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Not searching, but finding: how innovation shapes perceptions about universities and public research organisations

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Abstract Previous research about firms' perceptions on the usefulness of public research has not distinguished between technological innovators and non-innovators. With the exception of openness of search, we find that factors shaping such perceptions differ in both types of firms. Non-innovators need market power and the presence of an R&D department to profit from public knowledge. Innovators need less sheltered environments and lesser R&D effort, though the availability of resources and absorptive capacity is necessary. Using a sample of 1,031 Spanish manufacturing firms, we conclude that practical experience in technological innovation enhances firms' perceptions on the usefulness of public research, not directly but by enabling certain internal changes, i.e. it produces encounters between corporate choices and public research.

Keywords Public-private R&D interaction · Absorption of external knowledge · Openness · Information search

JEL Classification O32

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1 Introduction

Information is a crucial ingredient of entrepreneurial discovery (Fiet & Patel, 2008). Firms with good access to information are better placed to innovate and even to adopt appropriate technology (Mowery & Sampat, 2005).

Enterprises obtain information to improve their innovation-related activities from a variety of internal and external sources (e.g. their R&D departments, clients, universities). Universities and public research organisations (U-PROs, hereafter) play a decisive role in national and regional systems of innovation (Cooke, 2002; Mowery & Sampat, 2005). Cohen et al. (2002) found that public R&D has an important and positive influence on industrial R&D in the US manufacturing sector. Similar positive associations exist between firm growth and university knowledge spillovers (Audretsch and Lehmann 2005). It is therefore important to understand what factors shape company perceptions of the usefulness of information provided by U-PROs.

Previous research on the importance of public knowledge to firms has been almost exclusively focused on innovators (Amara & Landry, 2005; Mention, 2010; Rapini et al., 2009), defined as firms which have recently launched new products into the market or implemented new industrial processes. Non innovators are defined as companies not involved in these activities in recent years. Adopting these definitions of innovators and non-innovators, here we inquire as to whether non-innovators also value public knowledge. Then, we investigate whether antecedents associated to the perceptions of this specific source of information differ in both types of firms. Non- innovators may, nevertheless, perform certain technology-related activities such as the introduction of advanced manufacturing technology, the development of own machinery and software or prototype testing. They may consider public knowledge as useful in improving their activities. Therefore, we provide a complementary view of the question, an exercise

especially overdue in analyses of countries or industries where non-innovators, as above defined, account for a substantial share of companies.

Most previous analyses of the usefulness of innovation-related information, and more specifically of knowledge provided by U-PROs (hereafter, public knowledge), focus exclusively on innovators or do not distinguish between innovators and non-innovators (Amara & Landry, 2005; Arvanitis et al., 2008; Laursen & Salter, 2004; Mention, 2010; Rapini et al., 2009; Varis & Littunen, 2010). Also, most of them analyse countries where the vast majority of firms are innovative according to the above mentioned definition.

In many other countries, however, a substantial share of companies is not innovative, according to the narrow definition of innovators above. Even in the European Union (EU-27) 61.2% of manufacturing firms were not innovative in 2006 (EUROSTAT 2010).Therefore, it is important to understand whether these companies also perceive the information provided by U-PROs as useful and identify factors influencing their perceptions. Non-innovators could also benefit from public knowledge in several ways; for instance, to undertake their first steps towards innovation or to improve their current technology-related activities (e.g. software adaptation). However, factors which shape their views of public knowledge may differ from those which shape innovators'.

The rest of the paper is organised as follows. Section 2 presents a review of the literature and the hypotheses to be tested. The resource based view (RBV) of the firm and the exponential theory of learning are used to argue that innovators and non-innovators may have different perceptions of the value of public knowledge, making it interesting to analyse the two groups separately. These theories suggest that practical experience may improve the ability of individuals and organisations to find useful external information. Practical experience of innovation, we argue, is a crucial determinant of the perception of U-PROs among firms. Such experience, we claim, may even lessen the need of R&D as

an absorptive device (Cohen & Levinthal, 1989). Distinguishing between innovators and non-innovators, our article attempts to contribute to theories of the absorption of external knowledge at the company level and, hence, improve our understanding of university-industry interactions. Section 3 indicates the research context and presents a database representative of Spain's medium-sized and large manufacturing companies and containing information on 1,031 firms with over 50 employees. Section 4 and Section 5 present, respectively, the descriptive results and the econometric analysis. Section 6 discusses the results and Section 7 offers some conclusions, including possible implications of our research for public policies and companies.

2 Theoretical background and research hypotheses

2.1 Perceptions of usefulness. Searching versus finding

Information is "a collection of facts from which a conclusion may be drawn" (Fiet & Patel, 2008, p.216). U-PROs can provide information to industry through conferences, publications, patents, etc. (Arvanitis et al., 2008; W.M. Cohen et al., 2002). The perceived usefulness of information is defined here as company assessment of the extent to which a source of information may contribute to improving its innovation-related activities (Agarwal & Prasad, 1998). Ease of use and compatibility of information are important properties for understanding the perceived usefulness of information (Agarwal & Prasad, 1998). Ease of use is determined by the degree to which decision-makers view usage of the information to be relatively free of effort. Compatibility is the degree to which information is perceived as being consistent with the needs and past experience of the firm (W.M. Cohen & Levinthal, 1989).

We attempt to contribute to a line of research which investigates factors that influence

company perception of information obtained from U-PROs and identifies firm types more likely to use this source (Laursen & Salter, 2004; Swann, 2002). The importance of perceptual factors is well established in the literature on organisations since the strategy process begins with company awareness of the resources at its disposal, including external sources of information

Innovators and non innovators value different sources of information (Varis & Littunen, 2010). Factors associated to the perception of public knowledge, we argue, are not necessarily the same for both. To justify such an assumption, we combine the resource based view (RBV) of the firm and the theory of experiential learning, which is used in management literature. According to this theory, based on Dewey, Lewin and Piaget, ideas are formed and re-formed through experience (Kolb, 1984). Experience provides people and organisations with unique opportunities to practice, make errors and receive a feedback. Knowledge is created through the transformation of here-and-now concrete experience. The RBV of the firm also assigns crucial importance to firms' learning processes and to their practical experience of innovation (Foss, 1998; Malerba, 1992; Teece et al., 1994; Von Tunzelmann, 2009).

That experience may influence, in turn, information search is not a new idea in the management literature. Knowledgeable consumers (as defined by their actual experience with concrete products) search more efficiently for product information (Brucks, 1985). According to Simon's (1957) theory of "bounded rationality" individuals and firms face constraints such as the amount of information they can acquire and process. Since organisations may be clogged by data, goal-directed learning is important to support the efficient gathering of information (Kolb, 1984). Therefore, the skills and the experience that the firm already possesses are key antecedents of a successful search strategy (Nelson, 1982).

Certain theoretical models of technological change arrive to a similar conclusion. In Cohen and Levinthal's (1989) model, learning or absorptive capacity encompasses a firm ability "to identify, assimilate and exploit" external knowledge but such ability is enhanced by the performance of R&D rather than by practical experience of innovation. By contrast, in Levinthal and March's (1981) model, experience induces firms to modify their search strategies related to innovation.

Innovators, in our view, will have more opportunities to learn and to accumulate know-how than non innovators. Since academic knowledge is particularly complex (Czarnizki et al., 2011), companies with a well focused search strategy are more likely to profit from public knowledge since their cognitive costs are probably lower.

What the RBV calls 'learning by doing' is similar to what the experiential theory of learning and related approaches call 'experience': a feedback mechanism that changes the effects of resources, strategies and market conditions on perceptions of the firm. Let us give it a common label: 'finding', by opposition to 'searching'[1]. We have justified that practical experience in technological innovation activates such a 'finding' mechanism. Following the discussion, we propose that the perception of public knowledge will be determined by different factors in innovators and non-innovators.

2.2 Hypotheses and control variables

Based upon the literature, some hypotheses are constructed.

R&D. According to the empirical literature, firms which perform R&D are more likely to perceive public knowledge as useful (Laursen & Salter, 2004; Mohnen & Hoareau,

[1] The label 'searching' would thus apply to information search both specifically referred to U-PROs and to other sources of information, namely those that reflect the openness of the firm.

2002). For Cohen and Levinthal (1989), the "absorptive capacity" of a firm depends on its R&D effort. However, in their model, the characteristics of external knowledge influence the ease of learning. Firms will need to spend more resources in R&D to assimilate complex knowledge or knowledge not specifically targeted to their needs, as is often the case of public knowledge. Concerning each type of external knowledge, we claim, a factor *internal to the firm* may, in turn, modify the ease of learning. This internal factor is the company's past experience of innovation. Therefore, we propose, the ease of learning from U-PROs may be greater for companies which have such an experience than for those which have not. Consequently, innovators may need to allocate fewer resource to formal R&D. Levinthal and March's (1981) model shows that fast learners (as defined by previous performance and experience) may fairly easily learn to reduce expenditures on search, defined as resources allocated to R&D. Building on their results, we contend that innovators, owing to their previous experience, may find it easier to identify science-based information fitting the needs of the company. In doing so, innovators may need to allocate fewer resources to formal R&D than non-innovators in order to absorb public knowledge. This internal factor was not considered by previous empirical studies on this topic. In contrast with the point of view held here, those studies implicitly assumed that R&D has the same effect on the perceptions of all types of firms, whatever their past experience.

We, therefore, formulate the following hypothesis:

Hypothesis 1. Perceived usefulness of public knowledge and R&D activity are positively associated in non-innovators (the association of the variables is not significant in innovators).

Size. Company size indicates the dimensions of the firm's financial and human

resources. Small firms may lack resources for information scanning. They may be more likely to use less costly and time-consuming sources of information, such as close business associates, and fail to perceive clearly the usefulness of U-PRO information. The larger the firm, the greater the possibility that it appreciates knowledge produced by universities (W.M. Cohen et al., 2002; Laursen & Salter, 2004; Mohnen & Hoareau, 2002). However, we claim, only actual experience of innovation will make this change of perception in resources significant, through increased opportunities for learning by doing and ideas getting feedback.

Human capital. Another important resource available to firms is human capital. Firms with no formal R&D activities may nevertheless benefit from public research (Mangematin & Mandran, 2000; Rapini et al., 2009). A possible reason is that they develop some absorptive capacity beyond the R&D department; for instance, at the shop floor level. The skills composition of the workforce is also a source of knowledge available to the company (Asheim & Isaksen, 2002; Beneito, 2002).

While in Cohen and Levinthal's (1989) model absorptive capacity is confined to the R&D function, we contend that such capacity may also be embodied in people and teams within the company.

The possible association between innovation expenditure other than on R&D (e.g. training) and knowledge sourcing has rarely been tested. However, companies with a highly skilled workforce may have put in place internal learning processes and this may contribute to the absorption of science-based information. Again, only experience of innovation, through increased opportunities for learning and feedback obtaining, will make resources significant enough to change perceptions.

Therefore, we formulate the following hypotheses:

Hypothesis 2. Perceived usefulness of public knowledge and firm size are positively

associated in innovators (the association of the variables is not significant in non-innovators).

Hypothesis 3. Perceived usefulness of public knowledge and skills of the workforce are positively associated in innovators (the association of the variables is not significant in non-innovators).

Strategic innovation. Strategic innovation consists of a redefinition of the business in terms of the company's targets (customers), product mix or marketing strategy (Markides, 1997). Firms have always faced the need to match corporate technology to specific organisational practices. However, strategic innovation is risky, as it may involve difficulties in recognising and responding to new customers' demands, distribution channels, production methods and supply chains (Pavitt 2002). Dosi et al. (1992, p.194) advises against the combination of technical and strategic innovation "because the effort is likely to be outside the firm's learning range". Changes in strategic orientation tend to be more reactive than proactive: they respond to corporate need to adapt to adverse or unforeseen situations, generating turbulence within the company and thereby affecting the search for external knowledge sources. This may be the case, in particular, for public knowledge, which is far more expendable than information originating in the productive chain, crucial for the day-to-day survival of the company. Innovators have often made the effort of efficiently coordinating their R&D and marketing functions (Miotti & Sachwald, 2003); the additional burden of implementing new strategies may limit their potential to search for science-based information. Therefore, we argue, public knowledge could be seen as less useful in this case. We test, consequently, the following hypothesis:

Hypothesis 4. Perceived usefulness of public knowledge and the implementation of

strategic innovation are negatively associated in innovators (the association of the variables is not significant in non-innovators).

Competition. The possession of "ex ante" market power provides companies with financial resources to invest in R&D (W. M. Cohen, 1995) and, probably, to engage in information search. Firms which operate in concentrated markets may be more prone to gather and absorb U-PROs' knowledge, which entails high search costs. The possession of market-power may especially benefit non-innovators because their search strategy is probably less targeted and, hence, more costly. By contrast, we claim, actual experience of innovation provides firms with a feedback mechanism that reduces uncertainty even in competitive markets. Thus, the effect of market power will be only appreciable in non-innovators.

We formulate the following hypothesis:

Hypothesis 5. Perceived usefulness of public knowledge and level of competition are negatively associated in non innovators (the association of the variables is not significant in innovators).

We introduce the following control variables in the model:

Openness. Laursen and Salter (2004) find that firms which use many sources of information are also more likely to use university research more intensively (size, R&D and other variables controlled). They conclude that the "openness" of a firm's innovation search, namely the number of external knowledge sources it draws upon, is strongly associated to the use of public knowledge. We expect that companies which draw on numerous external sources of knowledge will be more likely to perceive U-PROs as important sources of information. There is no reason to believe that the "finding" mechanism activated by practical experience in technological innovation will have an

influence on openness. Openness obeys to the search strategy of the firm and can be identified to what we call 'searching' by opposition to 'finding'.

Collaboration. Firms which collaborate with public research organisations are more likely to use public knowledge or benefit from incoming spillovers (Cassiman & Veugelers, 2002; W.M. Cohen et al., 2002; Lopez, 2008). We expect that such firms will have a more positive perception of public knowledge. Since, in our sample, collaboration is defined as cooperation in product or product innovation, this control variable affects innovators only.

Economic sectors are also controlled for.

3 Research context and data

According to EUROSTAT (data from 13/10/2010), Spain's gross expenditure on R&D (GERD) represented 1.35% of gross domestic product in 2008. The estimate in the EU-27 for 2008 was 1.9%, and thus the value is significantly lower in Spain. The same source shows that in Spain, industry, higher education and government performed, respectively, 54%, 27% and 18% of GERD in 2008. On average, higher education and government accounted for smaller shares in the EU-27 (63%, 23% and 13%). This does not imply that industrial interest in public R&D is low: business funding of university R&D was 9% in Spain *versus* 6% in the EU-27 and USA. Spain is an interesting case study since U-PROs would appear to have the potential to positively influence industrial R&D; at the same time, the share of non-innovative firms is still above the EU average.

The data employed in the following analysis were obtained from a plant-level survey, targeting firms in the Spanish manufacturing industry and conducted in 2003 (1,031 in total). In order to establish the dimension of the population of plants in terms of sector,

region and size, we used the information provided by the Central Directory of Companies (DIRCE), available from the National Statistics Institute. Sectors were defined according to the National Classification of Economic Activities (CNAE), which follows the standards of the European NACE rev1. We selected companies for analysis from the Dun & Bradstreet Spain list. Given their size, sector and geographic location, the sampled firms are statistically representative of firms with over 50 employees. At a confidence level of 95.5%, the sampling error is ± 2.8%. In most cases we interviewed Directors of Production, each personal interview lasting approximately one hour.

Companies were asked to report how useful 16 different sources of information were in improving their innovation-related activities, e.g. product and process innovation, basic research, technical design, product design, imitation, development activities, etc [2].

To split the sample, we use the variable "innovation", which distinguishes between technological innovators and non-innovators. Innovators are defined as firms which introduced at least one product or process innovation in 2000-2002 (the three year-period before the year of the survey, similar to, for instance, Thether and Swann (2003). 82 per cent of the firms (somewhat over 800) have introduced a product or process innovation. The remaining 18 percent are non-innovators (less than 200). Given that the sampled firms are medium–sized and large companies, this percentage is quite high.

Non-innovators, as stated in the introduction, can nevertheless undertake some technology-related activities. For instance, in our sample, 14 per cent of these non-

[2] Unlikely other studies (Amara & Landry, 2005; Mention, 2010; Varis & Littunen, 2010) we do not use these company responses to approximate the objective influence of different sources of information. Less ambitious, although arguably more realistic, our approach assumes that firms' responses indicate the perceived usefulness of information for the innovative activities of the company.

innovators manufacture unique products (per project), and 31 per cent fabricate small lots of a wide variety of product (jobs-shop), adapting products to consumers' tastes and needs. The introduction of advanced manufacturing technology is also frequent; for example, 41 per cent of non-innovators use computer assisted design (CAD) or engineering (CAE). Moreover, 30 per cent of the non-innovators frequently develop their own software and computer programmes. These figures reflect technology-related activities. Some of these firms also conduct non-technological innovation. For instance, 35 percent of non-innovators frequently put new management techniques into practice. It is likely, therefore that these firms find U-PROs a useful information source.

4 Descriptive results

As shown by Table 1, customers are viewed as the most important source of information for the innovative firms sampled: 42% of them reported that these were their most important source of information. After customers, the four most important sources reported by respondents are all internal to the firm or the group; Production Departments rank first, while R&D Departments rank last.

(Table 1 around here)

The substantial importance which innovative firms assign to their own internal and intra-group sources of information is also apparent in studies of the US, Brazil Canada, Luxembourg and the UK (Amara & Landry, 2005; W.M. Cohen et al., 2002; Laursen & Salter, 2004; Mention, 2010; Rapini et al., 2009). Differences may be due to the deeper breakdown of our data, which distinguishes several internal sources, whereas CIS-type surveys do not; or, more substantially, to the higher scientific and technological intensity of the other developed countries compared to Spain. In such countries, specialised in

high-tech sectors, a supply-push model may be more successful, whereas in Spain, specialised in traditional sectors, a demand-pull model makes more sense for firms. On the other hand, firms strongly appreciate both information sources (internal sources and customers) in all the above mentioned countries.

U-PROs were mentioned among the least important sources of information in our sample. However, the vast majority of the firms considered that knowledge drawn from U-PROs had at least some utility (77% of firms)[3].

Precise percentages in the lower tier differ considerably from other studies since the share of firms which report that they profit from information provided by U-PROs seems to be lower in the US, Canada and the UK (Amara & Landry, 2005; W.M. Cohen et al., 2002; Laursen & Salter, 2004). This may be attributable to several factors, for instance the refinement of our variable which is measured on a 1-10 Likert scale. However, our results are in line with a study of the European food industry (Christensen et al., 1996). What is more, previous research acknowledges differences across countries with regard to the importance attributed by firms to U-PROs as information sources (Decter et al., 2007). Brazilian firms rate universities as sources of information more highly than US firms do; Rapini et al (2009) suggest that this may be due to the R&D weaknesses of industry in immature systems of innovation. Since the direct engagement of Spanish firms in corporate R&D is weak, this may be also the case in Spain. Another reason could be that company involvement in the financing of R&D performed by U-PROs is relatively high in Spain; this may enable firms to model to a certain degree the content and the tangible usefulness of part of the knowledge produced by U-PROs.

Non-innovators tend to assign less value to all sources of information than innovators

[3] As in some previous studies, our data also include non-university public research organisations. These institutions accounted for 18% of total expenditure on R&D in 2008 while universities provided 27%.

do (table available upon request). However, the rankings do not vary much. The top categories are the same for both groups (customers, own production department, parent company). So are those at the bottom (conferences, public administration, patents, scientific publications). There is some variation in the central categories, the highest one corresponding to the perceived value of "Own R&D Department", which is much more valuable for innovators than for non-innovators. The reason is probably because many non-innovators do not have an R&D Department. It should be stressed that non-innovators also value information provided by U-PROs.

5 Econometric analysis

The dependent variable is the degree of importance of U-PROs as information sources for innovation: 0 if none, 4 if maximum. The original variable has been recoded, as required for econometric treatment, as follows: first, a contingency analysis was performed to avoid thin cells (with values lower than 2 in the cross tabulation against the qualitative independent variables); second, close examination was made of the predictions of the econometric estimations, to avoid naïve models (which only predict zeros for certain values of the dependent variable). A discrete choice model is applied to take into account the fact that the data are ordered (i.e. ordered logit[4]).

Table 2 shows descriptive statistics for each group of companies, and a Mann–Whitney test confirms that non-innovators find that information provided by PROs is useful for them, although to a lesser extent than innovators. While non-innovators have not achieved product or process innovations, they may perceive such sources as useful to perform other technology-related activities, or to walk towards innovation.

[4] For the sake of robustness, we checked the results with ordered probit models and they were identical.

(Table 2 around here)

Among the independent variables, dummy and ordered variables have also been recoded, as necessary following a contingency analysis. As Table 2 shows, innovators display higher levels of R&D activities, size, skills, strategic innovation and openness. The degree of market competition is nevertheless similar in the two groups of firms.

The correlation between independent variables for each group of companies is low (coefficients never higher than 0.25, see Table 3).

(Table 3 around here)

We use thirteen industry dummies as control variables. Companies which assign most importance to knowledge from U-PROs are those which operate in chemical and basic metals, pharmaceuticals, and machinery and equipment (tables are available upon request). This ranking is quite similar to previous research in the UK and US.

Table 4, column 1, displays a model of the private use of information from U-PROs by innovative firms. Column 2 does so for non-innovators.[5]

(Table 4 around here)

Comparing the coefficient of R&D between columns 1 and 2 gives evidence in favour of Hypothesis 1: the impact is significant for non-innovators and not for innovators. Certainly, R&D is tangentially (10%) significant for non-innovators. A statistical reason could be that many innovators perform R&D activities (54% of all the observations), so the two categories overlap somewhat. However, this does not explain everything, because the correlation between the two variables is low (28% for the aggregated sample of innovators and non-innovators) and the proportion of less intuitive cases (innovators without R&D or non-innovators with R&D) is considerable (34%). Substantive reasons

[5] The number of observations drops compared to Table 2 because of the missing values.

for such differences between the two types of firms are analysed in the Discussion.

Firm size has a positive effect on the value innovators assign to U-PROs as information sources, which is not significant for non-innovators, i.e. the evidence supports Hypothesis 2.

There is evidence in favour of Hypothesis 3: the importance given to human capital, as a source of absorptive capacity, increases the value innovators assign to knowledge obtained from U-PROs, but not for non-innovators.

The evidence also supports Hypothesis 4: the implementation of strategic innovation has a negative effect on company perceptions of the usefulness of knowledge from U-PROs, in the case of innovators (not in non-innovators).

Competition is not significant for innovators, but it is so, negatively, for non-innovators, so Hypothesis 5 has support.

Openness has a positive influence on the value innovators assign to U-PROs as information sources. This is so for both types of firms, hence indicating that its effect does not depend on practical experience in innovation.

Notice that collaboration with U-PROs appears to be associated to the perceived usefulness of information provided by these sources to innovators. This means that it is important to control for this factor.

The marginal effects (not shown – available upon request) support these findings. For innovators, all marginal effects in the case of use of U-PRO knowledge higher than 1 have the same sign of the total effects in Table 4. Marginal effects are particularly large in the case of the use of U-PRO knowledge = 2. For non-innovators, all the non-zero marginal effects have the same sign of the total effects in Table 4 and they are particularly large in the case of the use of U-PRO knowledge = 1.

6 Discussion

Non-innovators are likely to value public knowledge, though to a lesser extent than innovators. Practical experience of innovation may help firms to reduce the uncertainty of innovative search. This circumstance, particularly important in the case of science-based knowledge, may predispose innovators to rank highly public knowledge. In contrast, as suggested by Swann (2002), their own lack of experience may make non innovators relatively reticent about the usefulness of science-based information.

Factors shaping the perception of the usefulness of public knowledge differ in both types of firms. Non-innovators come to value public knowledge in more restrictive circumstances than innovators. This is an important contribution of our article to theory. Openness is the only common feature associated, in both innovators and non-innovators, to a positive perception of the usefulness of public knowledge.

Among innovators, resources (as measured by size) and the absorptive capacity of companies (as measured by skills) positively influence company perception of the usefulness of public knowledge. It is not often we find such an association between public knowledge and absorptive capacity or resources in non-innovators.

In our sample, practical experience of innovation is more likely to produce differences between firms' perceptions than involvement in formal R&D. A large proportion of Spanish firms focus on technology adoption rather than on technology creation (Busom & Fernández-Ribas, 2008). In our view, they may adopt or imitate new technology at the shop-floor level (i.e. not necessarily in a R&D Department). Probably, the absorptive capacity of the Spanish manufacturing firm and its capacity to profit from public knowledge are better defined by a skilled workforce than by a R&D Department.

Whereas R&D is not significant for innovators' perceptions, it is significant for non-innovators'. Our results for the former are in line with Vega-Jurado et al. (2009) who

analysed a sample of innovative Spanish companies. Nevertheless our findings are counterintuitive since R&D is often seen as a complement to external knowledge. Though more evidence is required, since the impact for non-innovators is borderline significant, they point towards an interesting direction. Actual experience of innovation may help the firm to increase the ease of learning from U-PROs. Therefore, the absorption of public knowledge may require less R&D effort on the part of innovators. Also, effective search may help innovators to find targeted public knowledge. This is another contribution of our paper to theory: ease of learning may depend not only on external factors (complexity of knowledge or adaptation of external knowledge to the firm's needs) as in Cohen and Levinthal's model (1989) but also on an internal factor, namely previous practical experience of the company. While in their model (pg. 578), the "targeted quality" of knowledge may contribute to reducing the resources allocated by firms to R&D, our results suggest that search effectiveness may have similar effects. Experience may help firms to search selectively for technical solutions. This circumstance may explain the divergence of our results and those of Laursen and Salter (2004) who make no distinctions between innovators and non-innovators.

Non-innovators tend to value U-PRO information when they operate in non-competitive markets. Such sheltered environments are likely to reduce the uncertainty involved in information search and, therefore, encourage these companies to use science-based information. Innovators, by contrast, do not need such specific market stimuli, probably because their search is more focused. Previous experience may modify company perception of risks and opportunities, and such perceptions are likely to be clearer in firms which have practical experience of innovation.

The two groups of firms also differ in that the introduction of strategic change is negatively associated to the perception of public knowledge exclusively in innovators.

Finally, non-innovators are deprived of an important stimulus for the use of public knowledge, i.e. cooperation with universities.

To summarise, with the exception of openness, the other factors associated to firms' positive perception of the usefulness of information generated by U-PROs differ between innovators and non-innovators. Non-innovators declare that they profit from knowledge provided by such sources when they operate in sheltered environments and devote internal resources to search. Innovators state that they profit from such information in less restrictive circumstances; however, sufficient financial resources and a skilled workforce are necessary to exploit public knowledge and, hence, to find it useful.

A limitation of the present study is company size. We have defended the need to differentiate between innovators and non-innovators. However, our sample includes only firms with 50 or more employees and we suspect that as a result more non-innovators than innovators are excluded. This circumstance does not diminish the importance of finding distinctive determinants of the use of public knowledge, but makes it advisable to conduct further research with firms of all sizes, especially in the case of non-innovators.

7 Conclusions

The phrase "I do not search, I find" is attributed to Pablo Picasso. An obscure thought with many interpretations, it may refer to an implicit dichotomy between the conscious and unconscious mechanisms of creation. A search implies a conscious effort to bring the pieces together, whereas a finding may also emerge subconsciously. In the latter case, it is an intangible mechanism, possibly the artist's talent or attitude, which makes the creator suddenly aware that the pieces were there and it makes sense to join them up.

It is in this sense that our research has tried to advance our understanding of how firms

value knowledge from U-PROs. In theoretical terms, it indicates on the one hand that not only is searching important, but so are other subtle mechanisms which cause companies to be able to search for information profitably. We further claim that practical experience in technological innovation is one such mechanism.

Our results may have some managerial implications. If innovators aspire to use public knowledge, they might need to develop the skills of their workforces. To fully benefit from science-based information, non-innovators might need to acquire beforehand some practical experience in technological innovation. Naturally, developing criteria to make these conclusions operational would require additional research.

Our results also have some policy implications. First, fostering openness will increase the perception that public knowledge is useful. Second, policies should overcome the spontaneous trend to address innovators only and, instead, also address non-innovators. Third, the way to address non-innovators is not necessarily promoting the use of public knowledge to innovate, but rather promoting practical experience in innovation to use public knowledge. For non innovators there should be more emphasis on innovative culture than on technology transfer –a task in which not only firms and policymakers could be involved, but also universities. Fourth, our result implies that there is a need to reconcile strategic innovation, technological innovation and the use of public knowledge.

Finally, our results have one methodological implications regarding CIS (Community Innovation Survey) of the European Union and technology surveys alike (for instance, PINTEC in Brazil). These statistics focus on the usefulness of external knowledge sourcing exclusively in innovators. However, in many countries, these firms account for a minority of manufacturing firms. A broader statistical base, taking into realistic account the fact that non-innovators also value public knowledge, might be useful.

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Tables

Table 1 Perceived usefulness of information sources for innovation-related activities in Spanish manufacturing firms, 2003. Sample of innovators (1 = none, 10 = maximum importance)

Type	Information source	Number of cases	1	2	3	4	5	6	7	8	9	10	Total
Internal	Own R&D department	796	20%	2%	1%	1%	6%	3%	10%	17%	16%	25%	100%
	Own production department	822	2%	1%	1%	1%	4%	4%	11%	27%	18%	31%	100%
	Own marketing department	810	8%	2%	2%	3%	10%	7%	12%	23%	12%	21%	100%
	Parent company	438	16%	2%	3%	2%	7%	4%	6%	14%	16%	31%	100%
Market	Customers	824	2%	2%	2%	2%	4%	4%	8%	17%	18%	42%	100%
	Competitors	819	8%	3%	3%	4%	13%	8%	15%	23%	10%	12%	100%
	Consultants	815	17%	9%	8%	6%	18%	10%	14%	11%	4%	2%	100%
Institutional	Universities or PROs	816	23%	9%	8%	7%	15%	8%	13%	11%	3%	3%	100%
	Public administration	805	31%	10%	9%	8%	14%	8%	9%	5%	3%	3%	100%
Codified	Patents	802	34%	9%	7%	3%	10%	4%	6%	8%	4%	13%	100%
	Scientific publications	816	22%	9%	10%	7%	16%	9%	11%	9%	3%	4%	100%
	Industrial publications	816	13%	7%	8%	8%	19%	13%	14%	10%	3%	5%	100%
Other	Trade associations	821	6%	4%	4%	3%	12%	12%	16%	20%	10%	12%	100%
	Trade fairs	805	10%	6%	6%	5%	16%	10%	13%	19%	6%	8%	100%
	Conferences	809	25%	11%	8%	7%	16%	10%	9%	9%	3%	3%	100%
	Internet	773	12%	4%	5%	7%	15%	11%	14%	13%	8%	10%	100%

Table 2 List of variables and descriptive statistics

Variable	Description	Innovators						Non-innovators						Significance of Mann–Whitney test for median differences
		Median	Mean	Standard deviation	Min.	Max.	Number of cases	Median	Mean	Standard deviation	Min.	Max.	Number of cases	
Perceived usefulness	Perceived degree of importance of U-PROs as information sources for innovation (0-4 Likert scale)	1	1.28	1.18	0	4	816	1	0.81	0.98	0	4	180	*
R&D activities	Dummy variable equal to 1 if the respondent declared that the firm conducted R&D activities, 0 otherwise.	1	0.66	0.47	0	1	831	0	0.33	0.47	0	1	188	*
Firm size	Number of employees (in natural logarithm in the regressions).	98	162.05	281.03	50	5996	824	87	119.99	100.98	50	850	185	*
Skills	Degree of technical complexity of tasks (0-5 Likert scale).	1	1.45	1.41	0	5	827	1	1.14	1.32	0	5	186	*
Strategic innovation	Degree of non-technological innovation in the last three years, based on important changes in strategic orientation (0-4 Likert scale).	2	2.18	1.38	0	4	814	2	1.72	1.47	0	4	185	*
Competition	A coded response to the question, "in your opinion, in the main market where your firm operates, the number of competitors is…" Answers can range from 0 (very low) to 3 (very high).	2	1.76	0.96	0	3	829	2	1.82	0.95	0	3	186	n.s.
Openness	Perceived degree of importance of the 11 external sources of information for innovation listed in Table 1 (i.e. excluding "internal" sources and "universities or PROs"). We eliminated observations with more than 5 "don't know" responses.	4	4.48	1.70	0	9	818	4	4.00	1.67	0	8	186	*
Collaboration	For innovators, collaboration with U- PROs in product or process development in the last three years, with a score of 2 if mentioned in first place before other alternatives for product and process development, 1 if mentioned in second place, 0 if not mentioned. Other alternatives were: "mainly by the firm itself", "in collaboration with other firms", "mainly by other firms", "mainly by the group" and "others".	0	0.14	0.40	0	2	833	-	-	-	-	-	-	-

* $p<0.05$; n.s. Not significant

Table 3 Correlation matrixes

	Innovators								Non-innovators						
	1	2	3	4	5	6	7	8	1	2	3	4	5	6	7
1. Perceived usefulness	1								1						
2. R&D activities	.14	1							.21	1					
3. Firm size	.13	.09	1						.19	.21	1				
4. Skills	.11	-.03	.01	1					.11	.16	.05	1			
5. Strategic innovation	.09	.12	.01	.04	1				.13	.13	.12	-.03	1		
6. Competition	.03	-.05	.02	-.04	.11	1			-.17	-.13	-.08	.10	.15	1	
7. Openness	.60	.14	.05	.11	.22	.09	1		.57	.11	.06	.01	.25	.05	1
8. Collaboration	.18	.09	-.02	.02	.08	.04	.07	1	-	-	-	-	-	-	-

Table 4 Ordered logit model of the perceived usefulness of information provided by universities and PROs for innovation-related company activities

	1 Innovators	2 Non-innovators
Number of observations	781	173
Log likelihood function	-917	-150
Prob[$\chi 2$ > value]	0	0
	Coeff. (t-ratio)	Coeff. (t-ratio)
Constant	-3.74 (-5.73) ***	-7.02 (-4.34) ***
R&D activities	0.21 (1.35)	0.64 (1.72) *
Ln firm size	0.27 (2.49) **	0.47 (1.63)
Skills	0.1 (2.01) **	0.13 (0.94)
Strategic innovation	-0.12 (-2.16) **	-0.1 (-0.82)
Competition	-0.02 (-0.25)	-0.5 (-2.8) ***
Openness	0.91 (18.7) ***	1.1 (8.84) ***
Collaboration	0.73 (4.3) ***	
Industry dummies	Included	Included

*** p<0.01; ** p<0.05; * p<0.10