the effect of diffusion is by far higher than in any of the other sectors. However diffusion is not relevant for process innovation.

Intramural R&D is related to the introduction of new products and innovative sales. For process innovation, expenditure on acquiring machinery and equipment is most relevant. For the Energy sector information from universities and basic research is not relevant, most firms operate close to the market as the most effective sources of information include clients for product innovation and suppliers for process innovation.

ICT

Table 5.6.1 analyzes the relation between product innovation and diffusion of informal knowledge in the ICT sector (defined as NACE 30+32+33+64+72). The effect of the latent diffusion variable is significant for product innovation. Innovation expenditures increase firms' capacities to be product innovators. When innovation expenditures are disaggregated, intramural R&D and other expenditures are the two main expenditures for the successful introduction of new products. In general, smaller firms in the ICT sector are more likely to introduce new products. Public support has no relevant effect and the main sources of information are clients and universities.

Table 5.6.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.10875 *** **		**0.08796 *** **	
$INNOV_{total}$	0.01232 ***	0.01669 ***		
$R\&D_{Internal}$			0.00904 ***	0.0115 ***
$R\&D_{External}$			0.0014	0.00282
$INNOV_{Mach}$			0.00054	0.0014
$INNOV_{ExtKnw}$			-0.00246	-0.00201
$INNOV_{Other}$			0.01186 ***	0.01343 ***
Size	-0.01653 ***	-0.00747	-0.01635 ***	-0.00906
Δ Fund	-0.01145	0.01406	-0.01322	0.00139
Δ Suppliers	0.01755	0.02594	0.03505 *	0.04512 **
Δ Clients	0.10497 ***	0.14649 ***	0.10312 ***	0.13563 ***
Δ Universities	0.03616 **	0.05206 ***	0.0165	0.02518

Table 5.6.2 focuses on innovative sales and once more we observe that larger firms are more able to capture a higher sales share related to innovation. If they are able to use the diffusion process, they increase their capacity to increase sales as is shown by the significant coefficient of both specifications of the model. Innovation expenditures also have a positive effect, and from all the expenditures' components, intramural R&D and the funds used for the acquisition of machinery and equipment are the most significant ones. Clients and suppliers are relevant sources of information correlated with an increase of turnover due to innovations.

Table 5.6.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**1.66906 *** **		**1.72073 *** **	
$INNOV_{total}$	0.41154 ***	0.48464 ***		
$R\&D_{Internal}$			0.19609 ***	0.24582 ***
$R\&D_{External}$			-0.01133	0.01113
$INNOV_{Mach}$			0.0722 ***	0.08932 ***
$INNOV_{ExtKnw}$			0.02111	0.03286
$INNOV_{Other}$			0.07039 *	0.07848 **
Size	0.45371 ***	0.62102 ***	0.49921 ***	0.65997 ***
Δ Fund	0.19736	0.56395 **	0.26379	0.52969 *
Constant	4.22433 ***	1.22714 ***	5.54287 ***	2.68368 ***
Δ Suppliers	0.57524 *	0.70561 **	0.91775 ***	1.09448 ***
Δ Clients	1.90659 ***	2.2946 ***	2.41664 ***	2.83851 ***
Δ Universities	0.26108	0.44915 *	0.16557	0.30747

Table 5.6.3 shows the relation between diffusion of informal knowledge and process innovation. The latent variable that captures diffusion of informal knowledge related to process innovation is significant. A firm that spends resources on innovation activities has a higher probability of being a successful process innovator. A closer look at the different components of innovation expenditures shows that intramural R&D is negatively associated with the successful introduction of new processes.

Funds used to acquire new machinery and equipment and other expenditures are relevant in this sector.

The larger the firm the higher is the probability of introducing a new process. Suppliers are the main source of information when introducing new production processes. The use of universities as sources of information decreases firms' capacities of introducing new process innovations.

Table 5.6.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.10142 *****		**0.09365 *****	
$INNOV_{total}$	0.00983 ***	0.01396 ***		
$R\&D_{Internal}$			-0.00603 **	-0.00341
$R\&D_{External}$			0.00108	0.00233
$INNOV_{Mach}$			0.01476 ***	0.01585 ***
$INNOV_{ExtKnw}$			0.00618 **	0.00649 **
$INNOV_{Other}$			0.0112 ***	0.01189 ***
Size	0.03078 ***	0.04894 ***	0.02944 ***	0.04562 ***
Δ Fund	-0.02842	-0.0039	-0.0092	0.00691
Δ Suppliers	0.19809 ***	0.20121 ***	0.17028 ***	0.17607 ***
Δ Clients	0.00307	0.02628	0.00761	0.02868
Δ Universities	-0.05352 **	-0.04024	-0.04202	-0.03335

Conclusion 7: Diffusion and innovative performance in the ICT sector

In general, for the ICT sector the diffusion of informal knowledge has a positive effect on the three dimensions of innovative performance that we analyzed: product innovation, process innovation and innovative sales.

The innovative firms of this sector do not seem to benefit from the public support that they receive. Small firms are more likely to introduce a higher number of new products, although large firms achieve higher shares of innovative sales. Larger firms are also more likely to introduce more new process innovations.

Automotive

Table 5.7.1 summarizes the main relations between product innovation and diffusion of informal knowledge in the Automotive sector (defined as NACE 34). Diffusion is a relevant factor, with a stronger effect than that for the average industry as shown in Table 4.2. Surprisingly, innovation expenditures are not relevant for product innovation once we include knowledge diffusion. Even when we disaggregate these expenditures, the only positive relation is for other expenditures. We do not find any relation between size and the capacity of a firm to introduce new products; Estimations do not show a specific source of information as relevant for product innovation.

Table 5.7.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.21746 *****		**0.19518 *****	
$INNOV_{total}$	0.00635	0.01322 ***		
$R\&D_{Internal}$			0.00513	0.01183 ***
$R\&D_{External}$			-0.00331	-0.00439
$INNOV_{Mach}$			-0.0009	0.0001
$INNOV_{ExtKnw}$			0.00315	0.00494
$INNOV_{Other}$			0.01899 ***	0.02328 ***
Size	-0.02013	-0.00705	-0.02384	-0.01813
Δ Fund	-0.04582	-0.03874	-0.02881	-0.032
Δ Suppliers	0.06418	0.07769	0.0421	0.05114
Δ Clients	0.08445	0.1653 ***	0.09044 *	0.15929 ***
Δ Universities	0.06739	0.08492 *	0.04641	0.05095

Table 5.7.2 shows that the Automotive sector makes intensive use of the diffusion of informal knowledge. When innovation expenditures are considered in an aggregate way, they correlate significantly with innovative sales. However, when it is introduced in a disaggregate manner, none of its components are relevant. This can only be explained by measurement errors (see footnote 4). Suppliers are the main source of information for innovative sales. As in many of the other sectors, innovative firms do not seem to benefit from public support. A different result for this sector when compared to other sectors is that size is not a relevant variable explaining innovative sales.

Table 5.7.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**2.83411 *****		**3.14677 *****	
$INNOV_{total}$	0.42507 ***	0.53336 ***		
$R\&D_{Internal}$			0.12295	0.2504 ***
$R\&D_{External}$			0.05504	0.06505
$INNOV_{Mach}$			0.10299	0.12559 *
$INNOV_{ExtKnw}$			-0.06066	-0.00178
$INNOV_{Other}$			0.1749	0.17353
Size	0.30422	0.51751 **	0.25457	0.37838
Δ Fund	0.31415	0.35963	0.72872	0.50659
Constant	5.12892 ***	-0.15412	7.31503 ***	2.38938 *
Δ Suppliers	2.50827 ***	2.57819 ***	2.51963 ***	2.44392 **
Δ Clients	1.51306	2.3906 **	1.85886 *	2.667 ***
Δ Universities	-0.26484	-0.0809	-0.01452	0.15914

Table 5.7.3 shows that diffusion is a relevant variable when explaining the introduction of new process innovations in the Automotive sector. Innovation expenditures have a positive effect but only when they are entered as an aggregate total. Public funding has a positive effect on the chance of successfully introducing a process innovation. None of the information success has a significant effect on process innovation.

Table 5.7.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.16582 *****		**0.1683884**	
$R\&D_{Total}$	0.0302 ***	0.03507 ***		
$R\&D_{Internal}$			0.0020517	0.00853
$R\&D_{External}$			0.0115567	0.01101 *
$R\&D_{Machinery}$			0.0221977	0.02394 ***
$R\&D_{ExtKnw}$			0.0000799	0.00154
$R\&D_{Machinery}$			-0.0039552	-0.00495
Size	0.00852	0.03301 *	0.0020722	0.02236
Δ Fund	0.18575 ***	0.1855 ***	0.1550228	0.14562 **
Δ Suppliers	0.09444	0.09228	0.095531	0.09071
Δ Clientes	-0.01848	0.03286	0.0209364	0.06617
Δ Universities	-0.12939	-0.12019 *	-0.1059045	-0.10314

Conclusion 8. Diffusion and innovative performance in the Automotive sector

The Automotive sector shows a much stronger response to the diffusion of informal knowledge than any other sector. When we look at the probability of introducing either a new product innovation, knowledge diffusion is the only relevant variable explaining the successful innovation of firms in the sector. For process innovations, also total innovation expenditures and public funding have a positive effect.

When we consider innovative sales, we see that innovation expenditures still explain part of the increases in sales. Firms spending more on innovation generate higher income. However, these firms are not large firms as in the other sectors.

Eco-Innovation

This sector is formed by those firms that have reported in the CIS 3 survey to have reduced materials and energy used in the production (as indicated by the survey variable EMat≠0) or to have improved environmental impact or health and safety aspects (as indicated by the survey variable EEnv≠0).

Table 5.8.1 presents the relation between diffusion of informal knowledge and introduction of new products in the Eco-innovation sector. Diffusion of informal knowledge is significant and positively related to product innovation in both specifications of the model. Innovation expenditures at the aggregate level is not significant, however we see that if we disaggregate the different expenditures, some of them are positively related and other negatively related to product innovation. This might explain the fact that if we aggregate total expenditures the total effect is nullified. Intramural R&D and other expenditures are the most influential innovation expenditures for increasing the probability of being a product innovator in the Eco-innovation sector. Public funds are not relevant for being a successful product innovator. Information from clients and universities are positively related to being a successful innovator. However information from suppliers seems to have a negative effect. This shows that the product innovation of the sector is closer to demand basic research.

Table 5.8.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.13648 *****		**0.10169 *****	
$INNOV_{total}$	-0.00168	0.00337 ***		
$R\&D_{Internal}$			0.0097 ***	0.01327 ***
$R\&D_{External}$			0.00068	0.00164 *
$INNOV_{Mach}$			-0.00636 ***	-0.006 ***
$INNOV_{ExtKnw}$			0.00094	0.00275 ***
$INNOV_{Other}$			0.0153 ***	0.01668 ***
Size	-0.00215	0.01347 ***	-0.01477 ***	-0.00514 *
Δ Fund	-0.01779 **	-0.00274	-0.02453 ***	-0.01909 **
Δ Suppliers	-0.06109 ***	-0.06319 ***	-0.05187 ***	-0.05132 ***
Δ Clients	0.12531 ***	0.1617 ***	0.09552 ***	0.11589 ***
Δ Universities	0.04693 ***	0.06506 ***	0.01345	0.01883 **

Table 5.8.2 analyzes the relation of the introduction of a new product and the effect that this new product has on sales. We concentrate on diffusion and its relation with innovative sales. Diffusion of informal knowledge positively affects innovative sales, in both specifications of the model. Larger firms are able to acquire a higher proportion of innovative sales. Spending in innovation activities is relevant and when we consider the different components of innovation expenditures, expenses in intramural R&D and other expenditures determine the highest success. Extramural R&D and expenditures in other external knowledge are also positively related. As for sources of information, we find a similar behaviour to the one shown in table 5.8.1.: firms in Eco-innovation are closer to both demand (clients) and universities.

Table 5.8.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**2.1086 *****		**1.76215 *****	
$INNOV_{total}$	0.08181 ***	0.17484 ***		
$R\&D_{Internal}$			0.14883 ***	0.21342 ***
$R\&D_{External}$			0.03464 ***	0.05099 ***
$INNOV_{Mach}$			-0.05372 ***	-0.04678 ***
$INNOV_{ExtKnw}$			0.03571 ***	0.07 ***
$INNOV_{Other}$			0.14985 ***	0.16047 ***
Size	0.6256 ***	0.86636 ***	0.49557 ***	0.66437 ***
Δ Fund	-0.0211	0.25104 *	-0.15491	-0.03996
Constant	9.38065 ***	4.89225 ***	9.48284 ***	6.20595 ***
Δ Suppliers	-0.72766 ***	-0.69526 ***	-0.67132 ***	-0.62622 ***
Δ Clients	1.332 ***	1.75656 ***	1.0921 ***	1.3782 ***
Δ Universities	0.23907 *	0.48732 ***	-0.09282	-0.01724

Table 5.8.3 focuses on the introduction of new process innovations. The process innovating firms make use of the diffusion of informal knowledge; however the effect is less than that in general (cf. Table 4.4). Innovation expenditures are correlated with the successful introduction of new process innovations. In the disaggregate

level, expenditures in acquisition of machinery and equipment have the strongest effect. We also find a positive relation with extramural R&D and external acquisition of knowledge. We see that process innovation in this sector is closer to suppliers.

Table 5.8.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.02428 *****		**0.02852 *****	
$INNOV_{total}$	0.01269 ***	0.01368 ***		
$R\&D_{Internal}$			-0.00231 **	-0.00134
$R\&D_{External}$			0.0027 ***	0.00293 ***
$INNOV_{Mach}$			0.01452 ***	0.01468 ***
$INNOV_{ExtKnw}$			0.00364 ***	0.00412 ***
$INNOV_{Other}$			-0.0031 **	-0.00293 **
Size	0.01619 ***	0.02111 ***	0.02029 ***	0.02562 ***
Δ Fund	0.03275 ***	0.03577 ***	0.03044 ***	0.03252 ***
Δ Suppliers	0.10851 ***	0.10912 ***	0.09325 ***	0.09455 ***
Δ Clients	-0.08542 ***	-0.08166 ***	-0.06933 ***	-0.06586 ***
Δ Universities	-0.04248 ***	-0.04 ***	-0.02661 ***	-0.02563 ***

Conclusion 9. Diffusion and innovative performance in the Eco-innovation sector

Diffusion of informal knowledge is positively affecting the performance of the Eco-innovation sector. Innovating firms are closer to the flows of informal knowledge and show a positive reaction to these flows.

Independently of these flows, expenditures in innovation are relevant as an explanatory variable in the success of being an innovator. Product innovation and innovative sales are closer to demand and universities while process innovations are close to the supplier.

Gazelles

Gazelles are firms that share three important characteristics: they grow fast, are young, and are SMEs at the moment of the start of the growth process.[8]

Table 5.9.I. shows a strong relation of diffusion of informal knowledge on product innovation, very similar to the general results shown in Table 4.2. Total expenditures in innovation are also relevant and when we analyze innovation expenditures at a disaggregate level we observe that intramural R&D, acquisition of knowledge and other expenditures increase the probability of firms being a successful product innovator. Public support has no significant effect and information from clients is the

[8] To select these firms we generate the birch index, and select the upper 10% of the index. At the beginning of the process in 1998 they need to have ten or more employees, and at the end they need to be smaller than 250 employees:

$$birch = (Employment / Employment98)(Employment - Employment98)$$

only relevant source of information, indicating that firms are close to demand when introducing new products.

Table 5.9.1 Effect of knowledge diffusion on product innovation

$KnDif_{pdt}$	**0.17044 *****		**0.13468 *****	
$INNOV_{total}$	0.01183 ***	0.01866 ***		
$R\&D_{Internal}$			0.0127 ***	0.0175 ***
$R\&D_{External}$			-0.00179	-0.00008
$INNOV_{Mach}$			-0.00063	0.00065
$INNOV_{ExtKnw}$			0.00683 **	0.01045 ***
$INNOV_{Other}$			0.02062 ***	0.02069 ***
Size	-0.00298	0.00281	-0.00145	0.0045
Δ Fund	-0.0322	-0.00071	-0.02063	-0.00632
Δ Suppliers	0.01098	0.01913	0.01255	0.02925
Δ Clients	0.22102 ***	0.24107 ***	0.21871 ***	0.23718 ***
Δ Universities	0.02923	0.05696 **	0.00665	0.01514

Table 5.9.2 analyzes the relation with innovative sales. Firms closer to the diffusion of informal knowledge are most likely to increase their innovative sales. Size is not a relevant factor. Clients are the main information source for innovation. Innovation expenditures are relevant also if we introduce the latent variable for diffusion. Intramural R&D and other expenditures are the most relevant ones components explaining higher innovative sales shares.

Table 5.9.2 Effect of knowledge diffusion on innovative sales

$KnDif_{pdt}$	**1.99201 *****		**2.08286 *****	
$INNOV_{total}$	0.41533 ***	0.52384 ***		
$R\&D_{Internal}$			0.18337 ***	0.27303 ***
$R\&D_{External}$			-0.05436	-0.02748
$INNOV_{Mach}$			0.06341 *	0.08551 **
$INNOV_{ExtKnw}$			0.1156 **	0.16583 ***
$INNOV_{Other}$			0.24182 ***	0.23761 ***
Size	0.06818	0.14129	0.26422	0.34572
Δ Fund	-0.28798	0.08081	0.28257	0.53906
Constant	4.17962 ***	0.47074	4.31664 ***	0.66984
Δ Suppliers	0.51542	0.62432	0.80918 *	1.07439 **
Δ Clients	4.28749 ***	4.50962 ***	4.70292 ***	4.99327 ***
Δ Universities	0.08141	0.38655	-0.00412	0.10873

Table 5.9.3 focuses on process innovation among Gazelles. Diffusion is relevant and so are total expenditures in innovation. Extramural R&D, acquisition of machinery and equipment and external knowledge are positively correlated with the probability of being a process innovator. In process innovation, firms are closer to suppliers, and far from universities.

Table 5.9.3 Effect of knowledge diffusion on process innovation

$KnDif_{pcs}$	**0.04516 ****		**0.05076 ****	
$INNOV_{total}$	0.0289 ***	0.031 ***		
$R\&D_{Internal}$			-0.00184	0.00012
$R\&D_{External}$			0.01015 ***	0.01087 ***
$INNOV_{Mach}$			0.02397 ***	0.02459 ***
$INNOV_{ExtKnw}$			0.01326 ***	0.01434 ***
$INNOV_{Other}$			0.00173	0.00155
Size	-0.01549	-0.00951	0.01571	0.02284
Δ Fund	-0.01035	-0.00163	0.00325	0.00911
Δ Suppliers	0.23129 ***	0.23381 ***	0.23383 ***	0.24016 ***
Δ Clients	0.01583	0.02126	0.05038	0.05758 *
Δ Universities	-0.09945 ***	-0.09264 ***	-0.07375 **	-0.07115 **

Conclusion 10: Diffusion and innovative performance in Gazelles

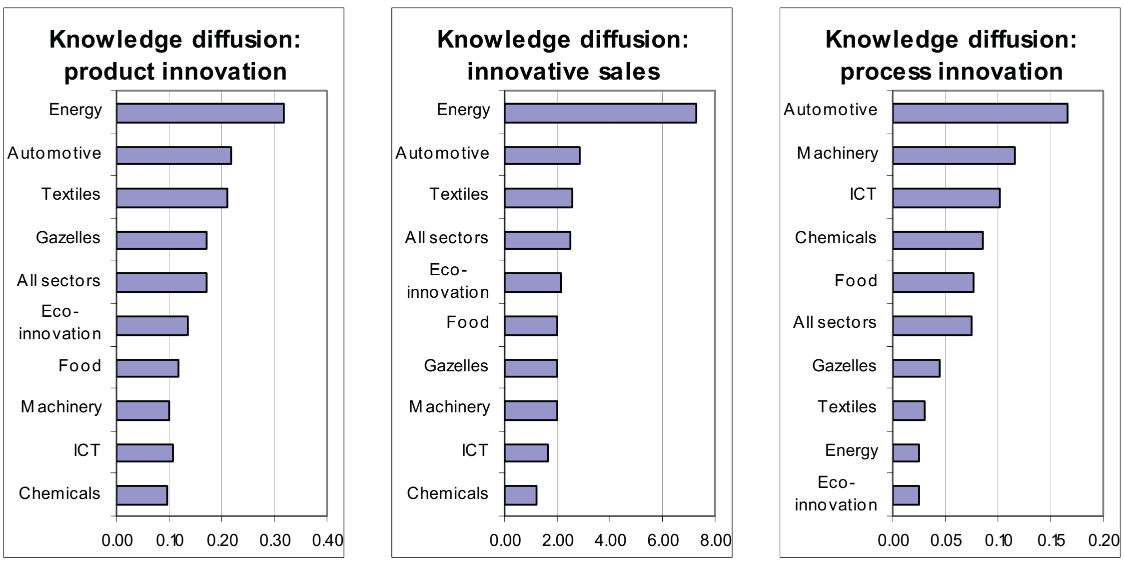
Gazelles are firms that share three important characteristics: They grow fast, are young, and are SMEs at the moment of the start of the growth process. We observe that those firms closer to diffusion of knowledge are in general more innovative.

Public funds have no effect on the success of these firms. Information given by suppliers is very relevant for introducing new processes. Innovation expenditures in general positively have a positive effect on innovation performance of these firms.

6. Conclusions

In this paper, we have tried to argue that there the diffusion of informal knowledge generated by the innovation activities in a sector are relevant in explaining innovation performance. The active use of this informal knowledge improves the innovation performance of all firms. For product innovation and innovative sales the highest effect of the diffusion of informal knowledge is seen in Energy, Automotive and Textiles, the smallest effect in Machinery, ICT and Chemicals. For process innovation, the highest effect is seen in Automotive, Machinery and ICT and the smallest effect in Textiles, Energy and Eco-innovation.

Figure 4. The effect of knowledge diffusion on product and process innovation and innovative sales



The combination of innovation expenditures and diffusion reveals that for some sectors the main influence of this input is to bring the firm closer to the innovation activity, more than directly affecting the probability of the firm to be innovative. For some sectors, also after including the diffusion variable, innovation expenditures have a positive impact on innovation outputs.

In general, process innovators are closer to suppliers and product innovators are closer to clients. Universities are relevant for product innovation in the Food sector, ICT and Eco-innovation and for process innovation for Machinery and Textiles. Government funding, in general, is most effective for process innovation.

The diffusion of informal knowledge thus has a positive impact on firms' innovation performance. For policy this implies that targeted policies aimed at stimulating innovation in specific firms will benefit all firms as, through an increased stock of knowledge, more informal knowledge will be diffused thereby increasing the innovation performance of all innovating firms.

Acknowledgements

We gratefully acknowledge financial support from the European Commission's Innovation Watch (Systematic) project. We are particularly indebted to Sergiu Parvan, who supported and very efficiently managed numerous visits to the Safe Center at EUROSTAT. This paper has benefited from the constructive comments and suggestions by Nina Leheyda and the other participants at the Innovation Watch (Systematic) project meetings in Athens in September 2007 and Oslo in February 2008. We would also like to express our gratitude to Adriana van Cruysen for her editorial work on this report. Any remaining errors are the sole responsibility of the authors.

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